Patent Trolls on Markets for Technology – An Empirical Analysis of Trolls' Patent Acquisitions

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Patent trolls appropriate profits from innovation solely by enforcing patents against infringers. They are often characterized as relying on low-quality patents, an assessment that, if correct, would imply that eradicating such patents would effectively terminate the troll business. In this paper, we shed light on this issue by empirically analyzing trolls' patent acquisitions. We draw on a unique dataset of 565 patents acquired by known patent trolls between 1997 and 2007, which we compare to 1,130 patents acquired by practicing firms. Our findings regarding patent characteristics support recent theoretical propositions about the troll business model. Trolls focus on patents that have a broad scope and that lie in patent thickets. Surprisingly, and contrary to common belief, we find that troll patents are of significantly higher quality than those in the control group. This result implies that elevating minimum patent quality will not put an end to the patent troll business, and suggests that it is sustainable in the long run. Furthermore, we discuss the fact that trolls are peculiar players on markets for technology insofar as they are solely interested in the exclusion right, not in the underlying knowledge. We posit that transactions involving patent trolls may only be the tip of the iceberg of "patent-only" transactions, a conjecture with strong implications for the efficiency of markets for technologies. Managerial and policy implications are discussed.

Keywords: markets for technology, patent acquisitions, patent trolls, empirical study
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1. Introduction

Patent trolls, or nonpracticing entities (NPEs), are firms whose business model is focused on enforcing patents against infringers in order to receive damages or settlement payments (e.g. Reitzig et al., 2007). Some consider patent trolls to be a serious threat to innovation in high-technology industries, and, thus, policy makers have paid considerable attention to this topic (e.g. U.S. Federal Trade Commission, 2003; Jaffe and Lerner, 2004; Lemley and Shapiro, 2007). Extant research has studied the legal underpinnings of the troll business (Magliocca, 2007; Golden, 2007; Lemley and Shapiro, 2007), provided (some) empirical evidence on troll-type patent litigation (Lerner, 2006; Magliocca, 2007; Reitzig et al., 2010), and illuminated the various strategies underlying the troll business and its sustainability to policy changes (Reitzig et al. 2007; Henkel and Reitzig, 2007).

However, a systematic quantitative study of patent troll activity is lacking, and with it an empirically based judgment about the strategies, technology fields, and sustainability of future troll activity. Such judgment is critical for both policy makers aiming at curtailing the troll business and managers facing the threat of patent troll attacks.

The current lack of empirical studies is mainly due to data availability issues. Many infringement cases involving trolls are settled out of court, and even those that do end up in court are difficult to gather. We thus pursue a different route, by analyzing trolls' patent acquisitions. In so doing, we obtain a systematic outlook on those patent troll activities that are based on acquired patents, which constitute a considerable and growing share (Reitzig et al., 2010, Table 1 and Figure 2).

We draw on a unique dataset of 565 patents acquired by known patent trolls between 1997 and 2007, which we compare to 1,130 patents acquired by practicing firms. Our findings regarding patent characteristics support our hypotheses, derived from the literature and from considerations of the troll business model. Trolls seem to be able to acquire patents that are most appropriate for their business model. Compared to practicing firms, trolls focus on patents that: (a) have a broad scope and are thus infringed upon with a high probability; (b) lie in patent thickets and thus have a high substitution cost; and, most importantly—and contrary to common belief—(c) are of significantly higher quality than those in the control group and thus have a high probability of being upheld in court. The latter result in particular suggests sustainability of the troll business in the future.

Beyond the analysis of trolls' patent acquisitions, our study contributes more generally to the understanding of markets for technology (e.g. Arora and Gambardella, 1994; Gans and

Stern, 2003; Lamoreaux and Sokoloff, 1999; Arora et al., 2001). Trolls often procure their patents by acquisition (as we describe above) or by in-licensing (Reitzig et al., 2010, Table 1). On the selling side, they always generate their revenues as licensors or sellers of patents. Hence, patent trolls appear to be very active players on markets for technology, as both buyers and sellers. But trolls are rather peculiar participants in these markets. As Reitzig et al. (2010) point out with a focus on trolls' role as sellers, the troll phenomenon calls into question the established notion that intellectual property rights always improve the functioning of markets for technology. We concur with this assessment; however, we argue that trolls challenge our understanding of markets for technology even more fundamentally. As buyers of patents, they are solely interested in the exclusion right, not in the underlying knowledge. Similarly, when trolls sell or license patents, the transaction again does not involve a technology transfer since by definition of the troll business model the potential licensee already uses the patented invention. Extrapolating from our empirical analysis, we posit that transactions involving patent trolls may be only the tip of the iceberg of "patent-only" transactions. Thus, patent transactions may be—to an extent that needs to be determined by future research—indications not of efficiency-enhancing knowledge trading and division of labor, but rather of inefficient duplication of inventions and failure of *ex ante* licensing.

The remainder of the paper is structured as follows. In Section 2, we discuss the troll business model, review the pertaining literature, and derive hypotheses. In Section 3 we describe our data and empirical strategy. In Section 4 we present our results. Section 5 concludes.

2. Background and hypotheses

2.1. The patent troll business model

We follow Reitzig et al. (2007, p. 137) in defining "patent sharks or trolls as individuals or firms that seek to generate profits mainly or exclusively from licensing or selling their (often simplistic) patented technology to a manufacturing firm that, at the point in time when fees are claimed, already infringes on the shark's patent and is therefore under particular pressure to reach an agreement with the shark." The term "nonproducing entity" or "nonpracticing entity" is often used synonymously with "patent troll" and "patent shark" and has the advantage of avoiding a derogatory connotation. However, it equally describes pure research firms and institutions that seek to license their technologies *ex ante*, i.e., before infringement occurred. To avoid this misunderstanding, we use the common term "patent troll" in this paper. In doing so, we do not imply a moral judgment. A firm fitting the above definition may indeed behave like a proverbial malicious troll by deliberately hiding its patents, but it may also represent a serious inventor who failed to license his inventions *ex ante* and who years later finds them infringed. In fact, trolls may have a positive effect by inducing corporations to more carefully respect the patent rights of financially or otherwise constrained inventors, since these may seek the help of trolls to enforce their rights.

The above definition alludes to the observation that trolls often base their business on trivial patents. Lerner (2006), in his study of litigation of patents that relate to financial products and services, obtains results that are consistent with this view. The historical examples of patent trolls in agriculture analyzed by Magliocca (2007) also support the notion of troll patents being of dubious quality, as do high-profile cases such as *NTP v. Research in Motion.*[1]

However, recent theoretical and empirical contributions suggest a more complex picture. From a game-theoretical analysis, Henkel and Reitzig (2007) derive three distinct strategies that trolls may follow. Pursuing the "injunction-based" strategy, the troll seeks a favorable settlement with the infringer under the legal threat of an injunction or some similar legal measure. Since patent invalidation proceedings usually take too long to counter such a threat, patent quality matters little for this strategy. As a result, low-quality patents may be preferred by trolls because they are easier to obtain, or harder for the infringer to find. The situation is different for the "damages-based" and the "switching cost-based" strategy. In the former case, the troll goes after damages awarded by the court for past infringement, while in the latter case the troll exploits the high cost that the infringer would have to bear, even without time pressure, for switching to a noninfringing technology. Both of these strategies do leave enough time for invalidation proceedings, and so require legally sound patents. Empirical findings by Reitzig et al. (2010) indicate that trolls do indeed play all of these strategies.

2.2. Sustainability of the troll business

Two inefficiencies in the patent system—excessive damage awards and patentee-friendly injunctions—favor the patent troll business model (Reitzig et al., 2007), most notably the first two strategies mentioned above. Infringement damages are calculated, in the majority

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[1] In March 2006, Blackberry maker Research In Motion paid an irrevocable fee of US$ 612.5 million to NTP in an out-of-court settlement. At the time of the settlement, all five pertaining patents had already been preliminarily invalidated by the U.S. Patent and Trademark Office, a fact attesting to their low quality. See http://news.cnet.com/BlackBerry-saved/2100-1047_3-6045880.html?tag=mncol;txt (accessed 09/11/2009).

of cases, as "reasonable royalties," which e.g. the Directive 2004/48/EC (§13.1b) of the European Parliament on the enforcement of intellectual property rights defines as "the amount of royalties or fees which would have been due if the infringer had requested authorisation to use the intellectual property right in question." However, in calculating such *ex post* damages, courts typically do not—although theoretically they should—take into account the hypothetical cost of replacing the infringed technology with a noninfringing alternative *ex ante*, i.e., before lock-in occurred (Reitzig et al., 2007). Thus, for easy-to-invent-around inventions the common calculation method leads to excessive outcomes, facilitating the damages-based troll strategy. As to the second inefficiency, generous grants of injunctions obviously favor the injunction-based troll strategy. The easier and faster it is for trolls to obtain injunctive relief, the higher their leverage in negotiations with infringers.

