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Patent trolls on markets for technology – An empirical analysis of NPEs' patent acquisitions

Timo Fischer[a], Joachim Henkel[a,b,*]

[a] TUM School of Management, Technische Universität München, Arcisstr. 21, D-80333 Munich, Germany
[b] Center for Economic Policy Research (CEPR), London, United Kingdom

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ABSTRACT

Patent trolls, or NPEs, 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 NPE business. In this paper, we shed light on this issue by empirically analyzing NPEs' patent acquisitions. We draw on a unique dataset of 392 U.S. patents acquired by known NPEs between 1997 and 2006, which we compare to three control groups of 784 U.S. patents each acquired by practicing firms. We find that the probability that a traded patent is acquired by an NPE rather than a practicing entity increases in the scope of the patent, in the patent density of its technology field and, contrary to common belief, in the patent's technological quality. Our findings thus support recent theoretical propositions about the NPE business model, showing that NPEs procure patents that are more likely to be infringed, harder to substitute for, and robust to legal challenges. The fact that NPE-acquired patents are of significantly higher quality than those in the control group implies that elevating minimum patent quality will not put an end to the NPE business, and suggests that this business is sustainable in the long run. We furthermore discuss the fact that NPEs 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 NPEs may only be the tip of the iceberg of "patent-only" transactions, a conjecture with strong implications for the efficiency and the study of markets for technologies. Managerial and policy implications are discussed.

1. Introduction

Patent trolls, or NPEs, are firms whose business model is focused on enforcing patents against infringers in order to receive damages or settlement payments (e.g., Golden, 2007; Lemley and Shapiro, 2007; Reitzig et al., 2007). In principle, NPEs may help financially constrained inventors to enforce their patent rights and may thus increase incentives to innovate for such inventors. However, more frequently they are considered to be a serious threat to innovation in high-technology industries and, thus, policy makers have paid considerable attention to this topic (e.g., Jaffe and Lerner, 2004; Lemley and Shapiro, 2007; U.S. Federal Trade Commission, 2003). Extant research has studied the legal underpinnings of the NPE business (Golden, 2007; Lemley and Shapiro, 2007; Magliocca, 2007), provided (some) empirical evidence on NPE-type patent litigation (Bessen and Meurer, 2012; Lerner, 2006; Magliocca, 2007; Reitzig et al., 2010), and illuminated the various strategies underlying the NPE business and its sustainability to policy changes (Henkel and Reitzig, 2007; Reitzig et al., 2007).

However, extant empirical studies of the NPE phenomenon (Bessen and Meurer, 2012; Lerner, 2006; Reitzig et al., 2010; Risch, 2012; Shresta, 2010) are limited to NPE activities that become visible through litigation, and are thus unlikely to draw a representative picture. NPE patent disputes are often settled out of court without becoming public. In fact, anecdotic evidence holds that many NPEs aim at quick settlements and try to avoid risky and costly court proceedings. And even those cases that do end up in court are difficult to gather. We thus pursue a different route, by analyzing NPEs' patent acquisitions. While not all of these patents may eventually be enforced, the potential for enforcement and thus a threat for infringers are present. Most importantly, we capture also those patents whose assertion does not become public. Our study thus provides a systematic outlook on those NPE activities that are based on acquired patents (rather than patents filed by NPEs themselves), which constitute a considerable and growing share (Reitzig et al., 2010, Table 1 and Fig. 2). Our results facilitate an empirically based judgment about the strategies, technology fields, and sustainability of future NPE activity. Such judgment is critical for both policy makers

* Corresponding author at: TUM School of Management, Technische Universität München, Arcisstr. 21, D-80333 Munich, Germany. Tel.: +49 89 289 25741.
E-mail addresses: fischer@wi.tum.de (T. Fischer), henkel@wi.tum.de (J. Henkel).

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Table 1
NPEs in our dataset.

NPE	Acquired patents	Type	NPE	Acquired patents	Type
Acacia technologies	34	1	Intertrust	2	2
American video graphics	26	1	Orion IP	12	2
Catch curve	7	2	NeoMedia technologies	2	2
Data treasury	13	2	Pinpoint	4	1
Divine technology ventures	15	1	PhoneTel communications	8	2
ESpeed	1	2	Rambus	8	1
Firepond	2	1	Rates technology	2	1
Forgent networks	1	2	Refac technology	4	1
Gemstar	11	2	Rembrandt technologies	105	1
Hoshiko	6	2	Techsearch	44	1
INPRO licensing	26	1	TV Guide	1	2
Intellect neuroscience	3	2	VCode holdings	3	2
Intellectual ventures	35	1	Voice Capture	1	1
Intergraph	15	2	University patents	1	2

aiming at curtailing the NPE business and managers facing the threat of NPE attacks.

To shed light on NPEs' patent acquisitions we draw on a unique dataset of 392 patents acquired by known NPEs between 1997 and 2006, which we compare to three different control groups of 784 patents each that were acquired by practicing firms, in the same year as the matched NPE patent. Our exploratory study yields interesting insights. NPEs seem to be able to acquire patents that are most appropriate for their business model. The probability that a traded patent is acquired by an NPE rather than a practicing entity increases (a) in the scope of the patent, and thus the probability that it is infringed; (b) in the patent density of the technology field, and thus in the cost of substituting for the patented technology; and, most importantly and contrary to common belief (c) in the patent's technological quality, and thus in its probability of being upheld in court. For all three characteristics, also the mean values are significantly higher for the group of NPE-acquired patents than for the control group. The results concerning patent quality in particular suggest sustainability of the NPE business in the future.

