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DO UNIVERSITIES LOOK LIKE PATENT TROLLS? AN EMPIRICAL STUDY OF UNIVERSITY PATENT INFRINGEMENT LITIGATION IN THE UNITED STATES

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Do universities look like patent trolls? An Empirical Study of University Patent Infringement Litigation in the United States

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Abstract

In an attempt to increase revenues from patenting and licensing activities, some universities have started in recent years to pursue "overzealous" strategies to protect their existing patents, by enforcing them in court and selling them to the highest bidder. In our paper, we provide the first comprehensive evidence on the characteristics of universities' litigation strategies, by comparing patents litigated by universities to those litigated by patent trolls and other entities. In doing so, we collect data on patent infringement lawsuits in the United States in the years 2003-2016 and we analyze three dimensions that have been identified in the literature as characteristics of patent trolls' behavior: (i) the intensity with which a patent is litigated, (ii) the choice to file a patent lawsuit in the Federal District Court of Texas Eastern, and (iii) the quality of the asserted patents. We find that while overall universities' litigation strategies seem to differ from those of patent trolls, this is not the case in the ICT field, the most targeted by trolls, where universities frequently litigate their patents in the Eastern District of Texas and that are of lower quality compared to patents litigated by other entities.

Keywords: University patents, patent litigation, patent assertion entities, patent quality.
Jel Classification: C25, O34, K41.

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1 Introduction

Since the passage of the Bayh-Dole Act in 1980, the number of university patents in the United States has significantly increased (Council et al., 2011) and universities have become increasingly involved in technology transfer activities. At the same time, some universities have also recently become more aggressive in trying to monetize their intellectual property (IP) assets: some studies have found that universities transfer patents to patent trolls (Feldman and Ewing, 2012; Fusco et al., 2019), while others reveal that they are repeat initiators of patent infringement litigation (Rooksby, 2011).

Because universities play an important role in both the production and the dissemination of knowledge, the way they monetize their patents might have a significant impact on society. There are, in particular, specific concerns about the access to university-created inventions that in many cases are publicly funded (Drivas et al., 2017; Thompson et al., 2018).

Despite the importance of this phenomenon, only few studies have examined university patent litigation. Our research partially fills this gap in the literature by providing an empirical analysis of university patent litigation strategies, by comparing patents litigated by universities to those litigated by patent trolls. The reason for this parallel is that both universities and patent trolls are non-practicing entities (NPEs), i.e. entities that do not intend to practice their patents (Lemley, 2008).

Patent trolls are often criticized for harming innovation by enforcing weak and outdated patents that have been infringed by third parties (Chien, 2010). In particular, patent trolls are accused of primarily focusing on suing for patents that relate to an already developed product, thus harming companies and individuals who do not have sufficient resources to fight them in court (Chien, 2013; Feldman and Lemley, 2015; Cohen et al., 2019). Scholars have taken a keen interest in their patent acquisition activities, but especially in their litigation activities, because of the latter's damaging potential on innovation (Bessen and Meurer, 2013; Chien, 2013; Kiebzak et al., 2016). Their influence in the patent market is of great importance as the study by Allison et al. (2010) suggests that patent trolls are the most litigious actor in the market, as almost 50% of the most litigated patents belong to them.

In this regard, universities, as all NPEs, enjoy a privileged position when asserting their patents, such as advantages in litigation tactics, the impossibility of counter-attack by the defendant, and a pure financial interest in the patent (Lemley and Feldman, 2020).

Since 2000, universities are increasingly pursuing patent enforcement (Ascione et al., 2021), sometimes with remarkable success. For example, the California Institute of Technology recently won a $1.1 billion patent verdict against Apple and Broadcom for infringement of patents held by the university on Wi-Fi technology, the largest jury verdict in 2020 and the sixth largest patent verdict ever. Also noteworthy is the University of New Mexico (UNM) case, which in 2019 asserted two patents that were not invented by

UNM faculty, but were purchased from the Industrial Technology Research Institute (ITRI), a Taiwanese entity established and funded by the Taiwanese government.

In this paper, we therefore focus on the increasing presence of universities in the courts in the United States. With a few exceptions (Shane and Somaya, 2007; Rooksby, 2011, 2012, 2013; Firpo and Mireles, 2018, 2020), economists and legal scholars have not extensively studied the phenomenon of university patent litigation and the few empirical studies that do address university litigation left unanswered numerous questions about litigation strategies that universities regularly adopt. We thus seek to understand whether the increasing presence of universities in court is related to an increased willingness of universities to defend their intellectual property in order to better ensure its transfer or, rather, to an increased interest in purely monetizing their patents.

We contribute to the debate in several ways. First, we expand the coverage of the phenomenon analyzed by Rooksby (2013); Firpo and Mireles (2018, 2020), both in terms of time span and data considered, i.e. we consider all USPTO patents between 2003 and 2016. Second, we directly compare the characteristics of patents litigated by universities to those litigated by both patent trolls and other entities (which in most cases are product companies). Finally, we deepen our understanding of the phenomenon by analyzing whether the results differ depending on whether the litigated patents belong to the ICT sector, the industry in which trolls litigate the most and where patents are often used for strategic and monetization reasons.

The rest of the article is organized as follows. In the next section we present the background literature and the goals of our research. In Section 3, we describe patent and litigation data and we present our variables of interest. In Section 4, we describe the methodology and report the results of our empirical analysis. Section 5 concludes with the discussion of the policy implications of our results.

2 Background and motivation

University research is a building block for research and development (R&D) in the most advanced countries. In the US, higher education institutions (HEIs) accounted for around 13% of total R&D expenditure and 50% of basic research in 2017, with the federal government as the largest funder providing more than half of the total R&D budget (Beethika Khan and Okrent, 2020).