Legal and economics scholars have envisioned legal changes that could impede the patent troll business (Magliocca, 2007; Golden, 2007; Lemley and Shapiro, 2007), and courts and policy makers, notably in the United States, are about to address the above inefficiencies. In September 2007, the U.S. House of Representatives passed the bill for the Patent Reform Act (H.R. 1908), which defines "reasonable royalty" much more narrowly than then existing law.[2] Since the U.S. Supreme Court's ruling in *eBay Inc. v. MercExchange, L.L.C.*, it appears all but impossible for nonproducing entities to obtain injunctions.[3] Finally, trivial patents are harder to obtain and more easily invalidated since the Supreme Court's 2006 decision in *KSR International Co. v. Teleflex, Inc.*[4]

The above policy initiatives notwithstanding, we follow Henkel and Reitzig (2007) in their conjecture that the patent troll business model will be sustainable in the future. First of all, the troll business is favored by the patent system's lack of transparency, which makes it difficult to identify all patents that a new product might infringe upon and to determine for any given patent if it reads on the product or not (e.g. Bessen and Meurer, 2008). In light of ever increasing numbers of patent applications, it appears unlikely that this situation will improve in the near future, and so inadvertent infringement will remain hard to avoid with any certainty. Regarding legal measures, not all countries have taken actions against trolls, and even in the United States some patent reform efforts have stalled (see Footnote 2). Also, trolls

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2 See Section 5 of the bill. Note, however, that the bill never became law. (http://www.govtrack.us/congress/bill.xpd?bill =h110-1908, accessed 09/11/2009).

3 The Supreme Court determined that an injunction should not automatically issue upon finding of patent infringement (http://www.supremecourtus.gov/opinions/05pdf/05-130.pdf, accessed 09/11/2009).

4 See http://www.supremecourtus.gov/opinions/06pdf/04-1350.pdf (accessed 09/11/2009).

may learn to circumvent legal restrictions, e.g. by maintaining minor production operations in order to be considered a producing entity. Most importantly, however, the switching cost-based troll strategy is affected by neither of the legal changes outlined above. Since this strategy requires legally sound patents, we expect forward-looking trolls to acquire patents that are of high quality and thus likely to be upheld in court.

2.3. Trolls' vs. practicing firms' patent acquisitions

When patent trolls procure patents, be it by acquisition or filing, they are competing for these patents with practicing firms. In fact, by the very design of the troll business model, trolls are only interested in patents covering inventions that are used, or are likely to be used, by some practicing firm. In turn, if a practicing firm anticipates that trolls might procure patents on inventions it uses, it will have an interest to preempt the troll and secure the patent or a license to it (or, if possible, to destroy it).

Focusing on patent procurement by acquisition, the likely winner of this competition is determined by the contenders' relative abilities in two disciplines: to identify suitable patents, and to extract their value. Regarding identification, we note that procuring patents, identifying infringers, and enforcing patents against them are a patent troll's sole activities, which suggests that they should be superior to practicing firms in this discipline.

Regarding value extraction, three different uses of patents by practicing firms matter in our context (e.g. Levin et al., 1987; Cohen et al., 2000): a) preventing imitation or substitution of own products; b) cross-licensing with competitors (Hall and Ziedonis, 2001; Ziedonis, 2004); and c) licensing against royalties. Except in industries in which each patented invention is used by only one practicing firm (as is often the case, e.g. in the pharmaceutical industry), and unless cross-licensing is strictly symmetrical, appropriating the full value of a patent will involve licensing against royalties. However, there are two reasons why doing so will often be difficult for practicing firms. First, if no amicable agreement is reached and the party that expects to receive royalties threatens to sue its counterpart for infringement, the latter may threaten to sue in turn. Second, the patentee may have other business relationships with the infringer, which an infringement suit may jeopardize. Trolls, in contrast, are neither vulnerable to counter-litigation for infringement nor to a termination of some other business relationship (Golden, 2007; Lemley and Shapiro, 2007; Reitzig et al., 2007), and so are in an excellent position to enforce their patents. Thus, trolls should be superior to practicing firms in extracting value from patents suitable for the troll business and able to outplay the latter when competing for those patents.

We now discuss characteristics of patents that make them suitable for the troll business model, and from these derive three hypotheses regarding the likelihood of a patent being acquired by a troll as opposed to a practicing firm. Our first hypothesis relates to patent scope; the broader the scope of a patent, the larger the number of products and processes that, *ceteris paribus*, will infringe upon it (Merges and Nelson, 1990). Since trolls rely on infringement of the patents they own, characteristics that increase the likelihood of infringement—and thus patent scope in particular—should make a patent more attractive for them. Practicing firms, on the other hand, are mainly interested in infringements that come close to their own use of the patented invention, and thus should value patent scope to a lesser degree than trolls do. We thus posit:

Hypothesis 1. *The probability of acquisition by a patent troll compared to a practicing firm increases with the scope of the patent.*

The second patent characteristic patent trolls should favor is a high cost of substituting the underlying invention in products. This substitution cost increases with the difficulty of inventing around the patent, which in turn is high if the patent density and complexity of the relevant technology field is high. This means that many patents exist that have a high degree of overlap between them and with the patent under consideration, so that finding a gap for a non-patented substitutive technology is difficult. In other words, the focal patent is part of a patent thicket (Shapiro, 2001). In principle, practicing firms could benefit from high substitution costs if they seek royalty income by enforcing the patent against infringers. However, as discussed above, patent trolls have an advantage over practicing firms in patent enforcement due to the absence of a product-based revenue model. We hence posit:[5]

[5] In addition to increasing the cost of substitution, the fact that a patent lies in a dense and complex patent environment will likely also increase the probability of it being infringed. It is less clear, however, if this increased probability affects the relative attractiveness of the patent for trolls and for practicing firms in the same way as an increase in infringement probability due to scope does. This is because from the perspective of a practicing firm, a broader scope increases the probability of infringement by products that do not directly compete with the firm's own products, while a denser and more complex patent environment should make infringement by *competing* products more likely. Practicing firms care about the latter type of infringement, but less about the former. In any case, these considerations do not put into question Hypothesis 2, they only make the mechanism by which density and complexity of a patent environment affect relative acquisition probabilities somewhat ambiguous.

Hypothesis 2. *The probability of acquisition by a patent troll compared to a practicing firm increases with the patent density and complexity of the technology field.*

Third, the legal quality of a patent, in the sense of it withstanding invalidation proceedings, is a necessary precondition for a sustainable patent troll strategy. In contrast, practicing firms in industries characterized by complex technologies (Kash and Kingston, 2001) such as electronics often use patents for cross-licensing or deterrence (instead of strict exclusion as e.g. commonly practiced in the pharmaceutical industry). In this case, a patent's legal soundness is less critical than for a troll pursuing a sustainable strategy. Since legal soundness is closely linked to a patent's technological quality, we posit:

Hypothesis 3. *The probability of an acquisition by a patent troll compared to an acquisition by a practicing firm increases with the patent's technological quality.*

3. Empirical approach

3.1. Data

To identify patent acquisitions by trolls or practicing firms, we use data obtained from the European Patent Office's (EPO's) PATSTAT and INPADOC databases. PATSTAT contains static bibliographic data on patents, which we matched with patent legal status data and, in particular, information on changes in ownership from the INPADOC database. While both databases are provided by the EPO, they contain data from all national patent authorities that transmit their patent bibliographic and legal status data to the EPO. We concentrate on data from the United States Patent and Trademark Office (USPTO) and the German Patent and Trademark Office (GPTO), because we are confident that for these two patent authorities both patent bibliographic and legal status data have a reliable quality in the EPO's databases. While registering a patent acquisition at the national patent authority is not legally required, doing so brings legal advantages for the acquirer both in the United States (Serrano, 2008) and in Germany. As long as the change of ownership of a patent is not registered at the patent office, a third party can acquire the patent in good faith (creating obvious disadvantages for the first acquirer). Additionally, in infringement suits, plaintiffs have to prove that they are legitimized to enforce the patent. This is most easily and—importantly—most quickly done by being listed as the current patent owner in the patent register. For these reasons, the database can be assumed to comprise, for the United States and Germany, a large share of all patent acquisitions.[6] We complemented the data obtained from INPADOC by data on patent characteristics from PATSTAT.