Beyond the analysis of NPEs' patent acquisitions, our study contributes more generally to the understanding of markets for technology (e.g., Arora and Gambardella, 1994; Arora et al., 2001; Gans and Stern, 2003; Lamoreaux and Sokoloff, 1999). NPEs 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, NPEs appear to be very active players on markets for technology, as both buyers and sellers. But NPEs are rather peculiar participants in these markets. As Reitzig et al. (2010) point out with a focus on NPEs' role as sellers, the NPE 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 NPEs 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 NPEs sell or license patents, the transaction again does not involve a technology transfer since by definition of the NPE business model the potential licensee already uses the patented invention. Extrapolating from our empirical analysis, we posit that transactions involving NPEs may be only the tip of the iceberg of "patent-only" transactions. Thus, as we will explain in the Discussion section, 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 *exante* licensing.

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

2. Background

2.1. Patent trolls and NPEs: definition

We follow Reitzig et al. (2007, p. 137) in defining "patent sharks or trolls [or NPEs] as individuals or firms that seek to generate profits mainly or exclusively from licensing or selling their [...] 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."[1] This definition has two key parts. First, NPEs generate profits mainly or exclusively from licensing patents, which distinguishes them from practicing entities that generate profits mainly from a product or service based business model. Second, NPEs do not offer a license to the patent right after development of the focal technology, but wait until the patent is infringed. This point—*ex post* licensing—importantly distinguishes NPEs from technology vendors.

The term "NPE" ("nonproducing entity" or "nonpracticing entity") is often used synonymously with "patent troll" and "patent shark." The drawback of this term is that it equally describes pure research firms and institutions that seek to license their technologies *ex ante*, i.e., before infringement occurred. Nonetheless, in order to avoid a derogatory connotation we will use the neutral term NPE in the following, in the meaning of "patent troll." If we use "troll" sporadically, 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 (e.g., Magliocca, 2007). In fact, NPEs 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 NPEs to enforce their rights.

Some authors consider dubious quality of its patents a defining feature of an NPE, a view to which high-profile cases such as *NTP v. Research in Motion* likely have contributed.[2] However, the business

[1] The quoted definition contained the qualifier "(often simplistic) [...] technology." For the purpose of this study, we dropped "often simplistic."

[2] 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 04/21/2011).

of non-practicing firms seeking infringement damages or *ex-post* licensing can in principle also function with patents of high quality (Henkel and Reitzig, 2007; Lemley and Shapiro, 2007; Reitzig et al., 2010). In fact, the latter situation is likely to be more challenging for the infringer, and thus more relevant from a management perspective. The key question—addressed in this study—is if NPEs can (and do) procure suitable high-quality patents. We thus define "NPE" without reference to patent quality.

Finally, in line with most of the literature we are agnostic in our definition about the way in which a firm procures a patent (e.g., Reitzig et al., 2010; Shresta, 2010). That is, an NPE may either rely on patents it has acquired or on patents it has filed for itself. In this paper, we focus on patents that NPEs have procured by acquisition.

2.2. The NPE's legal environment

The legal environment impacts the NPE business in two ways. First, it affects the incidence of inadvertent infringement, in a number of ways: (i) The patent system and its implementation may induce infringement by granting patents on trivial (e.g., Reitzig et al., 2007: 147) or not novel inventions (e.g., Graham and Mowery, 2003: 226); in both cases, engineers may duplicate the patented invention without even thinking of patent clearance. (ii) Patents may not be clearly delineated, in which case it is difficult to decide if a patent reads on a product or not (Bessen and Meurer, 2008). Such patents may be inadvertently infringed even though the infringer was aware of them. (iii) The more burdensome patent clearance, the more likely it is that some relevant patent slips an innovator's attention. This problem is particularly prevalent in complex product technologies such as electronics (Bessen and Meurer, 2005; Lemley and Shapiro, 2007; Magliocca, 2007).

The above three points contribute to making the patent system to some extent non-transparent, and thus favor the NPE business. While, at least in the U.S., trivial patents are harder to obtain and more easily invalidated since the Supreme Court's 2006 decision in *KSR International Co. v. Teleflex, Inc.*[3], the ever rising numbers of patent applications and the increasing complexity of products, in particular in the field of ICT, suggest that inadvertent infringement will remain hard to avoid with any certainty.

Second, the legal environment affects NPEs' returns to enforcing patents by setting the rules for damage awards and injunctions. Infringement damages are calculated, in the majority of cases, as "reasonable royalties," which for example 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 authorization 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 non-infringing alternative *ex ante*, i.e., before lock-in occurred (Reitzig et al., 2007). Furthermore, Lemley and Shapiro (2007; 1994) argue that reasonable-royalty damage awards lead to a "systematic overcompensation of patent owners in component industries," since courts typically do not correctly account for the fact that the infringed invention constitutes only a small part of the overall complex product. As a result, for inventions that are easy to invent-around *ex ante* (but not *ex post*) or part of a complex product, the common calculation method leads to excessive outcomes, again favoring the NPE business. Generous grants of injunctions work in the same direction. The easier and faster it is for NPEs to obtain injunctive relief, and the harder it is to replace the disputed technology, the higher their leverage in negotiations with infringers (Henkel and Reitzig, 2007; Lemley and Shapiro, 2007; Magliocca, 2007).