Traditionally, universities have been perceived as a support structure for innovation, whose approach to knowledge creation and diffusion influences the entire economy (Nelson, 1993). However, their role in the innovation arena changed after the second academic revolution (Etzkowitz, 2001), when universities started to engage in entrepreneurial activities, not without tensions, in order to transform the outcomes of their inventions into patented and thus marketable products (Etzkowitz, 1990). Therefore, HEIs changed their role in the innovation ecosystem, by integrating university culture with the commercial

assumptions underlying IP law (Ghosh, 2016). Therefore, such changes in the relationship between HEIs and intellectual property are interesting to study for the innovation system as a whole (Adams, 1990).

In particular, while there is no doubt about the increasing involvement of universities in patenting activity (Ryan Jr and Frye, 2017), there is no consensus on whether this has effectively promoted technology transfer (Feldman and Lemley, 2015). On the one hand, the increasing involvement of universities in patenting activity has created financial incentives for companies to develop and commercialize products that would otherwise entail untenable trial costs, and for university professors to support the development and commercialization of inventions that are often at an embryonic stage and require further development efforts from their inventors (Jensen and Thursby, 2001; Ouellette and Weires, 2019). On the other hand, IP protection of university inventions has also had some unintended consequences for the diffusion of scientific knowledge. Not only does academic patenting hinder the use and production of science (Murray and Stern, 2007), but patent licensing agreements are sometimes "divorced" from innovation (Feldman and Lemley, 2015) and, when they are part of technology transfer, they appear to be incidental, since actual knowledge transfer takes place much earlier, through collaborations and informal know-how (Thompson et al., 2018). Other types of university technology transfer tend to be generally more important than university-licensed patents, and alliances between universities and private firms can often take place ex ante, even before patents are filed (Martínez and Sterzi, 2019).

In line with the increasing involvement of universities in patenting activities, universities started to establish technology transfer offices (TTOs) to assist researchers with patent applications and manage licensing revenues, especially after the Bayh-Dole Act. However, licensing does not seem to be too fruitful for universities. In the US, revenues from patent licensing activities account for only a fraction of total university research expenditures (Collinsworth and Crager, 2014; Eisenberg and Cook-Deegan, 2018), and few universities have made profits from licensing activities. An extensive study by Brooking Institution (Valdivia, 2013) shows that 84% of US universities did not break even in technology transfer in 2012, given the staffing and filing costs. Moreover, empirical evidence also shows strong heterogeneity across universities: looking at data from 155 universities, the eight universities with highest licensing revenues accounted for 50% of licensing revenue across the entire sample, suggesting that few patents granted to academic institutions are likely to be highly valuable (Ryan Jr and Frye, 2017).

Thus, in the attempt to increase revenue streams from patenting activity, TTOs started to make use of heterogeneous monetization strategies. First, they increasingly use exclusive (rather than non-exclusive) licenses, although these often act as a barrier to downstream R&D rather than an incentive (Mazzoleni, 2006; Özel and Pénin, 2016).[1] Second, universities also increasingly rely on patent markets to sell their patents (Fusco et al., 2019; Caviggioli et al., 2020). For example, USPTO data on patent reassignment in

[1] In this sense, Ayres and Ouellette (2016) suggest that universities should be allowed to propose exclusive licenses only after first "offer[ing] the invention under a nonexclusive license for a nominal fee".

recent years show that universities are among the entities with the highest volume of outbound patent assignment transactions.[2] In addition, there is recent evidence that universities have adopted new ways of patent marketing by organizing auctions (e.g., in the case of Pennsylvania State University) or relying on auctions organized by third parties (for example, in the case of Ocean Tomo[3]), and by collaborating with patent trolls (Feldman and Ewing, 2012; Fusco et al., 2019; Love et al., 2020). For example, Intellectual Ventures, one of the largest patent holding companies in the US and a notorious patent troll, has disclosed its relationships with more than 400 universities (60 of which are American-including Columbia, University of California, Texas University, and California Institute of Technology), although only two of these have resulted in commercial products (Cordova and Feldman, 2015)[4]; Love et al. (2020) confirm that in most instances university patent transfers are made to patent trolls and note that these transfers very often concern legal liability without really encouraging commercialization. Third, recent evidence also suggests that universities have started to enforce patents at the end of their patent term and against companies that have already developed successful commercial products without having actually exploited the university patent (just as patent trolls would do) (Firpo and Mireles, 2020). In 2014, for example, Boston University won settlements with 25 companies (included large companies in the tech industry such as Amazon, Apple and Microsoft, among others) it sued for infringing their patented technology (US5686738 - filed in 1995) for producing blue light-emitting diodes (LEDs).[5] Another famous case of late enforcement of patents was Carnagie Mellon University, which in 2016 received $750 million from Marvell Technology as a settlement for a case of infringement of two patents (US6201839, filed in 1998 and US6438180, filed in 1999) whose purpose was to reduce "noise" on hard drives. This case set the record for the largest payment in a patent case related to a computer science invention (Rooksby, 2016).

The strong interest of universities in patent enforcement became apparent when university associations lobbied against anti-troll legislation that would also thwart their ability to engage in litigation (Valdivia, 2015). In addition, another step appears to be about to be taken by a consortium of 15 of the most prominent US research universities, including California Institute of Technology, Berkeley, Columbia, Harward, and Yale, as explained in a June 10, 2021, EFF article.[6] Indeed, a patent exploitation company has been formed by this consortium with the goal of "receiving payments for patents that have not been successfully licensed via a bilateral 'one patent, one license' transaction". This new LLC will specifically

[2] In January and February 2019, four universities appeared among the top ten patent assignors by number of transactions (*IAM Magasine*, 2019).

[3] US university patents account for 20% of business for Ocean Tomo, a company known for its patent auctions (Ledford, 2013).

[4] Recent research by Fusco et al. (2019) confirms the relationship between Intellectual Ventures and universities, showing that the former appears to be the buyer of almost two hundred university patents issued at the USPTO, representing about 50% of all patents transferred to patent trolls.