The first step in our sample construction process was to identify names of patent trolls. Using extensive analyses of newspaper articles and online documents, we identified the names of 78 firms operating in the United States and Germany that meet our definition of a patent troll.[7] In this process, we spent considerable resources for making sure that the alleged patent troll is not a real technology vendor who unsuccessfully offered *ex ante* licenses and afterward sued infringers.[8] This distinction is made difficult by the fact that a considerable share of the patent trolls in our sample changed their business model from manufacturing or *ex ante* technology licensing to an *ex post* licensing patent troll business model, or are in the process of completely shifting their business models. To be transparent about this fact, we classified the patent trolls in our sample into two groups (see Table 1). Type 1 firms always pursued a patent troll business model according to our information, while Type 2 firms shifted their business model to a patent troll business model at some point in time.

-- *Insert Table 1 about here* --

Our sample could suffer from two types of selection biases. First, patent trolls operating recently should be easier to identify than patent trolls operating some years ago, because, among other things, the Web sites offering the richest information on troll litigation did not exist 10 years ago. Second, some patent trolls may have managed to stay out of the attention of the media so far; however, because most patent trolls attack several or even a

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6 Regarding U.S. reassignment data, Serrano (2008) comes to the same conclusion. Unfortunately, this does not seem to hold for all jurisdictions. In our INPADOC database, the large majority of patent transactions are transactions of U.S. and German patents.

7 We followed the same approach as Reitzig et al. (2010) to identify the patent trolls. We used Web sites and blogs that specialize on the discussion of patent litigation cases (e.g. 271patent.blogspot.com, boycottnovell.com/files/trolltracker/, patentlyo.com), technology-oriented sites (e.g. eetimes.com, heise.de, zdnet.com, technologyreview.com), and traditional newspapers that we accessed via LexisNexis. Furthermore, we used the Web sites of the (alleged or real) patent trolls and of their targets. After screening all available data we classified the identified firms on a case-by-case basis.

8 We conducted two rounds of troll classification. In October 2008 we identified the names of the patent trolls that we used to build up our sample for the first time. In October 2009 a second team redid the troll classification. The interrater agreement was 97.5%. We conservatively dropped those firms for which no agreement was achieved.

large number of firms, the probability is high that information on the trolls will leak to specialized Web sites. Nonetheless, we cannot claim to provide a complete picture of all patent trolls.

Using the INPADOC database, we were able to identify 2,859 patents that had undergone a change in ownership name with one of the 78 patent trolls mentioned above listed as the new owner. However, in many cases only a firm's legal form or its address had changed, or the patent had only been transferred to a subsidiary. To eliminate these false positives, we screened the data manually. In this process, we identified all sellers and made sure that they were not legally affiliated with the buyers.[9] Conservatively, we also dropped all patents that had been transferred from a person to the acquiring firm. In these cases we were not able to ascertain if the patent had really been purchased from outside or if a founder or employee of the firm had transferred the patent to the firm. Furthermore, we learned from experts that in some cases only one patent per patent family is reassigned to reduce cost. To avoid biases, we thus kept only one patent per patent family (the one closest to the priority filing) in our dataset if we encountered transfers of several family members. Doing so led to the deletion of 119 patents.[10] Finally, we restricted our dataset to transactions that took place between 1997 and 2007, in order to limit potential bias from incomplete identification of trolls, and because the number of relevant transactions drops markedly for earlier years. We ended up with 565 patents that had been acquired by 39 distinct patent trolls (see Table 1).

For every identified patent acquired by a patent troll, we randomly selected two control patents acquired by a practicing firm in the same year within the same jurisdiction to build a control group. Also for the patents in the control group, we manually screened each reassignment and checked if the new patent owner is a practicing firm and if the reassignment corresponded to a real change in ownership.

3.2. Variables

The dependent variable in our model is a dummy variable that captures if a patent was acquired by a patent troll or by a practicing firm. Following, we discuss the independent variables (see Table 2).

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9 We did not exclude cases where the buyer acquired the "seller" along with its patents. In some cases patent trolls presumably acquire whole firms to get access to their patents. However, in most cases we do not know whether firms or only patents were acquired.

10 We found in only one case a German patent and a U.S. patent of one family that were both transferred. In the other 118 cases we found family members applied for at the same patent authority.

-- Insert Table 2 about here --

Patent scope. We use the number of distinct assigned four-digit International Patent Classification (IPC) classes as a proxy variable for the number of possible fields of application for the technology, one dimension of patent scope often used in extant research (Lerner, 1994). Another commonly used proxy variable for patent scope is the number of claims (Lanjouw and Schankerman, 1997) or the number of claims per backward references (Harhoff et al., 2003). However, the problem with this indicator is that the number of claims depends on how the patent was written by the applicant (Reitzig, 2004, van Zeebroeck et al., 2009), while the assignment to IPC classes is carried out by the examiner and thus should be more objective.

Patent density and complexity of technology field. We measure the patent density and complexity of a technology field using the recently proposed "triple" indicator (von Graevenitz et al., 2008, 2009). This indicator reflects the degree of mutual blocking that the patent portfolios of the larger firms in a technology field show. Its calculation draws on the number of references classified as X or Y in the EPO patent examination process, which means that these prior art documents have limited the patentability of the focal invention. If two firms each own at least one patent that has blocked one of the other's patents, then these firms constitute a blocking pair. If among three firms there are three such blocking pairs, then these three firms form a "triple." The triples indicator captures how many such triples exist in a given technology field.[11] The higher the amount of triples, the more blocking dependencies between firms exist.

Patent technological quality. A patent's technological quality can be proxied by the number of forward citations it has received. The more forward citations a patent has received, the higher its technological contribution to the field (Trajtenberg 1990, Harhoff and Reitzig, 2004). However, we cannot preclude that other, non-technology-related effects influence the number of forward citations (Harhoff and Reitzig, 2004). In particular citations made by the applicant may contain no information on technical quality (Reitzig, 2005). In the EPO patent examination process, examiners assign citations to certain categories in order to separate technological and other citation reasons. As these assignments are stored in PATSTAT, we can use them to identify technology-related citations and include this measure in a robustness

[11] To translate IPC classes into distinct technology fields, we applied the commonly used OST-INPI/FhG-ISI (OECD, 1994) classification.

check (see Footnote 15). To control for the influence that patent age has on the number of forward citations, we include a time variable in our main model that counts the days since the patent's priority filing. In our robustness checks (again, see Footnote 15), we also conducted regressions using five-year truncated forward citations, forward citations by patent age, as well as regressions using an age variable defined by the application date or the grant date. Table 3 shows correlations between all variables for the overall sample.

-- *Insert Table 3 about here* --

3.3. Controls

We employ a number of control variables to avoid omitted variable biases.

Proximity to basic research. Patents may also reference non-patent literature, which for the most part refers to articles in scientific journals. The number of these references can be used as a proxy for the proximity of the patent to science (Narin et al., 1987; Meyer, 2000; Narin and Noma, 1985; Narin et al., 1997).

Age of the underlying technology. The age of the invention at the time of patent acquisition is proxied by the time elapsed between the filing of the priority application and the acquisition of the patent (see above). The priority date marks the time when the first application on an invention was filed at a patent authority and is thus the closest proxy to the date when the invention was made.

Patent economic quality. An indicator of the patent's economic quality is the number of family members it has. Examination fees and, in particular, maintenance fees increase with family size, which should be a good indicator of the patent's economic value as perceived by the applicant (Putnam, 1996; Lanjouw et al., 1998; Harhoff et al., 2003).

Crowdedness of technology field. The patent crowdedness of the patent's main technology field is measured by counting the number of patent applications therein (cf. Harhoff and Reitzig, 2004). In our study, this indicator captures whether the complexity of the patent clearance process due to a more or less crowded patent environment influences the acquisition decisions of patent trolls and practicing firms.

Other Controls. We further control for the patent's number of backward references, though the interpretation of this patent characteristic is not clear. While it has been suggested to measure the amount of extant technology in a technology field (Ziedonis, 2004), other scholars argue that it also measures the scope of the patent (Harhoff et al., 2003). Furthermore, we control for the number of claims a patent makes. This patent characteristic is also ambiguous. Despite being used as a measure for a patent's scope, some scholars argue that the number of claims is correlated with the patent's legal sustainability (Reitzig, 2003; Lanjouw and Schankerman, 2000). The more claims a patent has, the higher the chance that at least one will survive an invalidation procedure. Next, we control for effects specific to the technology fields that the patents belong to, using dummy variables for first-digit-level IPC classes. In addition, we use four dummy variables capturing different five-year patent application periods (1982–1986, 1987–1991, 1992–1996, 1997–2001). Finally, we control for whether the patent was already granted at the time of acquisition.