Legal and economics scholars have envisioned legal changes that could reduce the returns to NPEs' patent enforcement (Golden, 2007; Lemley and Shapiro, 2007; Magliocca, 2007), and courts and policy makers, notably in the U.S., are about to address the above issues. 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 the existing law.[4] 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.[5] On the other hand, not all countries have taken action against NPEs, and even in the U.S. some patent reform efforts have stalled (see Footnote 4). Also, NPEs may learn to circumvent legal restrictions, e.g., by maintaining minor production operations in order to be considered a producing entity. Most importantly, however, even without injunctions NPEs with legally sound patents will be able to extort elevated licensing fees from infringers that would face high switching costs when replacing the disputed technology (Henkel and Reitzig, 2007). Thus, also those aspects of the legal environment that affect NPEs' returns to enforcing patents will likely remain such that the NPE business will remain profitable. Provided, of course, that NPEs can procure suitable patents—which is the central question addressed in this study.

2.3. Existing research on NPEs

Several theoretical studies aim at isolating the main mechanisms underlying the NPE business. Lemley and Shapiro (2007) show how the prospect of obtaining an injunction improves an NPE's negotiation position, and how this effect is exacerbated in the case of complex products and "royalty stacking." Reitzig et al. (2007) analyze how an unrealistic calculation of damage awards by courts, and in particular the failure to consider low-cost *ex ante* invent-around possibilities, makes "being infringed" more attractive than *ex ante* licensing. Henkel and Reitzig (2007) develop a game-theoretic model of NPEs' strategy choice, distinguishing between strategies based on injunctions, damages, and switching costs, respectively. They show that the former two can in principle be impeded by legal policy measures, while the latter is sustainable to policy changes. Pursuing a switching-cost strategy, an NPE exploits the cost that the infringer would have to bear, even absent time pressure, for switching to a non-infringing technology. As the damages-based strategy, this strategy leaves enough time for invalidation proceedings and so requires legally sound patents. Davis (2008) integrates NPEs into a comprehensive conceptual framework of IP vendors; Turner (2011) shows in an equilibrium model that NPE activity leads to more patents and reduces social welfare as well as the rate of invention.

Empirical research on NPEs is relatively scarce. Magliocca (2007) studies historical examples of NPEs that acquired dormant agricultural patents of dubious quality and enforced them against farmers. He deduces characteristics that make patents most suitable for NPEs—in particular, a high cost of substituting for the patented invention. Lemley and Shapiro (2007) present case studies of 3G cellular and of Wi-Fi technology, showing how the problems of hold-up and royalty-stacking bias damage awards upward. In a quantitative study, Lerner (2006) analyzes the litigation of business

[3] See http://www.supremecourtus.gov/opinions/06pdf/04-1350.pdf (accessed 09.11.09).

[4] 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 04.21.11).

[5] 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 09.11.09).

method patents related to financial services. His results are "consistent with suggestions that individuals [i.e., NPEs] are exploiting the system to obtain and litigate financial patents of questionable quality" (Lerner, 2006: 26). Reitzig et al. (2010) analyze a dataset of patent enforcement cases by NPEs, showing that the characteristics of NPEs' patents indeed relate to their strategies as theoretically predicted (Henkel and Reitzig, 2007). In particular—and in contrast to Lerner's (2006) results—Reitzig et al. (2010) find that NPEs may also enforce high quality patents. In the same vein, Shresta (2010) finds litigated NPE patents to have higher average values on quality-related characteristics (in particular, forward citations) than comparable patents litigated by practicing firms. Litigation success rates do not differ significantly between the two groups. Risch (2012), by studying 10 highly litigious NPEs in detail, obtains similar results. Bessen et al. (2011) analyze stock market events around NPE lawsuit filings. They identify a loss of wealth of half a trillion dollars to defendants over the period 1990–2010, most of which constitutes a loss of social welfare and thus implies reduced incentives to innovate.

Existing research on NPEs thus yields a picture that is mixed with respect to the quality of NPEs' patents and also incomplete. In particular, all existing quantitative studies focus on NPEs' patent litigation and thus screen out enforcement activities that did not become public. Furthermore, litigation cases are mainly informative about NPEs' past activities, less so about the likely future development of the NPE business. By analyzing NPEs' patent acquisitions, our study sheds light on these issues.

2.4. NPEs' vs. practicing firms' patent acquisitions

Since our goal is to analyze NPE activity rather than to test a theory, we pursue an exploratory approach. In this section, we thus discuss NPEs' vs. practicing firms' patent acquisitions in general terms, without deriving hypotheses related to patent characteristics.

By the very design of the NPE business model, NPEs are interested in patents on inventions that are or will be used by practicing firms. In turn, if a practicing firm anticipates that NPEs might procure a patent on an invention it uses, it will have an interest to pre-empt the NPE and secure the patent or a license to it (or, if possible, to destroy it). Thus, NPEs compete with practicing firms when they acquire patents. If a given patent is more likely to be acquired by one or the other type of firm depends on the contenders' relative ability to identify the patent and to extract its value.

Regarding identification, we note that procuring patents, identifying infringers, and enforcing patents against them are an NPE's sole activities, which suggests that they should be superior to practicing firms in this discipline. However, there is little reason to conjecture that NPEs' and practicing firms' relative ability to identify patents varies systematically with patent characteristics.

In contrast, NPEs' and practicing firms' relative ability to extract value from a patent should depend on the patent's characteristics. To see why, consider the various uses of patents and resulting motives to patent (e.g., Cohen et al., 2000; Levin et al., 1987). Blind et al. (2006) cluster these motives into five groups, of which reputation and incentive motives do not apply to acquired patents. Motives that apply to both own filed and to acquired patents are protection from imitation, blocking, and exchange, the latter comprising cross-licensing with competitors (Hall and Ziedonis, 2001; Ziedonis, 2004) and licensing against royalties.