[5] Incidentally, other companies did not settle and the jury found that they infringed the '738 patent and failed to prove the patent's invalidity. However, the defendants appealed to the Federal Circuit, which reversed and made the patent invalid for not meeting the enablement requirement.

[6] https://www.eff.org/deeplinks/2021/06/15-universities-have-formed-company-looks-lot-patent-troll (accessed July 2021).

focus on sectors characterized by software patents, as well as non-exclusive sub-licensing. The EFF article concludes that the consortium "will use the threat of litigation to try to get all competitors in a given industry to pay for the same patent".

Concerns about the behavior of some universities in pursuing their litigation strategies have also been shared by US Courts and judges, such that universities are now increasingly considered as for-profit businesses and they are increasingly unlikely to be granted immunity under the experimental use exemption (Rowe, 2005).[7]

Given this background, some scholars have analyzed the consequences of patent litigation in universities (Shane and Somaya, 2007) and questioned to which extent universities can be compared to patent trolls (Lemley, 2008; Firpo and Mireles, 2018, 2020; Rooksby, 2011, 2013). As early as in 2007, Shane and Somaya warned of the potential negative effects of an excessive presence of universities in court. In particular, they focus on the impact that patent litigation can have on universities' efforts to license their technologies. Using an unbalanced panel of 116 universities litigating their patents in court between 1991 and 2000, they find that litigation has a negative impact on licensing activity and suggest that this result is due to litigation disrupting overall TTO's activity by reducing the resources available to commercialize technologies and build licenses.

More recently, Rooksby (2011) and Firpo and Mireles (2018, 2020) describe the characteristics of cases of infringement lawsuits initiated by universities (and the patents at issue), raising questions about the potentially strategic nature of universities' behavior in these litigations. In particular, Rooksby (2011) study includes 57 cases between 2009 and 2010 involving 125 patents. The author concludes that certain characteristics, such as the preference for a jury over a judge, suggest that university behavior is similar to that of for-profit actors. Firpo and Mireles (2018) examine litigation cases filed by universities, foundations, and nonprofits organizations from 2000 to 2015, totaling 585 cases, and find partial evidence of strategic (troll-like) behavior in university patent litigation. However, their analysis is based only on indirect evidence, since they compare the mean values of patent quality for their sample of patents litigated by universities with the mean values of (i) the "most litigated patents" from Allison et al. (2009) and (ii) non-university patents litigated at the Federal District Court of Texas Eastern - both of which are considered evidence of aggressive patent assertion. In a more recent paper, Firpo and Mireles (2020) continue to investigate the troll-like behavior of universities and non-profits, finding inconclusive evidence on the matter but emphasizing that "some universities are engaging in behavior that can be particularly troubling."

In this paper, we build on Firpo and Mireles (2018, 2020) and compare the characteristics of infringement

[7] In particular, a recent opinion by the Federal Circuit (Madey v. Duke) makes clear that universities should not be granted immunity under experimental use (Rowe, 2005), pointing out that "Duke [...] like other major research institutions of higher learning, is not shy in pursuing an aggressive patent licensing program from which it derives a not insubstantial revenue stream".

cases initiated by universities with those initiated by patent trolls and other entities in the United States. In doing so, we analyze three dimensions that have been identified in the literature as characterizing patent trolls' behavior: (i) the intensity with which a patent is litigated (enforcing the patent with a large number of defendants in a short period of time), (ii) the choice of Federal District Court of Texas Eastern to prosecute the litigation, and (iii) the quality of the invention protected by the patent.

Number of defendants

In order to exploit economies of scale, patent trolls often litigate their patents against multiple defendants simultaneously, a habit not shared by producing companies (Allison et al., 2010; Lemley and Feldman, 2020). This strategy is economically feasible because the cost of proving further infringement does not increase linearly since the legal apparatus built up for one defendant can be used against many (Allison et al., 2009, 2010; Feng and Jaravel, 2020). As a result, patent trolls are not afraid to name multiple defendants when they engage in litigation and often seek a quick settlement (Chien, 2013).

Federal District Court of Texas Eastern

Filing suit in Federal District Court of Texas Eastern is widely recognized in the literature as a strategic decision characteristic of troll-like behavior (Rooksby, 2011; Cohen et al., 2016; Firpo and Mireles, 2018; Cohen et al., 2019). Traditionally, the Eastern District of Texas has established itself as a jurisdiction that has attracted a large number of patent infringement cases filed by patent trolls (Cohen et al., 2019) because of its reputation as a favorable venue for plaintiffs in patent infringement actions suits (Masters and Weber, 2009) and because of the expeditious docket (Coursey, 2009). The choice to file suit at this court, when no other ties with the venue are acknowledged, might depend on the idea that the presiding judges sympathize with IP owners (Liang, 2010).

Patent quality

There is quite a heated debate about the quality of patents litigated by patent trolls. On the one hand, empirical evidence shows that patent trolls have lower rates of success compared to producing companies (Allison et al., 2010; Lu, 2012; Risch, 2015; Allison et al., 2017). In particular, data from Darts-IP (2018) show that in Germany, the European country most affected by patent troll-related litigation, producing companies win infringement cases almost 15% more often than patent trolls do. Cohen et al. (2019) find that patent trolls disproportionately assert patents close to their expiration date, which they consider an indication of low-quality lawsuits. On the other hand, Risch (2012) analyzes the patents asserted by the ten most-litigious patent trolls in the United States and found them to be of similar or of higher quality than those asserted by producing companies, when quality is approximated by the number of forward citations or by the number of claims in the patent application.

Thus, in recent years, the literature has already shown how the behavior of patent trolls and producing companies differs with respect to these three dimensions (Allison et al., 2009; Fischer and Henkel, 2012; Firpo and Mireles, 2018; Cohen et al., 2019). In this context, the aim of this paper is to analyze the characteristics of patents litigated by universities in order to understand to what extent they are similar to those litigated by patent trolls.