3.4. *Descriptive results*

The complete dataset contains 1,695 patent acquisitions, with 565 acquisitions by patent trolls and 1,130 acquisitions by practicing firms.

In Figure 1 we show the number of patents acquired by patent trolls by main IPC sections and acquisition year. It is interesting to find that patent trolls specialize on patents in some IPC sections. Hardly any patent acquired by a patent troll is assigned to IPC sections D (Textiles and Paper), E (Fixed Constructions), or F (Mechanical Engineering, Lighting, Heating, Weapons and Blasting); most of them are related to the IPC sections G (Physics) and H (Electricity). This corresponds to the assessment of practitioners in the area of electrical engineering, who state that they are especially affected by the increase in patent trolls' patent enforcement. To give an impression of which technology fields are preferred by trolls, we used the OST-INPI/FhG-ISI (OECD, 1994) classification to translate IPC classes to technology fields. Figure 2 shows the distribution of patent trolls' acquisitions by acquisition year and technology field. Telecommunications and information technology are the fields in which patent trolls recently acquired the most patents.

-- *Insert Figures 1, 2 about here* --

Figure 3 sheds additional light on patent trolls' activities in markets for technology. In our manual screening of patent sellers, we identified, if possible, whether the seller is a practicing firm, a research institute, or an intermediary such as a bank or a patent broker.[12] Furthermore, we identified the size of the firm. Figure 3 illustrates these characteristics of the sellers of patents acquired by trolls and practicing firms, respectively. Patent trolls seem to

[12] To do this we relied heavily on Web searches because the majority of sellers was not listed in firm databases. We were able to identify the business model of sellers of 94% of all patents in our sample.

rely to a lesser degree on large practicing firms from which to acquire their patents. However, we must be cautious in interpreting these findings. For a large percentage of sellers, we were unable to determine firm size. We assume that these firms are small and relatively new, making them harder to find in our Web-based search process. The share of patent acquisitions from small firms by practicing firms should, thus, be higher than measured because the size of 22% of practicing firms' patent sources is unknown (compared to 11% for those of trolls).

-- *Insert Figure 3 about here* --

Comparing patents acquired by patent trolls to those acquired by practicing firms (Table 4), we find no significant differences (at the 10% level) for assigned IPC classes, the number of backward references and whether the patent was granted before acquisition or not, but (highly) significant differences in all other tested characteristics. Patent trolls clearly acquire patents that received more forward citations, are older, have fewer family members, lie in more complex and crowded technology fields, have more claims, and contain more non-patent literature references than patents acquired by practicing firms.

-- *Insert Table 4 about here* --

3.5. Model specification

To clearly identify those characteristics of a patent that make it relatively more attractive to a patent troll than to a practicing firm, we estimate logit models using the dummy variable "acquired by a patent troll" as the dependent variable. A logit model, estimated using maximum likelihood techniques, represents the probability of outcome 1 of the dependent variable Y_i as a function of the covariate vector X and the coefficient vector $ß$:

$$\pi_i = \Pr(Y_i = 1 \mid ß) = \left(1 + e^{-X_i ß}\right)^{-1}$$

However, we need more sophisticated models than the standard logit estimator for the following reason. In the step before the manual screening, we identified 2,859 patents acquired by the patent trolls we had identified, compared to 1,638,214 patent acquisitions by other entities. The need to manually filter each patent severely limited the size of the control group, which we chose to make twice as large as the patent troll group. Thus, we heavily oversample patents acquired by patent trolls. In this situation—that is, if the proportion of positive outcomes in the sample does not match the proportion of positive outcomes in the population—logistic regression yields biased estimates (Prentice and Pyke, 1979; Scott and Wild, 1997). King and Zeng (2001) propose a method to correct for such oversampling of rare events. They prove that the bias in the coefficient estimates generated by oversampling rare events can be estimated using the following weighted least-squares expression:

$$\text{bias}(\hat{\beta}) = (X'WX)^{-1} X'W\xi$$

where $\xi_i = 0.5Q_{ii}\left[(1+w_1)\hat{\pi}_i - w_1\right]$, Q_{ii} are the diagonal elements of $Q = X(X'WX)^{-1}X'$, $W = \text{diag}\left\{\hat{\pi}_i(1-\hat{\pi}_i)w_i\right\}$, and w_1 represents the fraction of rare events in the sample relative to the fraction in the population. Intuitively, one regresses the independent variables X on the residuals using W as the weighting factor (Sorenson et al., 2006).

Tomz (1999) implemented this procedure in the relogit STATA command. We apply a logit estimator in our first model (since relogit does not provide log-likelihood, pseudo-R^2, LR test values, or marginal effects) and estimate a second model using Tomz's procedure to yield unbiased coefficients.

4. Results

4.1. Findings from main models

We find support for our hypothesis that patent trolls pick patents that have, on average, a higher probability of being infringed upon than those in the control group. The coefficient and the marginal effect of the number of assigned IPC classes[13] are positive and highly significant (0.1% level), which confirms Hypothesis 1. Also, the higher the patent density of a technology field, the more likely a patent in this field will be acquired by a patent troll rather than by a practicing firm, a finding that confirms Hypothesis 2 (0.1% level). Furthermore, we find that patent trolls acquire patents that are, on average, of higher technological quality and thus have higher legal sustainability than patents acquired by practicing firms (confirming Hypotheses 3, again on the 0.1% level). The probability of an acquisition by a patent troll increases with the (logarithmic) number of the patent's forward citations.[14] While in line with

[13] The results are comparable when using the number of assigned European Classification (ECLA) classes. ECLA classes are more finely grained and up to date than static IPC assignments available in PATSTAT.

[14] The results are robust to the selection of specific types of forward citations. Model estimations using only the number of X- or only the number of Y-type forward citations yielded comparable results. Also using forward citations per age of the patent or five-year truncated forward citations yields basically the same results. The results are also stable when deploying different types of time exposure controls, e.g. a time variable starting at the priority filing date, the patent application date, or the patent grant date.

our hypothesis, this finding is surprising. It contradicts commonly held beliefs that patent trolls concentrate on enforcing low-quality patents. So, at least for those patent trolls that purposefully pick patents (rather than "discover" them in their "attic"), this belief requires revision.[15]

-- Insert Table 5 about here --

Comparing the results of the logit (Model 1) and the rare events logit (Model 2) model specifications in Table 5, we see only slight differences. By and large the coefficients' signs, values, and p-values are identical in both models. Additionally, we find that patent trolls tend to acquire patents that have, on average, more non-patent literature backward references. This indicator suggest that these patents have a closer proximity to basic research and are, thus, more difficult to substitute and have a higher likelihood to be infringed upon. However, the age of the underlying technology measured by the time elapsed between the patent's priority application and its acquisition has no impact on the relative probability of acquisition by a patent troll. Furthermore, patent trolls acquire patents that have less backward references (to other patents). Surprisingly, patent trolls tend to acquire more patents that are still in examination in relation to practicing entities. This finding may suggest that patent trolls trust more in their own patent quality assessment capability (since they rely less on examiners' judgment) than practicing firms do. Interestingly, the patent crowdedness of the technology field, measured by the number of patent applications in the patent's technology field, has no significant influence on patent trolls' acquisitions. This finding underlines that it is not the crowdedness of a technology field, but rather the density of overlapping patent rights that makes an acquisition favorable for a patent troll.