Based on these uses, an NPE can in principle extract at least the same value from a given patent as a practicing firm, by licensing the patent exclusively to this firm. But in general an NPE can do better. 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. While such licensing can be practiced by any type of firm, there are two reasons why NPEs can do so more effectively. First, if no amicable agreement is reached and the potential licensor considers suing 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. In contrast to practicing firms, NPEs 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; Shresta, 2010), and so should be superior to practicing firms in extracting value from patents by licensing against royalties.

3. Empirical approach

3.1. Data

To identify patent acquisitions by NPEs or practicing firms, we use data obtained from the European Patent Office's (EPO's) Worldwide Patent Statistical Database (PATSTAT) as of April 2009 and the EPO's legal status database INPADOC as of February 2009 (European Patent Office, 2009a,b). 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 make use of data from the United States Patent and Trademark Office (USPTO), because the NPEs in our sample mostly operate in the U.S. using U.S. patents. While registering a patent acquisition at the national patent authority is not legally required, doing so brings legal advantages for the acquirer in the United States (Serrano, 2010). 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, a large share of all patent acquisitions (Serrano, 2010). 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 NPEs. Using extensive analyses of newspaper articles, blogs, firm homepages, and other online documents, we identified the names of 70 firms operating in the U.S. that meet our definition of an NPE laid down above.[6] In detail, our screening process comprised five steps:

(1) We gathered the names of all firms that were alleged to follow an NPE business model.
(2) We checked that the potential NPEs are very active in enforcing their patents. Such enforcement may involve patent litigation, but many NPEs only threaten with litigation without actually suing. We thus made sure to capture patent enforcement both with and without litigation.

[6] As Reitzig et al. (2010), we used Web sites and blogs that specialize on the discussion of patent litigation cases (e.g. 271 patent.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 Websites of the (alleged or real) NPEs and of their targets.

(3) We checked whether the potential NPEs have no substantial production or service based business model.
(4) We were careful to exclude true technology vendors who unsuccessfully offered licenses *ex ante* and later sued infringers.
(5) We repeated the screening process using a different team of raters to establish interrater reliability, and kept only those firms which were consistently classified as NPEs.[7]

In line with our definition, neither the size of the firm matters nor if it conducts its own R&D and applies for patents itself. Step 4 in the above process revealed that a considerable share of the firms in our sample changed, or are in the process of changing, their business model from manufacturing or *exante* technology licensing to an *expost* licensing NPE business model. To be transparent about this fact, we classified the NPEs in our sample into two groups (see Table 1). Type 1 firms always pursued an NPE business model according to the available firm information, while Type 2 firms shifted their business model to an NPE business model at some point in time and actively pursued this model from then on.

Our sample could suffer from two types of selection biases. First, NPEs operating recently should be easier to identify than NPEs operating some years ago, because, among other things, the Websites offering the richest information on NPE litigation did not exist 10 years ago. Second, some NPEs may have managed to stay out of the attention of the media so far; however, because most NPEs attack several or even a large number of firms, the probability is high that information on the NPEs will leak to specialized Websites. Nonetheless, we cannot claim to provide a complete picture of all NPEs.

Using the INPADOC database, we were able to identify 1328 patents that had undergone a change in ownership name with one of the 70 NPEs mentioned above listed as the new owner. However, in many cases only a firm's legal form or its name 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.[8] 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. Finally, we restricted our dataset to transactions that took place between 1997 and 2006, in order to limit potential bias from incomplete identification of NPEs, and because the number of relevant transactions drops markedly for earlier years. We ended up with 392 patents that had been acquired by 28 distinct NPEs (see Table 1).

For these 392 patents, we built three control groups. First, for every identified patent acquired by an NPE, we randomly selected two control patents acquired by a practicing firm in the same year. This approach allows us to investigate NPEs' patent acquisition criteria including patent age and technology field. However, correlations between these and other variables (e.g., forward citations) may bias our results. To control these effects econometrically we constructed two additional control groups. In the second control group, we identified for every NPE patent two control patents that were acquired by a practicing firm in the same year, and had also been applied for in the same year. This second control group enables us to control for cohort effects. In the third control group, we identified two control patents for every NPE patent that were acquired by a practicing firm in the same year and are assigned to the same 4-digit IPC class. This control group enables us to exclude biases from technology effects but comes with the cost that we cannot study differences between NPE-acquired and other patents in the characteristics of their technology fields. We were not able to construct a control group of patents that were reassigned in the same year and that is matched for both, technology and cohorts, because the available pool of transferred patents is too small to allow such a restrictive control group. Also for the patents in the control groups, 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.

With only reassigned patents in the sample, our results could be subject to selection bias since the risk of being reassigned might differ between patents attractive to NPEs and those attractive to practicing firms. To control for such bias, we estimate a selection equation comparing reassigned and non-reassigned patents as proposed by Heckman (1979). To construct the sample for the selection model, for each reassigned patent in each of the three main stage models we randomly selected a non-reassigned patent that was active (pending or granted) in the year of reassignment of the respective main stage patent (since, in principle, every active patent is at the risk of being reassigned). Additionally, the non-reassigned patent was matched by year of application (second control group) and by IPC class (third control group), respectively.