3 Data sources and main variables

3.1 Sample construction

We conduct our analysis by relying on US Patent Litigation Docket Reports dataset (PLDR, 2019 version), which contains complete patent litigation information on district court cases filed in US district courts from January 1, 2003, to December 31, 2016, for a total of over 55,000 cases (Schwartz et al., 2019). PLDR provides the information on the type of litigation (infringement actions, patent invalidity, etc.), the names of the parties involved in the litigation, the litigation venue, and the relative litigated patents.

In our analysis we consider only infringement cases where the plaintiff is the patent holder and sues the defendant(s) for infringement of a utility patent, which count 43,663 cases and 33,676 unique patents.

We then enrich the database by identifying infringement cases that involve universities or patent trolls among the plaintiffs. We categorize a litigation case as "**university litigation**" if at least a patent asserted in the infringement case is owned, at the time of the litigation, by a university (TTO included), a research institution, or a hospital. We identify the type of patent owners by relying on EPO PATSTAT Person Augmented Table (EEE-PAT) (Van Looy et al., 2006) that reports for each patent the names of the assignee(s) and its sector (university, public research organization, hospital, company, individual). We then do a match by patent and name of the assignee(s) with US Patent Assignment Dataset (PAD, Version 2017) and, whenever a correspondence was not found, we perform an automatic search for keywords in the assignee name in order to allocate unassigned entities to a specific sector.[8]

Whenever a university was not found, we then verify whether a patent troll is at the origin of the litigation ("**patent troll litigation**"). For this purpose, we follow two strategies. First, we identify patents owned by patent trolls at the time of the litigation by relying on a list of patent troll names (and theirs subsidiaries) provided by Darts-IP.[9] The list contains the names of firms that Darts-IP defines as "independent organizations (legal entities) which own or benefit from patent rights but do not sell or manufacture goods or services associated with them (i.e., non-operating companies) and which have an

[8] For example, we use the business entities code to individuate private business enterprises and keywords like "school" or "university" to identify universities.

[9] https://clarivate.com/darts-ip/ (accessed June 2021)

active (offensive) assertion or litigation role as plaintiffs towards the enforcement of their patent rights".[10] We do a probabilistic match between the assignee names in PAD and the list of patent troll names in order to identify if and when a patent was held by a patent troll. We identify 12,969 litigated patents where a patent troll is among the plaintiff (this corresponds to the category "Identified patent trolls" in Table 1). Second, since patent trolls make often use of dormant and shell companies with the purpose of litigating their patents without disclosing patent ownership and reducing personal liability (Morton and Shapiro, 2013; Federal Trade Commission, 2016; Sterzi et al., 2021), we extend the list of identified patent trolls provided by Darts-IP by including all entities that take the form of limited liability company (LLC), which is the most common type of entity used by patent trolls (Sterzi et al., 2021). This is, for example, the case of Intellectual Ventures: Darts-IP identifies almost two hundred entities linked to Intellectual Ventures, while for other sources the overall number of shell companies exceeds two thousands, and practically all of them take the form of LLCs.[11] By including LLC entities, we identify 8,240 additional patents asserted by patent trolls (this corresponds to the category "Other LLC entities" in Table 1). For robustness, we will also exclude these patents in some regressions in the empirical analysis.

Table 1: Number and share of infringement cases by type of plaintiffs

	Frequency	**Percent**	**Cum**
University	579	1.33%	1.33%
Patent troll	21,209	48.57%	49.90%
*Identified patent trolls**	12,969	29.70%	
Other LLC entities	8,240	18.87%	
Other entities	21,209	48.57%	100%
Total	43,663	100.00%	

Notes: Litigation years: 2003-2016. Infringement actions only.
* Identified patent trolls refers to the Darts-IP list of trolls

Finally, all the remaining cases are categorized as "**Other entities**", which consist of infringement suits filed by product companies (in most of the cases) and by individuals. The final database accounts for 43,663 infringement actions filed in the US and 33,676 litigated patents between 2003 and 2016. Table 1 shows the frequency for each of the three categories. Infringement cases filed by universities ("University litigation") are still quite a rare occurrence (1.3% of all the cases), while patent trolls file a more significantly number of patent infringement lawsuits as they account for almost 30% or 50% of the cases, depending whether we consider (or not) LLC entities as patent trolls.

For each litigation case, we then collect the information on the litigated patent, such as the technological

[10] https://www.darts-ip.com/de/npe-litigation-in-the-european-union-facts-and-figures-2/ (accessed July 2021)
[11] https://www.plainsite.org/tags/intellectual-ventures-shell-companies/ (accessed June 2021)

class and the application year, from the US-OECD patent quality database (version 2020) (Squicciarini et al., 2013) and the forward citations from the Patents View Database[12].

3.2 Main variables

In line with the characteristics highlighted at the end of Section 2, litigated patents are analyzed on three main dimensions to identify similar patterns across groups. The first characteristic under study is the number of defendants per patent ($DEFENDANTS$). The number of defendants refers to the sum of all the defendants by litigation case. Second, a binary variable has been created taking the value of one when a litigation is filed at the Federal District Court of Texas Eastern ($TEXAS$). A relevant share (about 1 out of 4 cases) of infringement actions takes place at this Court that, as explained before, has earned the reputation of being friendly to patent holders and has attracted numerous opportunistic patent litigations (Cohen et al., 2016). The third dimension accounts for the quality of the patent that we proxy in two ways. First, following Cohen et al. (2019), we consider patents litigated late in time as a sign of low litigation value. In particular, we consider the age of the patent at the time of the litigation (AGE), where age is defined as the time lag between grant date and litigation date. Second, we consider the number of citations received by the focal patent as they are indication that an innovation has contributed to the development of subsequent inventions (Henderson et al., 1998). In doing so, we build two measures that differentiate the technological importance of the patent at the time of the invention from the quality at the time of the litigation. The first measure ($5Y\_FILING\_CITATIONS$) indicates the number of citations received by the focal patent in the first five years after the filing date; the second measure ($5Y\_LITIGATION\_CITATIONS$) indicates the number of citations computed in the year of the litigation and in the four years before. While the former is largely used in the literature, measuring the potential technological and commercial importance of a patent at the beginning of its lifetime, the latter has the benefit of representing the economic value of a patent at the time of the litigation.