4.2. Robustness checks

We complement our analysis with six robustness checks estimated with rare events logit model specifications (Tables 6, 7). Model 3 has the same specification as Model 2, but uses only one half of the split control data. To be more specific, in the data construction phase

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15 To see how much the (traded) patents in our sample differ from "average" patents, we randomly drew 1695 patents, matched to our sample by year and by jurisdiction. For these patents, we find an average logarithmic number of 1.24 forward citations, compared to 1.65 for patents acquired by practicing firms and 2.40 for patents acquired by trolls (all differences are significant on the 0.1% level). That is, on average troll patents differ from "average" patents nearly three times as much as patents acquired by other firms do, a finding that underlines the high quality of patents acquired by trolls.

we selected *two* practicing firms' control patents for each patent troll patent. Model 3 compares the 565 patents acquired by patent trolls with a control group consisting of the first 565 practicing firms' control patents (labeled as first control group). The estimation results for this model (Table 6) are very similar to those obtained for Model 2 (Table 5).[16]

-- Insert Table 6 about here --

When we randomly selected patents for the control group, we deliberately matched them by year and jurisdiction to the group of troll patents, but not by IPC section, which we controlled for using dummy variables. Doing so allows us to study how the distribution of patents over IPC sections differs between patents acquired by trolls and those acquired by practicing firms. Figure 4 shows the number of patents acquired by patent trolls and practicing firms (split into first and second control group) for each of the eight main IPC sections. Since patent trolls focus on IPC sections G and H, they dominate the control groups in theses two sections. In order to make double sure—in addition to using IPC class dummies in our main specifications—that different patent characteristics observed are not only due to patents' different technology fields, we constructed a new control group of practicing firms' patents matched also by IPC section to the patents acquired by patent trolls. For each of the 565 patent troll patents, we tried to find a patent that was acquired by a practicing firm in the same year, belonging to the same patent authority, and assigned to the same first-digit main IPC section. Since manually checking each patent is a very time-consuming process, we used the patents in our control groups to build the matched sample. We were able to find a match for 437 out of 565 patents acquired by patent trolls. Repeating the estimation of the specification of Model 3 with this matched sample data set of 874 patents yielded the results shown in Table 6, Model 4. As practicing firms' patents and patent trolls' patents were matched by their main IPC sections, we do not need to control for IPC sections in this model. The estimation results are again nearly identical to those of Models 1 to 3.

-- Insert Figure 4 about here --

Another concern was that the two patent trolls that acquired the most patents—IPCom with 95 patents and Rembrandt Technologies with 105 patents—are a main driver of our estimation results. It is known that these two firms acquired high-quality patents from leading

[16] Also, using only the second matches yields basically the same results.

industry players. IPCom acquired all of its patents from Bosch, which had exited the market for GSM mobile telephony. Rembrandt Technology acquired the majority of its patents from a subsidiary of AT&T. To ensure that our results are not driven by these two largest trolls, we estimated the specification of Model 2 on a dataset without patents from IPCom and Rembrandt Technology and their corresponding control patents. The results shown as Model 5 in Table 6 are again nearly identical to the results of all other models. We provide more robustness checks in Table 7. Model 6 shows the estimation of the model specification used in Model 2 for U.S. patents only, and Model 7 for German patents only. The results are again stable for the U.S. patents. For the small sample of German patents, the effect of number of assigned IPC sections is only significant when using a one-sided test.

-- *Insert Table 7 about here* --

Lastly we exploited the troll classification made in the patent troll classification process to check if the results differed between firms that started with a patent troll business model and those that changed their business model to a patent troll business model. In Model 8 we only included patent trolls that pursued a patent troll business model from the beginning. The results are again stable.

5. Discussion

The analysis has supported our hypotheses that patent trolls acquire patents that have, relative to patents acquired by practicing firms, a higher likelihood of being infringed upon, higher substitution costs, and a higher likelihood of being upheld in court and, thus, of being enforceable. These characteristics are clearly desirable for the patent troll business model, and our results show that patent trolls successfully focus on patents most suitable for their business. Yet, the finding of higher legal stability of patents acquired by trolls is surprising as it contradicts the common notion of trolls exploiting patents of dubious quality.

Our empirical analysis thus supports recent theoretical work arguing that the troll business model will be sustainable in the long run (Henkel and Reitzig, 2007). Legal countermeasures may help to limit the payoffs that trolls can achieve, and may, in particular, prevent gigantic settlement sums as paid by Research In Motion to NTP (see Footnote 1). However, the potentially high cost of substituting an invention once it is incorporated into a complex product will continue to provide leverage to trolls, and so their *ex post* approach to licensing will often be more profitable than *ex ante* licensing (i.e., “true” technology selling).

Hence, our results suggest that the troll strategy of "locking-in-to-extort" indeed needs to be added, as proposed by Henkel and Reitzig (2007), to the list of ways to exploit the exclusion right conveyed by a patent, distinct from excluding to prevent imitation, cross-licensing to coexist, and ex-ante technology licensing for royalties.

Beyond the topic of patent trolls, our results bear relevance for the theory of markets for technology more broadly. Markets for technology facilitate the transfer of technologies to firms better positioned to profit from them (Arora et al., 2001). Technology transfers thus enable firms to reap benefits of division of labor by specializing on either knowledge creation or commercialization (Lamoreaux and Sokoloff, 1999; Arora et al., 2001). As patents enable these markets by the specification of tradable assets in technology, scholars have emphasized the importance of the patent system for markets for technology (Gans et al., 2008; Lamoreaux and Sokoloff, 1999). In turn, transactions on markets for technology are mostly measured by observing patent licenses (Gambardella et al., 2007) or patent sales (Serrano, 2008; Lamoreaux and Sokoloff 1999). However, transactions that involve patent trolls are false positives in these statistics. Neither as buyers or licensees nor as sellers or licensors of patents are trolls interested in the knowledge about the technology that a patent covers. Transactions involving trolls thus take place on the market for patents, but not on the market for technologies. This separation between an asset—knowledge—and the property right attached to it is specific to intangible assets and intellectual property rights, since only in this case can the asset that is subject to a given property right be independently recreated by parties other than the rightful owner. In the concrete case of patents, this separation is grounded in the fact that a firm may reinvent and practice some invention without owning or even knowing about the related patent, and, in turn, a patent owner may neither understand the knowledge underlying the patent nor know who else has this knowledge nor who uses it in practice.

While transactions involving patent trolls are clear-cut cases of such "patent-only" transactions, they are relatively small in number. However, it seems safe to also assume that a good share of patent transactions between practicing firms are pure patent transactions. Based on anecdotal evidence, we conjecture that many instances of cross-licensing in the fields of electronics, software, and telecommunications qualify as patent-only transactions. Future research needs to investigate the size of the share of such transactions. In any case, the use of the terms "markets for technology" and "markets for patents" as synonyms appears to need revision.

The existence of patent-only transactions points to two inefficiencies. The first is an inefficiency in the patent system. If a firm independently came up with and practices a patented invention without knowing about the patent, then the prospect of being granted a patent was apparently not required for this inventor as an incentive.[17] This implies that, from the point of view of incentives, patents are granted too generously (in particular, for too small inventions). The second inefficiency concerns markets for technology. In a case of a patent-only transaction, unknowingly reinventing the patented invention apparently had been easier than finding the patented invention and licensing it *ex ante*.

This discussion suggests an interpretation of patent transactions that strongly differs from received wisdom. To the extent that such transactions relate to patents only and are caused by inadvertent infringement, they are not indications of efficiency-enhancing technology transfers, but rather of inefficiencies in both the patent system and in markets for technology.[18]

Our analysis has a number of management implications. In order to avoid being sued and pressed for license payments by patent trolls, practicing firms have to find ways to impede the troll business. As Henkel and Reitzig (2008) recommend, practicing firms will have to establish more advanced patent clearing and monitoring processes, so that the risk of inadvertent infringement is minimized. In the short run, practicing firms must try to hinder the attempts of patent trolls to acquire patents. This is not an easy task, since—as discussed in Section 3—patent trolls have a higher valuation of the patents under consideration than practicing firms. To overcome this problem, practicing firms will have to cooperate with each other in acquiring patents before patent trolls do. Recently, some attempts in this direction were brought underway (e.g. the foundation of Allied Security Trust by Google, Cisco, Motorola, Ericsson, Sun, HP, Verizon, and other companies in 2008).

Our study has a number of limitations, pointing to opportunities for future research. First, our method of identifying patent trolls via Internet-based search biases the set of trolls we identify to those that have been active more recently. For this reason, the identified increase over time in the number of patent acquisitions by trolls must be interpreted with some care. However, since we do observe a strong increase around the year 2002, and hence

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[17] In case this firm imitated the invention on the basis of the information disclosed in the patent, it would know about the patent and would not infringe upon it inadvertently. Similarly, this firm would also know about the patent if it duplicated the invention in the course of a patent race.

[18] Note that in cases where infringement is deliberate, the occurrence of patent trolls might help to fix another inefficiency of the patent system; namely, the difficulty for financially constrained inventors to enforce their rights. This finding does not contradict our conclusions about inefficiencies in the patent system and in markets for technology, since these inefficiencies are not caused by trolls, but only made visible.

in a period that should be well covered by sources that are available on the Internet, we think that the apparent increase is largely real and not an artifact due to selection bias. Second, trolls may choose to have some acquired patents reassigned and not others. If this choice is endogenous to the respective patent's characteristics, then our assessment of the latter will be biased. We cannot exclude such bias. However, it is not obvious in which direction it would work. No matter which strategy the troll pursues and which type of patent it thus acquires (see Section 2.1), it benefits both from being able to quickly identify itself as the legitimate patent owner and from the element of surprise. The first goal is favored by having the patent reassigned, the second by abstaining from reassignment. We thus think that this type of bias should not distort our results to any appreciable extent.