3.2. Variables

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

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, as commonly done in extant research (Lerner, 1994). Other potential indicators of patent scope are the number of claims (Lanjouw and Schankerman, 1997) and the number of claims per backward references (Harhoff et al., 2003). However, 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 of technology field. We measure the patent density of a patent's technology field using the recently introduced "triples" indicator (Von Graevenitz et al. (2011)). The notion of "density" in this context refers to the degree to which patents overlap; dense webs of overlapping patent rights are referred to as "patent thickets" (Shapiro, 2001). The triple indicator captures the density in that it reflects the degree of mutual overlap that the patent portfolios of firms operating in a technology field possess. The triples indicator is calculated with EPO patent citation data. If a patent cites another patent critically (i.e., as an X or Y citation) the cited patent limits 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

[7] We conducted three rounds of troll classification. In October 2008 we identified the names of the NPEs 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. In October 2010 we screened the identified trolls again, relying on updated information about the firms' business model and history. We conservatively dropped five firms for which we could not fully assure that they do not offer ex-ante licensing.

[8] We did not exclude cases where the buyer acquired the "seller" along with its patents. In some cases NPEs 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.

Table 2
Description of variables.

Acquired by NPE	Dummy variable that equals 1 if the patent was acquired by an NPE
Number of assigned IPC classes	Counts the number of assigned different four-digit IPC classes.
Number of triples in technology field	Average number of mutual blocking patent triples in the focal patent's OST technology field at the EPO (Von Graevenitz et al., 2011).
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 (EPO DocDB simple family measure).
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	Average number of annual patent applications at the EPO, 1980–2003, in the focal patent's OST technology field (Von Graevenitz et al., 2011)

are three such blocking pairs, then these three firms form a "triple." The triples indicator captures how many such blocking dependencies exist in a given technology field.[9] While the triples indicator is calculated with EPO patent citation data, Von Graevenitz et al. (2011) report that they find patent thickets in the same technology fields as qualitative research that mainly addressed the U.S. patent system.[10] This indicator allows, for the first time, for directly measuring the density of technology fields. So far only the fragmentation of rights on the firm level has been used to proxy if a firm operated in an environment characterized by patent thickets (e.g., Cockburn et al., 2010; Galasso and Schankerman, 2010; Ziedonis, 2004). However, fragmentation and density are two distinct characteristics that can both be associated with patent thickets, the latter being particularly interesting in the context of NPEs. As NPEs exploit lock-in effects we are particularly interested in the effect of the density of overlapping rights in a technology field on their patent acquisitions.

Patent technological quality. A patent's technological quality can be proxied by the number of forward citations it has received (due to skewness of the distribution of this variable we use its logarithmic transformation). The more forward citations a patent has received, the higher its technological contribution to the field (Harhoff and Reitzig, 2004; Trajtenberg, 1990). However, we cannot preclude that other, non-technology-related effects influence the number of forward citations (Harhoff and Reitzig, 2004). To control for the influence that patent age has on the number of forward citations, we include application year dummies in our main model as well as a time variable that counts the days since the patent's priority filing. In robustness checks (see Footnote 17), 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. To definitely rule out cohort effects, we employ the second control group that is cohort matched to the patents acquired by NPEs.

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 (Meyer, 2000; Narin et al., 1987, 1997; Narin and Noma, 1985).

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 (Harhoff et al., 2003; Lanjouw et al., 1998; Putnam, 1996).

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 NPEs and practicing firms.

Other variables. We further include 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 (Lanjouw and Schankerman, 2000; Reitzig, 2003). 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 dummy variables capturing different patent application years. Finally, we control for whether the patent was already granted at the time of acquisition. Table 3 shows correlations between all variables for the overall sample.

3.3. Model specification

To identify those characteristics of a patent that make it relatively more attractive to an NPE than to a practicing firm, we estimate logit and probit models using the dummy variable "acquired by an NPE" as the dependent variable. In doing so, we control for oversampling of NPE patent acquisitions by using a rare events logit estimator, and for selection effects by using a sample selection probit model.

In the step preceding the manual screening, we had identified 1328 patent acquisitions by the NPEs on our list compared to 1,410,937 acquisitions by other entities. The need to manually screen each patent severely limited the size of the control groups, which we chose to make twice as large as the group of NPE patents. Thus, we heavily oversample patents acquired by NPEs. In

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

[10] There also exists first quantitative evidence that the relative patent density of technology fields in the patent system governed by the EPO is comparable to that in the U.S. patent system (Fischer and Ringler, 2010).

Table 3
Correlation matrix (overall sample with first control group, $N = 1176$).

	Acquired by NPE	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 NPE	1.0000										
Number of assigned IPC sections	.0330	1.0000									
Number of triples in technology field	.4487	−.1365	1.0000								
Logarithmic number of forward citation	.2826	.1055	.2116	1.0000							
Number of backward references	−.0283	.0307	−.0327	.1121	1.0000						
Number of nonpatent-literature backward references	.0482	.0627	−.0114	.0529	.3615	1.0000					
Number of family members	−.0537	.2456	−.0681	.0583	.1620	.0505	1.0000				
Number of claims	.0714	.0316	.0276	.1190	.1855	.2404	.0365	1.0000			
Time between filing of priority application and acquisition	.0810	.0375	−.0214	.2950	−.1059	−.0532	.0300	−.2284	1.0000		
Patent granted before acquisition	.0126	.0318	−.0080	.2702	−.0345	−.0641	.0317	−.0352	.3363	1.0000	
Number of patent applications in technology field	.4112	−.0475	.5936	.1504	−.0439	.0071	−.0480	.0470	.0148	.0014	1.0000

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 (and also probit) 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:

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

where $\xi_i = 0.5Q_{ii}\left[(1+w_1)\hat{\pi}_i - w_1\right]$, Q_{ii} are the diagonal elements of $Q = X(X'WX)^{-1}X'$, $W = \text{diag}\left\{\hat{\pi}_i(1-\hat{\pi}_i)w_i\right\}$, $\hat{\pi}_i$ is the uncorrected maximum likelihood estimation of the probability that observation *i* equals 1, and w_1 represents the fraction of rare events in the sample relative to the fraction in the population.[11] 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.