Due to missing data on some covariates, the dataset reduces to 87,919 records, which corresponds to 41,191 infringements and 30,882 litigated patents over the time span 2003-2016 in the US. Table 2 depicts the descriptive statistics of the dataset under study. This descriptive analysis provides evidence of differences and/or similarities across the three groups, namely Patent trolls, Universities and Other entities, considering the main characteristics of litigated patents, i.e. number of defendants, venue of litigation (Texas) and patent quality (patent age, the number of citations at the time of the invention, and at the time of the litigation).

Overall, taking the full sample, sharp differences are observed between patent trolls and other entities, where the former exhibit higher values in all respects. Dissimilarities look a little milder between trolls and universities, where the litigated patents are similar for age at the time of the litigation. Moreover, when

[12] https://patentsview.org/ (accessed June 2021)

Table 2: Descriptive statistics (2003-2016) by assignee typology and sector

Variables	mean	sd	OTHER mean (A)	TROLLS mean (B)	UNIVERSITIES mean (C)	(1) t-test	(2) t-test	(3) t-test
				Full sample				
DEFENDANTS	5.12	11.71	4.79	5.48	4.40	-8.64***	1.39	-3.17***
TEXAS	0.20	0.40	0.09	0.32	0.07	-87.75***	2.09**	20.07***
AGE	10.02	5.34	9.26	11.27	11.43	-56.43***	-15.99***	-1.07
5Y_FILING_CITATIONS	14.87	24.90	12.78	17.10	11.62	-25.47***	1.96**	7.62***
5Y_LITIGATION_CITATIONS	20.97	37.68	17.95	23.99	22.06	-23.59***	-4.54***	1.76*
N. Obs.	87,919		43,580	42,889	1,450			
				ICT				
DEFENDANTS	5.96	13.92	5.80	6.03	6.56	-1.71*	-1.01	-0.67
TEXAS	0.31	0.46	0.16	0.40	0.22	-55.15***	-3.21***	6.47***
AGE	10.96	5.45	9.61	11.69	11.43	-40.05***	-6.53***	0.84
5Y_FILING_CITATIONS	18.99	30.28	19.21	18.92	14.21	0.99	2.94**	2.84***
5Y_LITIGATION_CITATIONS	25.80	42.70	25.37	26.06	22.87	-1.69*	1.06	1.34
N. Obs.	47,334		16,520	30,481	333			
				non-ICT				
DEFENDANTS	4.15	8.33	4.18	4.13	3.76	0.50	1.67*	1.36
TEXAS	0.07	0.26	0.05	0.13	0.03	-29.07***	2.85***	9.89***
AGE	9.47	5.09	9.04	10.24	11.42	-21.95***	-15.31***	-7.74***
5Y_FILING_CITATIONS	10.07	15.20	8.86	12.63	10.84	-22.96***	-4.70**	3.29***
5Y_LITIGATION_CITATIONS	15.33	29.84	13.43	18.90	21.82	17.00***	10.30***	-2.64***
N. Obs.	40,585		27,060	12,408	1,117			

Notes: (1), (2) and (3) represent, respectively, the t-values of the tests on the difference between the following sample means: (A)-(B), (A)-(C) and (B)-(C). ***p<0.01,**p<0.05, *p<0.1.

looking at ICT sector, differences in litigated patents are smaller among patent trolls and universities. First, universities litigate a significant share of their patents in Texas (22%), below 40% of patents litigated by patent trolls, but above 16% of patents litigated by other entities. In addition, no more difference is found with respect to the number of defendants per patent and the number of citations at the time of the litigation.

The next section provides a more analytical look at the differences among the three identified groups of patent plaintiffs and it aims to propose a more detailed model that builds on these intuitions. To do so, an econometric model is estimated that enables to isolate the relationship between patent characteristics and group belonging. We employ a multiple regression framework since it retains the independent variables in their original form, thus making model interpretation easier than alternative multivariate procedures, such as Linear discriminant analysis or Multivariate analysis of variance.

4 Empirical Analysis

As explained before, this section is devoted to study the litigation strategies of plaintiffs by providing a broad-based statistical characterization of patent cases filed by different typologies of plaintiff, namely patent trolls, universities, and other entities. In particular, looking at the main characteristics of the patents under litigation over time, the aim of this empirical study is to identify some regularities, if any, in the recent increase in university patent litigation and to explore evidence of strategic behavior in order to identify similarities and differences across types of plaintiffs. The analysis concludes with a focus on *ICT*, i.e. the field that is targeted the most by patent trolls (Fischer and Henkel, 2012).

4.1 Patent trolls

In our first econometric exercise, we first characterize the litigation strategies of patent trolls by estimating the likelihood that a given litigated patent is asserted by a patent troll rather than another entity. To do so, we estimate the following Logit model in which the dependent variable is a dichotomous variable whereby litigated patents belonging to patent trolls are designated as "1" and "0" otherwise:

$$Pr(Y_i = 1) = \frac{e^{\beta' x}}{1 + e^{\beta' X}} \tag{1}$$

In other words, the probability to observe a patent litigated by a patent trolls - rather than other entities - is assumed to be a function of a vector of explanatory variables, x, namely the three dimensions as described in the previous sub-section.

The results are shown in Table 3 and confirm the hypothesis in Section 2: patent trolls litigate their patents more against a higher number of defendants and more frequently in Texas. With respect to the quality, patent trolls initiate litigation on relatively high quality patents when referring to a standard measure ($5Y\_FILING\_CITATIONS$): patents litigated by patent trolls receive more citations at the beginning of their lifetime than the average. However, the probability of a patent being litigated by a troll also decreases with the technological importance at the time of litigation ($5Y\_LITIGATION\_CITATIONS$). In other words, these results, together with the positive coefficient of AGE, suggest that trolls tend to litigate patents that are of high quality at the time of filing but that are less important at the time of litigation. Altogether these results corroborate the findings that patent trolls mainly monetize valuable but old technologies rather than playing as intermediaries in the patent market (Orsatti and Sterzi, 2018).