An interesting avenue of further research on patent trolls is to delve deeper into the processes of how these firms procure patents. Anecdotal evidence holds that patent trolls try to actively contact small firms in particularly interesting technology fields to acquire patents. On the other hand, the advent of specialized patent auction platforms such as Oceon Tomo plays neatly into patent trolls' business model. Furthermore, we offered only a first glimpse on trolls' patent sources. It is still an open question if patent trolls buy their patents mostly from small firms unable to enforce them, or from large firms abandoning certain technology fields. A second interesting issue is our observation that patent trolls acquire patents of higher quality than practicing firms do. Is the commonly held belief that trolls tend to enforce simplistic patents entirely wrong based on spectacular cases such NTP vs. Research In Motion that hinged on patents of rather low quality? Or do trolls that acquire patents and trolls that enforce their own patents differ in this respect? Finally, and more broadly, future research that contributes to disentangling markets for patents from markets for technology should be promising. In particular, it is an open question what share of patent transactions and licenses represent technology transfers and what share merely represent transfers of rights.

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Tables and Figures

Patent Troll	Acquired Patents US	Acquired Patents DE	Type		Patent Troll	Acquired Patents US	Acquired Patents DE	Type
Acacia Technologies	35	0	1		IP-COM	0	95	1
Acceris Communications	1	0	2		J2 Global	7	0	2
American Video Graphics	26	0	1		JGR Acquisition	3	0	2
British Technology Group	41	0	2		Orion IP	12	0	2
Catch Curve	7	0	2		NeoMedia Technologies	3	0	2
Data Treasury	13	0	2		Phoenix IP	3	0	2
Divine Technology Ventures	15	0	1		Pinpoint	4	0	1
E-Fax	1	0	2		Patriot Scientific	3	0	2
ESpeed	2	0	2		PhoneTel Communications	8	0	2
Firepond	2	0	1		Polaris	1	0	2
Forgent Networks	1	0	2		Rambus	8	1	1
Gemstar	11	0	2		Rates Technology	2	0	1
General Patent	2	0	1		Refac Technology	4	0	1
Hoshiko	6	0	2		Rembrandt Technologies	105	0	1
INPRO Licensing	26	0	1		Techsearch	44	0	1
Intellect Neuroscience	4	0	2		Teles	0	1	2
Intellectual Ventures	35	0	1		TV Guide	1	0	2
Intergraph	15	10	2		VCode Holdings	3	0	2
Intertrust	2	0	2		Voice Capture	1	0	1
					University Patents	1	0	2

Table 1 – Patent trolls in our dataset

Acquired by patent troll	Dummy variable that indicates 1 if the patent was acquired by a patent troll
Number of assigned IPC classes	Counts the number of assigned different four-digit IPC classes.
Number of triples in technology field	Counts the number of mutual blocking patent triples in the patents technology field.
Logarithmic number of forward citations	Counts the number of forward citations the patent received. The number of forward citations+1 is logarithmized to account for the variable's skewness.
Number of backward references	Counts the number of backward references that patent makes to patent literature.
Number of nonpatent-literature backward references	Counts the number of backward references that patent makes to non-patent literature.
Number of family members	Counts the number of family members.
Number of claims	Counts the number of claims the patent makes.
Days between filing of priority application and acquisition	Counts the number of days lapsed between filing of the priority application and the patent acquisition.
Patent granted before acquisition	Dummy variable that indicates 1 if the patent was already granted at the time of acquisition
Number of patent applications in technology field	Counts the number of patent applications ever filed in the patents technology field.

Table 2 – Description of variables

	Acquired by Patent Troll	Number of assigned IPC sections	Number of triples in technology field	Logarithmic number of forward citation	Number of backward references	Number of nonpatent-literature backward references	Number of family members	Number of claims	Time between filing of priority application and acquisition	Patent granted before acquisition	Number of patent applications in technology field
Acquired by Patent Troll	1										
Number of assigned IPC sections	0.0330	1									
Number of triples in technology field	0.4487	-0.0685	1								
Logarithmic number of forward citation	0.2826	0.0998	0.2744	1							
Number of backward references	-0.0283	0.0281	0.0553	0.2288	1						
Number of nonpatent-literature backward references	0.0482	0.0708	0.0255	0.0771	0.3533	1					
Number of family members	-0.0537	0.2471	-0.0568	0.0284	0.1439	0.0482	1				
Number of claims	0.0714	0.0443	0.0849	0.1558	0.2312	0.2316	0.0318	1			
Time between filing of priority application and acquisition	0.0810	0.0384	-0.0019	0.3448	-0.0548	-0.0321	0.0154	-0.1966	1		
Patent granted before acquisition	0.0126	0.0075	0.0608	0.4086	0.1761	0.0426	0.0034	0.0313	0.3560	1	
Number of patent applications in patents technology field	0.4112	-0.0782	0.5051	0.3165	0.1020	-0.0026	-0.0515	0.1051	0.0810	0.1890	1

Table 3 – Correlation matrix (overall sample, N = 1695)

	Practicing Firms' Patents (N=1130)					**Patent Trolls' Patents (N=565)**					**t-test on equality of means**
Variable	Mean	Standard deviation	Median	Min	Max	Mean	Standard deviation	Median	Min	Max	p-value
Number of assigned IPC classes	1.750	1.042	1	1	10	1.821	0.987	2	1	7	0.174
Number of triples in technology field	35.635	59.313	4.67	0	325	105.279	76.199	93.33	0	325	0.000
Logarithmic number of forward citations	1.614	1.249	1.609	0	5.050	2.444	1.474	2.639	0	6.254	0.000
Number of backward references	12.352	15.436	8	0	118	11.448	14.352	7	0	100	0.247
Number of nonpatent-literature backward references	3.083	10.322	0	0	100	4.175	11.319	0	0	101	0.047
Number of family members	4.197	7.093	2	1	181	3.503	3.228	2	1	22	0.027
Number of claims	16.597	13.795	14	1	162	18.950	18.453	14	1	165	0.003
Days between filing of priority application and acquisition	3419.548	1805.58	3138	7	15446	3673.531	1634.981	3380	63	8802	0.004
Patent granted before acquisition	.840	.367	1	0	1	.849	.358	1	0	1	0.604
Number of patent applications in technology field	69260.48	33147.67	69369.5	3218	138166	99118.97	26945.73	103461	16434	138166	0.000

Table 4 – Descriptive statistics and comparison of both groups of patents

	Model 1		Model 2
	Standard Model		Standard Model
Estimator	Logit		Rare Events Logit
Dependent variable	Acquired by Patent Troll		
Variable	Coefficients	Marginal Effects	Coefficients
Number of assigned IPC sections	.309*** (.071)	.053*** (.012)	.303*** (.070)
Number of triples in technology field	.0063*** (.0012)	.0011*** (.0002)	.0062*** (.0012)
Logarithmic number of forward citation	.356*** (.061)	.061*** (.011)	.349*** (.060)
Number of backward references	-.020*** (.005)	-.003*** (.001)	-.019*** (.005)
Number of nonpatent-literature backward references	.017** (.006)	.003** (.001)	.017** (.006)
Number of family members	-.021* (.011)	-.004* (.002)	-.014 (.011)
Number of claims	.003 (.004)	.001 (.001)	.003 (.004)
Time between filing of priority application and acquisition	.00007 (.00006)	.00001 (.00001)	.00007 (.00006)
Patent granted before acquisition	-1.298*** (.228)	-.269*** (.052)	-1.273*** (.226)
Number of patent applications in technology field	.000004 (.000003)	.0000007 (.00000)	0.000004 (.000003)
IPC section A	2.161** (.709)	.470** (.151)	1.910** (.701)
IPC section B	.699 (.741)	.134 (.155)	.491 (.732)
IPC section C	1.446** (.782)	.315*** (.188)	1.254 (.773)
IPC section G	3.587*** (.692)	.686*** (.097)	3.318*** (.683)
IPC section H	3.577*** (.697)	.703*** (.095)	3.307*** (.688)
Patent application 1977-1981	-.007 (.905)	.001 (.155)	.150 (.894)
Patent application 1982-1986	1.241** (.514)	.268* (.125)	1.191* (.508)
Patent application 1987-1991	1.108* (.333)	.228** (.099)	1.066* (.427)
Patent application 1992-1996	.950* (.375)	.177** (.074)	.910* (.370)
Patent application 1997-2001	1.308*** (.335)	.239*** (.062)	1.264*** (.331)
Constant	-5.603*** (.739)		-10.969*** (.730)
Observations	1695 (565 patent trolls / 1130 practising firms)		1695 (565 patent trolls / 1130 practising firms)
LR / McFadden's Pseudo R^2	389.54 / 0.3347		
*** p<0.001, ** p<0.01, * p<0.1			