Second, we include a selection equation to control for selection effects. We use a probit model that accounts for selection when modeling the probability of $Y_i = 1$ as proposed by Van de Ven and Van Praag (1981). This model is implemented in the STATA heckprob command that we use. For a reassigned patent, the instrument is a dummy capturing if it was granted at the point in time when it was reassigned. For a control group patent, the dummy captures if it was granted at the point in time when its matched patent was reassigned. This dummy variable should have an influence on the probability that the patent is traded because a patent grant reduces uncertainty about the legal right's value (Gans et al., 2008). On the other hand, it should not—and it does not—have any influence in the main equation. NPEs can also use patents that are not granted yet for extorting settlement payments.[12]

4. Results

4.1. Descriptive results

The complete dataset contains 2744 patent acquisitions, with 392 acquisitions by NPEs and 784 acquisitions by practicing firms in each of our three control groups. To give an impression of which technology fields are preferred by NPEs, we used the OST-INPI/FhG-ISI (OECD, 1994) classification to translate main 4-digit IPC classes to technology fields. Fig. 1 shows the distribution of NPEs' acquisitions by acquisition year and technology field. Telecommunications and information technology are the fields in which NPEs recently acquired the most patents.[13]

Fig. 2 sheds additional light on NPEs' activities in markets for technology. In our manual screening of patent sellers, we identified, as far as possible, whether the seller is a practicing firm, a research institute, or an intermediary such as a bank or a patent broker.[14] Furthermore, we identified the size of the firm. Fig. 2 illustrates these seller characteristics, separately for patents acquired by NPEs and practicing firms, respectively. NPEs seem to rely to a lesser degree on large practicing firms from which to acquire their

[11] The definition of w_i is length and is omitted here. See King and Zeng (2001), pp. 8–9.

[12] Results of the selection equation are not reported in a table for sake of brevity. We find that transferred patents compared to non-transferred patents received significantly more forward citations, lie in more crowded and denser technology fields and have more backward references to patents.

[13] In terms of IPC classes, classes G (58%) and H (35%) account for the majority of trolls' patent acquisitions.

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

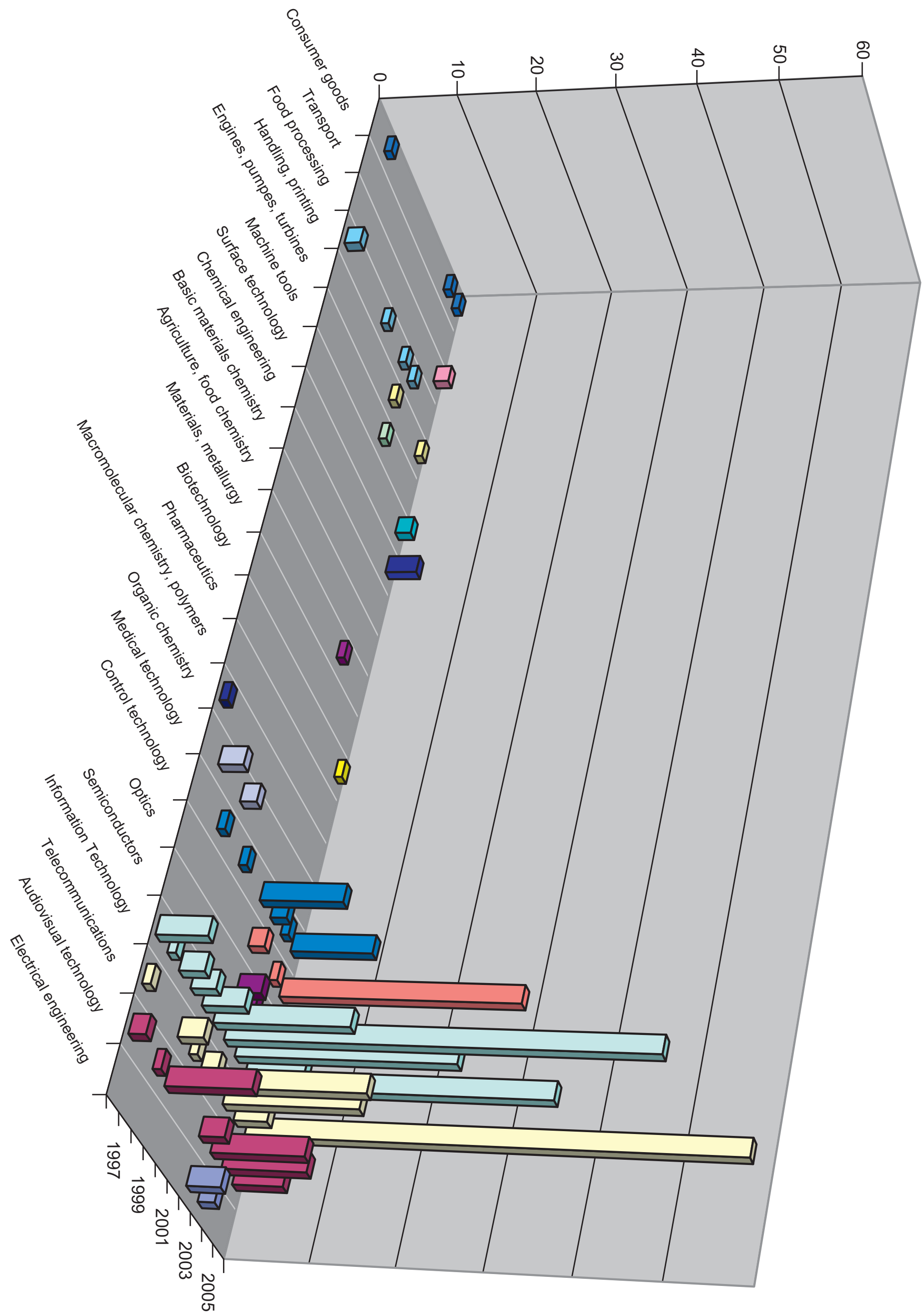

Fig. 1. Number of acquisitions by NPEs by acquisition year and technology field.

patents. However, these findings must be interpreted cautiously since 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 NPEs). However, we see that NPEs, compared to practicing firms, clearly procure a lower share of their patents from large firms.