Table 3: Patent troll characteristics. Logit regression results

VARIABLES	(1) TROLL (=1) vs NO-TROLL (=0)
DEFENDANTS	0.00532***
	(3.235)
TEXAS	0.864***
	(18.77)
AGE	0.0322***
	(11.77)
5Y_FILING_CITATIONS	0.00180***
	(3.039)
5Y_LITIGATION_CITATIONS	-0.00130***
	(3.255)
Constant	-3.058***
	(19.12)
Observations	87,919
Year dummies	YES
Field dummies	YES
Pseudo R2	0.247

Notes: Unit of observation: patent. Litigation years: 2003-2016; $^{+}$Robust z-statistics (in absolute value) in parentheses; ***p<0.01,**p<0.05, *p<0.1

4.2 Comparing universities to patent trolls

In what follows, we want to analyze the patent litigation strategies of universities by comparing the characteristics of the patents they litigate with those that are instead litigated by patent trolls. In doing so, we estimate Multinomial Logit models that explore the factors explaining the likelihood of a patent belonging to one of the three groups under study, namely Trolls, Universities and Other entities:

$$Pr(y = j) = \frac{e^{\beta_j x}}{1 + \sum_{k=1}^{J-1} e^{\beta_k x}} \qquad for \quad j = 1, 2, ..., J-1 \tag{2}$$

Where $Pr(y = j)$ is the probability of the n-th patent belonging to the j-th group and x is a vector of explanatory variables. Other entities group (OTHER) is designated as the reference category, J. The probability of membership in other categories is then compared to the probability of membership in the reference category.

The results of the Multinomial Logit regression are shown in Table 4. Columns (1) and (2) provide the outputs corresponding to TROLL and UNIVERSITY equations, while column (3) gives the statistical tests on the differences between coefficients across the two equations. First, it can be noted that all

the coefficients in column (1) are significant and consistent with those obtained with the Logit model (Table 3). Second, contrary to patent trolls, the characteristics of patents litigated by universities are more similar to those litigated by the reference group: university litigated patents differ significantly from the reference group only on two variables (AGE and $5Y\_LITIGATION\_CITATIONS$). With respect to age, we observe that, as for patent trolls, universities tend to initiate litigation on relatively older patents than those of the reference group. If patent age increases by one unit, the relative log odds of being in trolls and universities group increase by 0.03 and 0.05, respectively. The difference between the two coefficients is small but statistically significant at the five percent significance level. The second variable ($5Y\_LITIGATION\_CITATIONS$) shows a positive and significant coefficient. In this respect, universities differ from both trolls and other entities by litigating patents of relatively higher quality at the time of litigation.

Table 4: Multinomial Logit regression results. Full sample

VARIABLES	(1) TROLL	(2) UNIVERSITY	(3) χ^2 test
DEFENDANTS	0.00531***	-0.000748	0.61
	(3.200)	(0.0960)	
TEXAS	0.872***	0.229	11.76***
	(18.72)	(1.210)	
AGE	0.0340***	0.0553***	4.93**
	(12.37)	(5.826)	
5Y_FILING_CITATIONS	0.00175***	-0.000503	1.62
	(2.906)	(0.281)	
5Y_LITIGATION_CITATIONS	-0.00120***	0.00280**	12.26***
	(2.923)	(2.440)	
Constant	-2.477***	-6.040***	
	(15.41)	(13.79)	
Observations	87,919		
Year dummies	YES		
Field dummies	YES		
Pseudo R2	0.244		

Notes: Unit of observation: patent. Litigation years: 2003-2016; # The group OTHER is the baseline comparison group; +Robust z-statistics (in absolute value) in parentheses; ***p<0.01,**p<0.05, *p<0.1

Table 5 provides the outcomes of the Multinomial Logit regression on patent ownership group when restricting to ICT sample, i.e. the sector most affected by troll-like behavior and where patents are mainly used for strategic and monetization reasons. For what concerns patent trolls, with the exception of $5Y\_FILING\_CITATIONS$ which is no longer significant, all the coefficients in column (1) are once again significant with the expected sign and a higher magnitude than observed in Table 4. This tends to

confirm a particularly aggressive behavior of patent trolls in this sector. The outcomes corresponding to the UNIVERSITY equation are, on the other hand, notably different from those observed in Table 4. Indeed, the variable $TEXAS$ has now a positive and significant effect, meaning that universities litigate in Texas more frequently than other entities. The fact to litigate a patent at the Federal Court of Texas Eastern increases the log-odds of being in TROLL and UNIVERSITY category, holding all other independent variables constant, by 0.959 and 0.449, respectively. In addition, with respect to patent quality, universities seem to litigate patents of lower quality with respect to the reference group: patents litigated by universities are indeed older than patents litigated by other entities, and less cited ($5Y\_FILING\_CITATIONS$) than the average.

Table 5: Multinomial Logit regression results. ICT sample

VARIABLES	(1) TROLL	(2) UNIVERSITY	(3) χ^2 test
DEFENDANTS	0.00669***	0.00562	0.04
	(3.181)	(0.972)	
TEXAS	0.959***	0.449**	5.27**
	(16.96)	(1.997)	
AGE	0.0469***	0.0338**	0.69
	(12.58)	(2.143)	
5Y_FILING_CITATIONS	0.000332	-0.00636*	3.32*
	(0.470)	(1.719)	
5Y_LITIGATION_CITATIONS	-0.00123**	0.00147	2.00
	(2.476)	(0.767)	
Constant	-2.623***	-7.641***	
	(10.76)	(9.735)	
Observations	47,334		
Year dummies	YES		
Field dummies	YES		
Pseudo R2	0.195		

Notes: Unit of observation: patent. Litigation years: 2003-2016; # The group OTHER is the baseline comparison group; +Robust z-statistics (in absolute value) in parentheses; ***p<0.01,**p<0.05, *p<0.1

Table 6 shows the results of the Multinomial Logit model for the non-ICT sample. The main findings are the same as in the Table 4 for the whole sample, with two exceptions. First, for patent trolls, the coefficient related to the number of defendants is not significantly different from zero. The number of defendants per patent is the same across groups. Second, contrary to the ICT sector, patents litigated by universities are of high quality as measured by the number of forward citations; in particular, $5Y\_FILING\_CITATIONS$ now has a positive and significant effect and the difference between the coefficients in the two columns is not statistically significant.