Table 5 – Model estimations

	Model 3	**Model 4**	**Model 5**
	Troll patents and control patents–first control group only	Matched sample by IPC section	Without two biggest patent trolls
Estimator	Rare Events Logit	Rare Events Logit	Rare Events Logit
Dependent variable	Acquired by Patent Troll		
Variable			
Number of assigned IPC sections	.351*** (.085)	.338*** (.082)	.255** (.081)
Number of triples in technology field	.0047** (.0017)	.0044*** (.0011)	.0056*** (.0012)
Logarithmic number of forward citation	.375*** (.073)	.411*** (.069)	.414*** (.071)
Number of backward references	-.018** (.005)	-.018** (.006)	-.013** (.005)
Number of nonpatent-literature backward references	.011 (.007)	.021* (.010)	.018** (.007)
Number of family members	-.032* (.016)	-.011 (.010)	-.020 (.015)
Number of claims	.0015 (.0054)	.007 (.006)	.005 (.004)
Time between filing of priority application and acquisition	-.00002 (.00007)	.000097 (.00006)	-.00002 (.000008)
Patent granted before acquisition	-1.115*** (.266)	-1.324*** (.295)	-1.561*** (.351)
Number of patent applications in technology field	-.000003 (.000003)	.000002 (.000003)	.00001** (.000003)
IPC section A	2.264*** (.679)		1.533* (.706)
IPC section B	.672 (.705)		.286 (.740)
IPC section C	1.540* (.754)		1.084 (.784)
IPC section G	3.555*** (.670)		2.525*** (.688)
IPC section H	3.701*** (.683)		1.874** (.708)
Patent application 1977-1981	.261 (.972)	.801* (1.030)	-.512 (1.155)
Patent application 1982-1986	1.348* (.587)	.708** (.513)	.546 (.578)
Patent application 1987-1991	1.071* (.465)	.737 (.457)	.226 (.493)
Patent application 1992-1996	1.026* (.409)	.665* (.394)	-.157 (.422)
Patent application 1997-2001	1.188 (.372)	1.044** (.373)	-.147 (.396)
Constant	-10.963*** (.748)	-8.288*** (.446)	-9.332*** (.746)
Observations	1130 (565 patent trolls / 565 practicing firms)	874 (437 patent trolls / 437 practicing firms)	1095 (365 patent trolls / 730 practicing firms)
*** p<0.001, ** p<0.01, * p<0.1			

Table 6 – Robustness checks – part 1

	Model 6	Model 7	Model 8
	Only US patents	Only DE patents	Only patent troll class 1
Estimator	Rare Events Logit	Rare Events Logit	
			Rare Events Logit
Dependent variable	Acquired by Patent Troll		
Number of assigned IPC sections	.279*** (.076)	.253 (.187)	.432*** (.088)
Number of triples in technology field	.0068*** (.0012)	.029* (.013)	.0062*** (.0014)
Logarithmic number of forward citation	.429*** (.066)	.521* (.247)	.281*** (.072)
Number of backward references	-.016** (.005)	-.146* (.083)	-.016** (.007)
Number of nonpatent-literature backward references	.015* (.006)	-.067 (.129)	.004 (.010)
Number of family members	-.031* (.018)	.036 (.059)	-.014 (.012)
Number of claims	.007 (.004)	-.071** (.027)	.005 (.005)
Time between filing of priority application and acquisition	-.00001 (.00006)	.00005 (.0004)	.00018* (.00007)
Patent granted before acquisition	-1.234** (.391)	-.755 (.463	-1.124*** (.271)
Number of patent applications in technology field	.000004 (.000003)	.00003* (.00002)	.000005 (.000004)
IPC section A	1.550* (.686)	1.335 (2.012)	.627 (.771)
IPC section B	.412 (.716)	-2.634 (1.882)	.409 (.733)
IPC section C	.944 (.778)		.621 (.886)
IPC section G	2.756*** (.670)	2.354* (1.262)	3.198*** (.680)
IPC section H	2.373** (.682)	1.592 (1.471)	3.148*** (.680)
Patent application 1977-1981	.223 (.896)		1.118 (1.070)
Patent application 1982-1986	1.058* (.546)		1.919** (.727)
Patent application 1987-1991	.707* (.476)	1.331 (1.963)	1.756* (.620)
Patent application 1992-1996	.537 (.430)	.646 (1.393)	1.747* (.587)
Patent application 1997-2001	.707* (.409)	1.882* (.843)	2.363*** (.564)
Constant	-10.162*** (.762)	-11.802*** (2.592)	-12.478*** (.869)
Observations	1374 (458 patent trolls / 916 practicing firms)	321 (107 patent trolls / 214 practicing firms)	1266 (422 patent trolls / 844 practicing firms)

Table 7 – Robustness checks – part 2

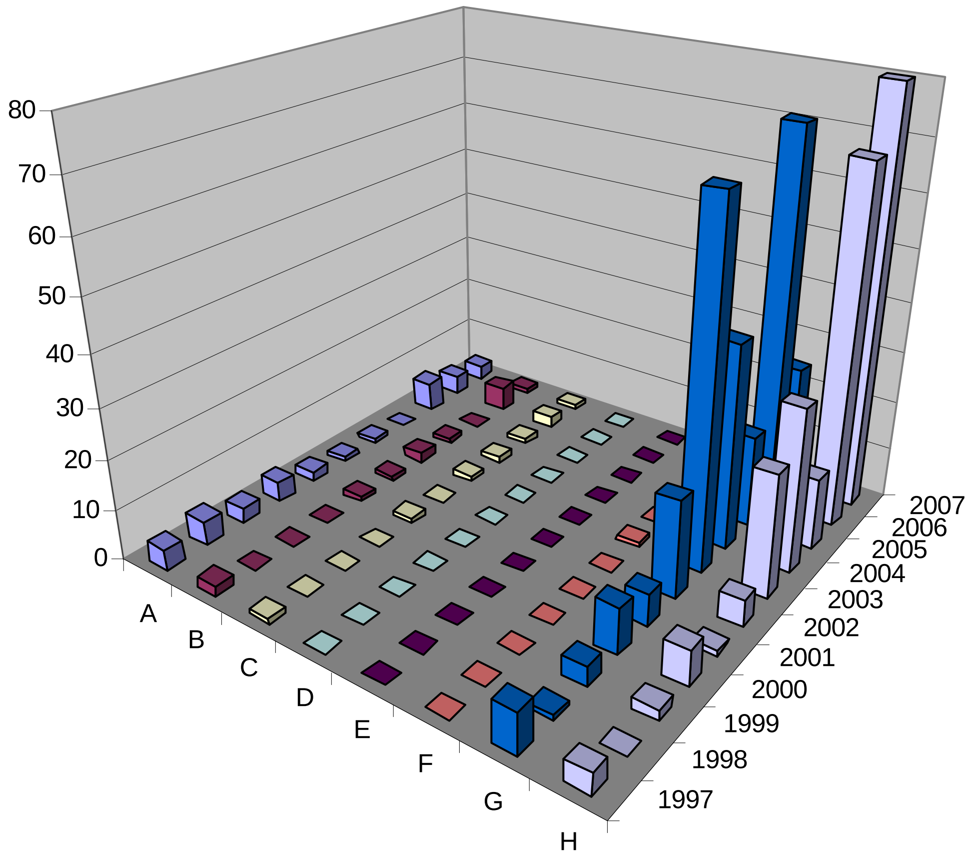

Figure 1 – Number of acquisitions by patent trolls by acquisition year and IPC class