Comparing patents acquired by NPEs to those acquired by practicing firms in our first control group (Table 4), we find highly significant differences (1% or .1% level) for five out of 10 characteristics. NPEs acquire patents that, on average, lie in denser technology fields, received more forward citations, have more claims, are older, and lie in more crowded technology fields than patents acquired by practicing firms. Furthermore, NPE patents have significantly (5% level) fewer family members and contain more non-patent literature references. No significant differences exist with respect to the number of assigned IPC classes, the number of backward references, and whether the patent was granted before acquisition or not.[15]

[15] Compared to the cohort matched control group, NPEs acquire patents that, on average, lie in denser technology fields, received more forward citations, have more

Table 4
Descriptive statistics and comparison of NPE-acquired patents and the first control group.

Variable	Patents acquired by practicing firms, first control group (matched by year of acquisition) (N = 784)					Patents acquired by NPEs (N = 392)					t-Test on equality of means
	Mean	Standard deviation	Median	Min	Max	Mean	Standard deviation	Median	Min	Max	p-Value
Number of assigned IPC classes	1.749	1.072	1	1	10	1.819	1.022	2	1	7	.174
Number of triples in technology field	21.424	27.956	5.45	0	93.68	54.680	25.974	47.53	0	93.68	.000
Logarithmic number of forward citations	2.002	1.207	1.946	0	5.231	2.961	1.256	3.091	0	6.389	.000
Number of backward references	14.640	16.158	10	0	118	13.469	15.168	9	0	100	.247
Number of nonpatent-literature backward references	3.714	11.011	0	0	99	4.304	11.340	0	0	101	.047
Number of family members	4.306	8.004	2	1	181	3.148	3.129	2	1	20	.027
Number of claims	17.684	14.764	15	1	162	21.066	20.538	16	1	165	.003
Days between filing of priority application and acquisition	3584.583	1841.011	3302	77	15,446	3940.051	1728.261	3526	771	8802	.004
Patent granted before acquisition	.938	.242	1	0	1	.949	.220	1	0	1	.604
Number of patent applications in technology field	2345.67	1346.39	1902	199	4979	3371.541	1101.086	3047	281	4979	.000

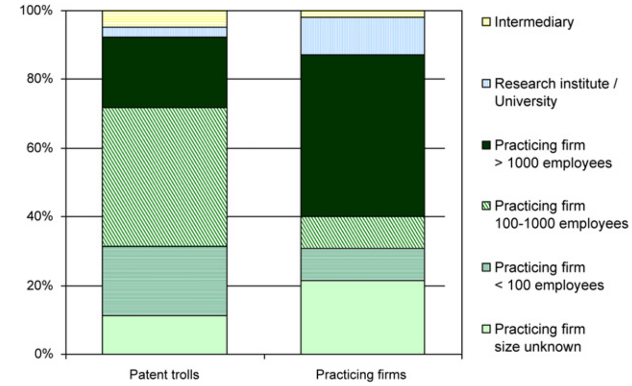

Fig. 2. NPEs' sources vs. practicing firms' patent sources.

4.2. Multivariate analysis

We start by comparing NPE-acquired patents to those in the first control group (Models 1a–1d). In all of these models, we find the coefficient and the marginal effect of the number of assigned IPC classes[16] positive and highly significant (.1% level). That is, broader scope increases the relative probability of a patent being acquired by an NPE rather than by a practicing entity. 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). A broader scope thus entails a larger potential for licensing revenues (in particular *ex post* royalties), which should increase the patent's attractiveness for an NPE more than for a practicing firm. The latter value patent scope mainly to the extent that a broader scope helps to cover their own products and processes more comprehensively. A scope that goes beyond these applications does contribute to a patent's value related to cross-licensing and deterrence; however, these strategic uses of patents are arguably less important for a practicing entity than suing for patent infringement is for an NPE. Such patent enforcement, finally, is much less attractive to a practicing entity than to an NPE since the former is vulnerable to retaliatory infringement litigation and, possibly, to the termination of other business relationships with the infringer.

Also, the higher the number of triples in a technology field (measuring the patent density), the more likely a patent in this field will be acquired by an NPE rather than by a practicing firm. We attribute this finding to higher substitution costs which are favorable for the NPE business model (Magliocca, 2007; Reitzig et al., 2007). This substitution cost increases with the difficulty of inventing around the patent, which in turn is high if the patent density of the relevant technology field[17] is high (cf. Cockburn et al., 2010). A high patent density 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

claims (5% level), and lie in more crowded technology fields than patents acquired by practicing firms. Furthermore, troll patents have significantly fewer family members. No significant differences exist with respect to the number of assigned IPC classes, the number of backward references, and whether the patent was granted before acquisition or not. Compared to the technology matched control group, NPEs acquire patents that, on average, received more forward citations, are assigned to more IPC classes, have more claims, and are older than patents acquired by practicing firms. Furthermore, troll patents contain significantly (1% level) more non-patent literature references. No significant differences exist with respect to the number of claims, the number of family members and the number of backward references.