Table 6: Multinomial Logit regression results. Non-ICT sample

VARIABLES	(1) TROLL	(2) UNIVERSITY	(3) χ^2 test
DEFENDANTS	0.00311	-0.0103	0.45
	(1.073)	(0.521)	
TEXAS	0.564***	-0.244	4.53**
	(6.896)	(0.642)	
AGE	0.0177***	0.0602***	10.99***
	(4.422)	(4.826)	
5Y_FILING_CITATIONS	0.0104***	0.00897***	0.23
	(6.770)	(3.044)	
5Y_LITIGATION_CITATIONS	-0.00243***	0.00259*	9.44***
	(2.876)	(1.681)	
Constant	-2.783***	-5.732***	
	(16.68)	(8.349)	
Observations	40,585		
Year dummies	YES		
Field dummies	YES		
Pseudo R2	0.179		

Notes: Unit of observation: patent. Litigation years: 2003-2016; # The group OTHER is the baseline comparison group; +Robust z-statistics (in absolute value) in parentheses; ***p<0.01,**p<0.05, *p<0.1

As a robustness check, the Multinomial Logit analysis is also performed using (i) only the Darts-IP list to identify the patent trolls (Tables A2, A3 and A4) and (ii) only US universities (Tables A5, A6 and A7). The results are presented in the Appendix and confirm the main results obtained in this section.

5 Concluding remarks

Over the past twenty years, TTOs have evolved from pursuing patent protection and licensing innovation to elaborating careful commercialization strategies, as revenue generation is now a relevant goal of their technology transfer operations. Indeed, recent evidence shows that university monetization activities have increased significantly, especially in the US, and that university TTOs appear now to be "patent-centric" in their attempt to fit entrepreneurship and commercialization into universities' missions (Carter-Johnson, 2020) as well as being "revenue-driven with a single-minded focus on generating licensing income" (Kesan, 2008).

Currently, some universities are redoubling their efforts to pave the way for sharing and selling their scientific results. For example, in mid-2018, Stanford University reorganized its TTO under a new director, centralizing its functions and hiring new business development staff, to provide "a higher return on marketing efforts".[13]

While the growing attention to monetization activities might help universities to increase funding, there is no consensus on whether this effectively promotes technology transfer. To be effective, technology transfer should include not only the public information disclosed in the patent, but also the transfer of know-how. However, this is not the case for most of licensing requests from universities, which, on the contrary, are often justified by the need to monetize the patented inventions (Lemley and Feldman, 2020). In this sense, the behavior of universities as non-practicing entities, in dealing with the patent system might be in many ways more akin to patent trolls than to product companies. Moreover, if the purpose of the Bayh-Dole act is to promote commercialization of academic inventions, the increasing participation of universities in litigation activity may be controversial because it is not the university as patentee but the defendant that achieves the goal of the patent system (Lemley and Feldman, 2016).

Our study provides the first comprehensive evidence of the characteristics of litigation strategies of universities in the United States in the time span 2003-2016, by comparing patents litigated by universities to those litigated by patent trolls. Our findings can be summarized as follows. On the one hand, universities seem not to engage in opportunistic litigation as patents litigated by universities differ from those litigated by patent trolls in several respects: unlike patent trolls, universities do not file most of their patent lawsuits in the Eastern District of Texas, do not litigate their patents against multiple defendants, while they litigate highly-cited patents at the time of the litigation. However, we also observe a great deal of heterogeneity at the sector level and a different picture in the ICT industry, the industry where trolls litigate the most and where patents are often used for strategic reasons. In the ICT field, the characteristics of patents litigated by universities are more similar to those litigated by patent trolls than

[13] https://hechingerreport.org/think-universities-are-making-lots-of-money-from-inventions-think-again/ (accessed July 2021)

those litigated by other entities: universities frequently litigate their patents in the Eastern District of Texas and they assert patents that are not of high quality compared to other entities.

Although our results are based on a still-emerging phenomenon, they call for serious consideration of the possible consequences that the rent-seeking behavior may have on technology transfer and innovation, and the evolution of the phenomenon therefore needs to be carefully monitored. Recent initiatives, such as the the Reclaim Invention Program by the Electronic Frontier Foundation (EFF)[14], are to be welcome as they might curb the increasing rent-seeking behavior that characterizes some universities in the United States.

[14] https://www.eff.org/it/reclaim-invention/pledge (accessed June 2021)

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Appendix

Table A1: Correlation matrix among variables under study

	DEFENDANTS	TEXAS	AGE	CITATION
TEXAS	0.049			
AGE	0.011	0.118		
CITATION	0.033	0.105	0.106	
EARLY_CIT	0.046	0.086	0.263	0.721

Table A2: Multinomial Logit regression results. Full sample
LLCs excluded from the analysis

VARIABLES	(1) TROLL	(2) UNIVERSITY	(3) χ^2 test
DEFENDANTS	0.00683***	-0.000303	1.01
	(3.446)	(0.0426)	
TEXAS	1.020***	0.227	17.79***
	(18.61)	(1.207)	
AGE	0.0496***	0.0577***	0.67
	(14.60)	(6.055)	
5Y_FILING_CITATIONS	0.00210***	-0.000492	1.65
	(2.968)	(0.241)	
5Y_LITIGATION_CITATIONS	-0.000678	0.00287**	8.69***
	(1.480)	(2.387)	
Constant	-3.178***	-6.087***	
	(12.65)	(13.85)	
Observations	73,474		
Year dummies	YES		
Field dummies	YES		
Pseudo R2	0.360		