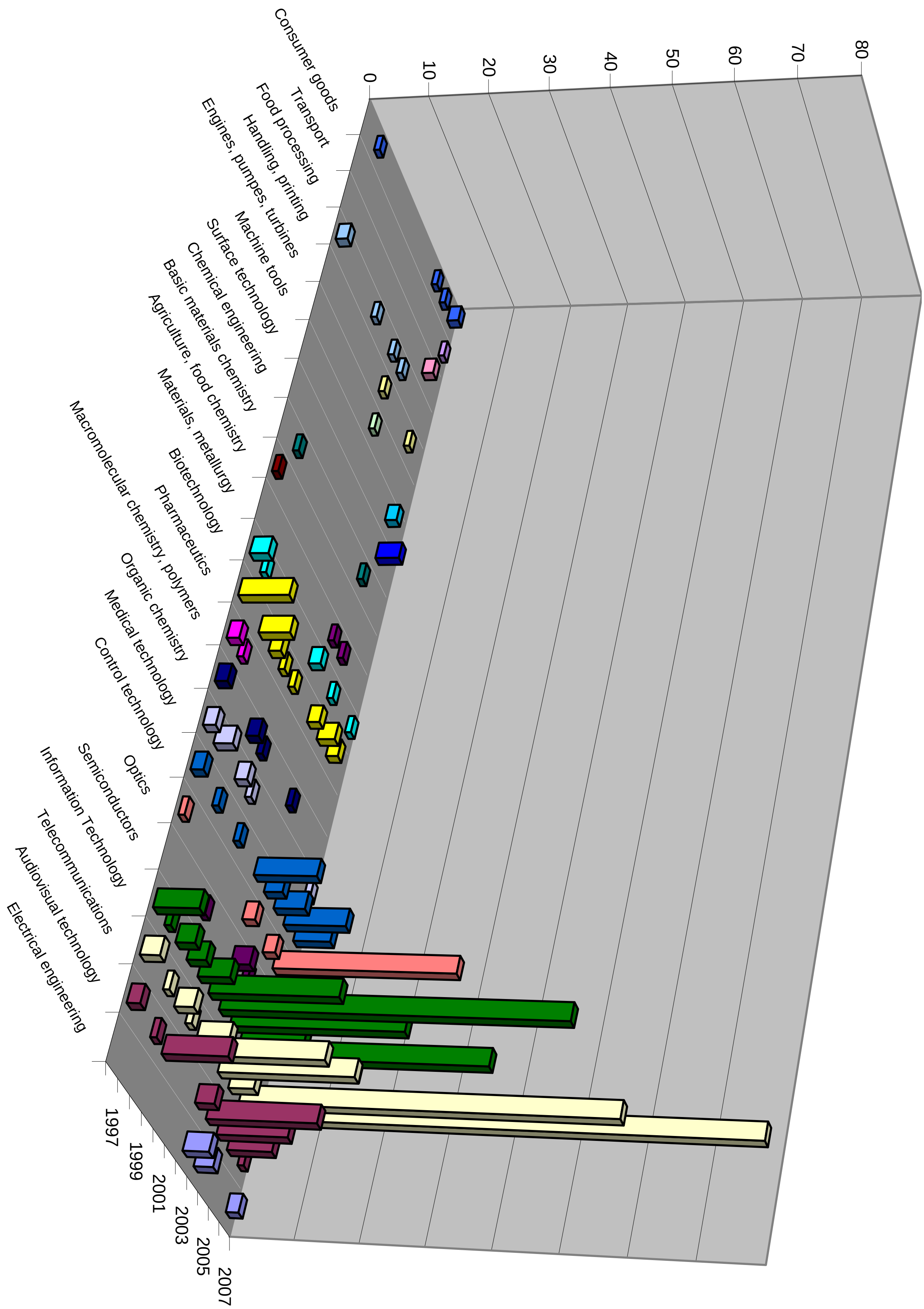

Figure 2: Number of acquisitions by patent trolls by acquisition year and technology field

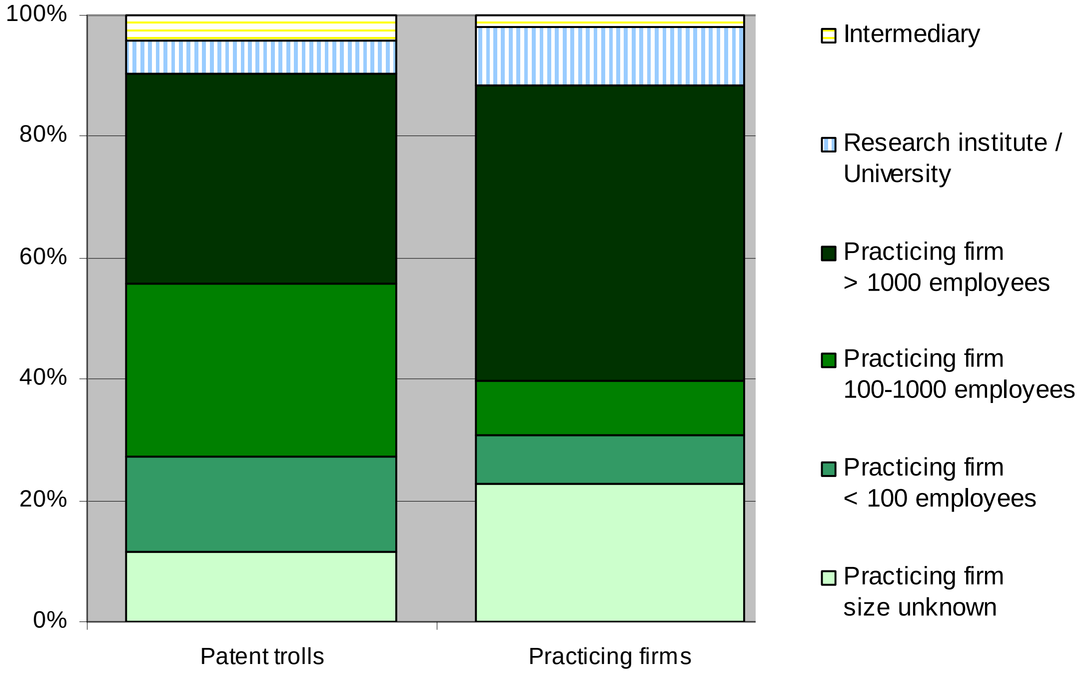

Figure 3: Patent trolls' sources vs. practicing firms' patent sources

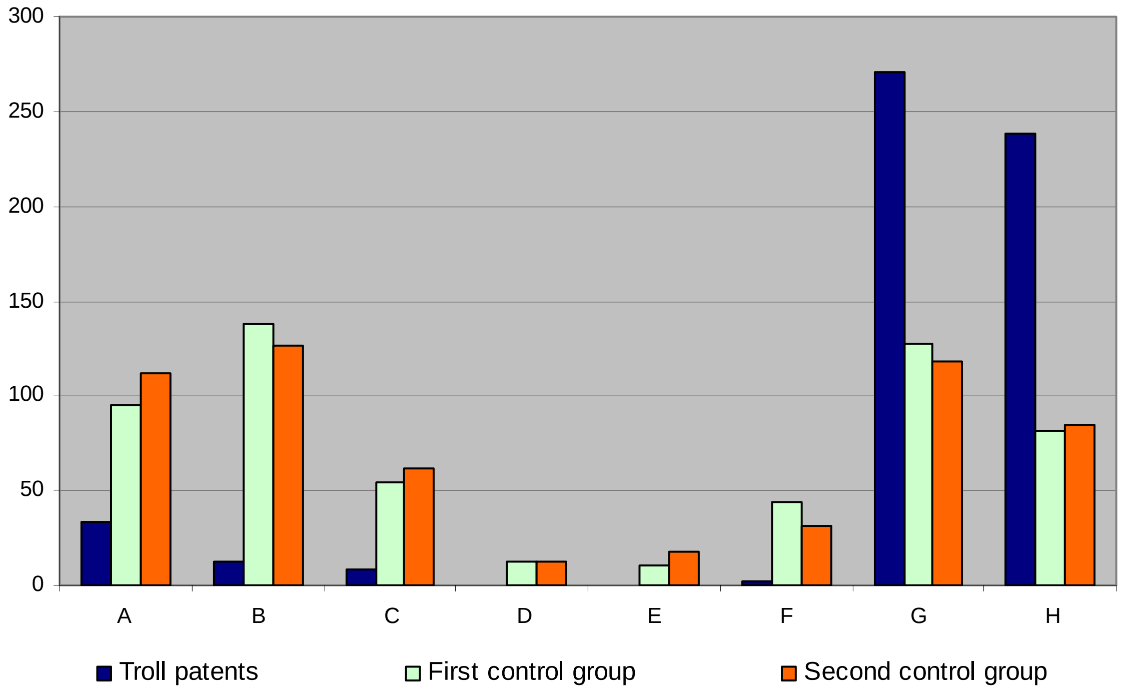

Figure 4 – Number of patents acquired by patent trolls and practicing firms by IPC class