Notes: Unit of observation: patent. Litigation years: 2003-2016; # The group OTHER is the baseline comparison group; +Robust z-statistics (in absolute value) in parentheses; ***p<0.01,**p<0.05, *p<0.1

Table A3: Multinomial Logit regression results. ICT sample
LLCs excluded from the analysis

VARIABLES	(1) TROLL	(2) UNIVERSITY	(3) χ^2 test
DEFENDANTS	0.00713***	0.00606	0.04
	(3.248)	(1.124)	
TEXAS	1.062***	0.454**	7.71***
	(17.31)	(2.058)	
AGE	0.0606***	0.0354**	2.59
	(14.99)	(2.270)	
5Y_FILING_CITATIONS	-0.000406	-0.00651*	2.84*
	(0.556)	(1.784)	
5Y_LITIGATION_CITATIONS	-0.00104**	0.00140	1.66
	(2.031)	(0.736)	
Constant	-3.488***	-7.735***	
	(9.625)	(9.832)	
Observations	39,538		
Year dummies	YES		
Field dummies	YES		
Pseudo R2	0.224		

Notes: Unit of observation: patent. Litigation years: 2003-2016; # The group OTHER is the baseline comparison group; +Robust z-statistics (in absolute value) in parentheses; ***p<0.01,**p<0.05, *p<0.1

Table A4: Multinomial Logit regression results. Non-ICT sample
LLCs excluded from the analysis

VARIABLES	(1) TROLL	(2) UNIVERSITY	(3) χ^2 test
DEFENDANTS	0.00542	-0.00784	0.59
	(1.264)	(0.464)	
TEXAS	0.832***	-0.234	7.54***
	(7.235)	(0.609)	
AGE	0.0248***	0.0622***	7.65***
	(4.020)	(4.982)	
5Y_FILING_CITATIONS	0.0241***	0.00957***	17.68***
	(10.26)	(3.201)	
5Y_LITIGATION_CITATIONS	-0.00405***	0.00281*	11.98***
	(3.047)	(1.697)	
Constant	-3.476***	-5.754***	
	(16.03)	(8.372)	
Observations	33,936		
Year dummies	YES		
Field dummies	YES		
Pseudo R2	0.371		

Notes: Unit of observation: patent. Litigation years: 2003-2016; # The group OTHER is the baseline comparison group; +Robust z-statistics (in absolute value) in parentheses; ***p<0.01,**p<0.05, *p<0.1

Table A5: Multinomial Logit regression results Full sample
US Universities

VARIABLES	(1) TROLL	(2) US UNIVERSITY	(3) χ^2 test
DEFENDANTS	0.00531***	0.00337	0.08
	(3.197)	(0.485)	
TEXAS	0.874***	0.174	11.84***
	(18.75)	(0.852)	
AGE	0.0339***	0.0837***	31.14***
	(12.32)	(9.483)	
5Y_FILING_CITATIONS	0.00179***	0.00262*	0.33
	(2.960)	(1.832)	
5Y_LITIGATION_CITATIONS	-0.00124***	0.00201*	8.71***
	(3.027)	(1.838)	
Constant	-2.478***	-6.820***	
	(15.41)	(12.29)	
Observations		87,489	
Year dummies		YES	
Field dummies		YES	
Pseudo R2		0.245	

Notes: Unit of observation: patent. Litigation years: 2003-2016; # The group OTHER is the baseline comparison group; +Robust z-statistics (in absolute value) in parentheses; ***p<0.01,**p<0.05, *p<0.1

Table A6: Multinomial Logit regression results. ICT sample
US Universities

VARIABLES	(1) TROLL	(2) US UNIVERSITY	(3)
DEFENDANTS	0.00671***	0.00950*	0.38
	(3.183)	(1.919)	
TEXAS	0.960***	0.255	8.87***
	(16.97)	(1.068)	
AGE	0.0468***	0.0524**	0.07
	(12.57)	(2.520)	
5Y_FILING_CITATIONS	0.000322	-0.00208	0.48
	(0.456)	(0.598)	
5Y_LITIGATION_CITATIONS	-0.00123**	0.000482	0.53
	(2.477)	(0.204)	
Constant	-2.622***	-7.842***	
	(10.75)	(9.375)	
Observations		47,225	
Year dummies		YES	
Field dummies		YES	
Pseudo R2		0.195	

Notes: Unit of observation: patent. Litigation years: 2003-2016; # The group OTHER is the baseline comparison group; +Robust z-statistics (in absolute value) in parentheses; ***p<0.01,**p<0.05, *p<0.1

Table A7: Multinomial Logit regression results. Non-ICT sample
US Universities

	(1)	(2)	(3)
VARIABLES	TROLL	US UNIVERSITY	
DEFENDANTS	0.00311	-0.00617	0.22
	(1.069)	(0.312)	
TEXAS	0.565***	-0.132	2.90*
	(6.907)	(0.323)	
AGE	0.0176***	0.0934***	55.41***
	(4.373)	(9.407)	
5Y_FILING_CITATIONS	0.0106***	0.0135***	1.03
	(6.859)	(4.784)	
5Y_LITIGATION_CITATIONS	-0.00251***	0.00152	6.80***
	(2.985)	(1.069)	
Constant	-2.785***	-6.503***	
	(16.69)	(11.28)	
Observations		40,264	
Year dummies		YES	
Field dummies		YES	
Pseudo R2		0.178	

Notes: Unit of observation: patent. Litigation years: 2003-2016; # The group OTHER is the baseline comparison group; +Robust z-statistics (in absolute value) in parentheses; ***p<0.01,**p<0.05, *p<0.1

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