[16] 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.

[17] We use the term "technology field" as defined by the OST-INPI/FhG-ISI classification (OECD, 1994).

substitutive technology is difficult. In other words, the focal patent is part of a patent thicket (Shapiro, 2001). In principle, also practicing firms could benefit from high substitution costs if they seek royalty income by enforcing the patent against infringers. However, NPEs have an advantage over practicing firms in enforcing patents for royalties, and should thus value patents being part of a thicket more highly than practicing firms (see also Shresta, 2010: 125).[18]

Furthermore, the probability of an acquisition by an NPE increases with the (logarithmic) number of the patent's forward citations.[19] That is, the higher a patent's technological quality, and thus its legal sustainability, the more likely it will be acquired by an NPE. The legal quality of a patent, in the sense of it withstanding invalidation proceedings, is a necessary precondition for a sustainable NPE strategy (Henkel and Reitzig, 2007). In contrast, practicing firms in industries characterized by complex technologies (Cohen et al., 2000; 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 an NPE pursuing a sustainable strategy: in cross-licensing, the goal is to ensure freedom to operate by in-licensing rather than invalidating the other firm's patents; and for deterrence, the pure threat of retaliation will in most cases suffice to prevent reciprocal infringement suits and concomitant attempts by the opponent to invalidate the focal firm's patents. An NPE, in contrast, enters into a direct confrontation with the firms it attacks, and attempting to invalidate the focal patents is a common defense (see Lanjouw and Schankerman, 1997; Merges and Nelson, 1990). For sustainable NPE strategies, this fact makes legal soundness of an NPE's patents a prerequisite for its business. Legal soundness, in turn, is related to the patent's technological quality: a larger inventive step corresponds, on average, to a higher technological quality of the patent, and at the same time makes it less likely that the patent will be invalidated on the grounds of obviousness (Reitzig, 2003); and undisputable novelty both signals technological originality and excludes invalidation on the grounds of prior art. The finding that NPEs focus on high-quality patents is remarkable. It contradicts commonly held beliefs that NPEs concentrate on enforcing low-quality patents.[20] So, at least for those NPEs that purposefully pick patents (rather than "discover" them in their "attic"), this belief requires revision.[21]

Comparing the results of the logit (Model 1a), the probit (Model 1b), the rare events logit (Model 1c), and the sample selection probit model (Model 1d) specifications in Table 5, we see only slight differences. By and large the coefficients' signs, values, and significant levels are identical across all models. In particular, the three variables discussed above show consistent signs and high significance levels (.1% level) across all models. In 1(c), the marginal effects are much smaller since the estimator accounts for the oversampling of rare events.

Beyond the variables discussed above, only the number of family members has a highly significant effect (1% level). The effect is negative. A potential explanation is that a large family size indicates a high value of the patent *as perceived by the patentee*, which is a practicing entity. Thus, other practicing entities—in particular the acquirer of the patent—may also find this patent valuable, due to similar ways of exploitation. Furthermore, we find weakly significant effects (10% level) for the number of backward references (negative), the number of claims (positive) and "patent granted before acquisition" (negative). Interestingly, the patent crowdedness of the technology field, measured by the number of applications in the patent's technology field, is only weakly significant, and only in Model 1d. In contrast, the density of the patent's technology field is highly significant. This finding underlines that it is not the crowdedness of a technology field, but rather the density of overlapping patent rights that makes it attractive for an NPE.

4.3. Robustness checks

We complement our analysis with robustness checks estimated with probit models with selection equation (Table 6). In Model 2, we check if the results differ between firms that have practiced an NPE business model since their foundation and those that only later changed their business model to that of an NPE (see Table 1). To this end, we only include NPEs that have pursued an NPE business model since their foundation (Type 1). The results are nearly identical to those of Model 1d. Another concern was that the NPE that acquired the most patents—Rembrandt Technologies with 105 patents—is the main driver of our estimation results (it had acquired the majority of its patents from a subsidiary of AT&T, a leading firm in its industry). We thus estimated Model 3 on a dataset omitting Rembrandt's patents and their control patents. The results (using the first control group) are again nearly identical to those of all other models. For Models 4 and 5, we use control groups matched by application year and IPC class, respectively. The results are again nearly identical to those of Models 1–3 (except that, in Model 5, patent density is insignificant because the control group is IPC-matched). Finally (not reported), we tentatively included "generality" of the patent[22] and a measure of fragmentation of rights in the respective technology field[23] as regressors, finding both insignificant. We also checked that controlling for the size of the patent applicant does not affect our results.[24]

5. Discussion

5.1. Sustainability of the NPE business

The analysis revealed that acquisition of a patent by an NPE becomes more likely relative to acquisition by a practicing firm the broader the scope of the patent and, thus, the higher the patent's likelihood of being infringed upon; the higher the patent density

[18] The extent to which a technology field is characterized by patent thickets also affects licensing and litigation between practicing firms, as studied by Bessen and Meurer (2005), Hall and Ziedonis (2007), Siebert and von Graevenitz (2010), Cockburn et al. (2010), and Galasso and Schankerman (2010).

[19] The results are robust to the selection of specific types of forward citations. Model estimations using forward citations per age of the patent or five-year truncated forward citations yield 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.

[20] To see how much the purchased troll patents in our sample differ from litigated patents, we compared their citations to citation statistics presented in Lanjouw and Schankerman (2001: 141), Table 4. They report on average 0.94 annual forward citations per year for litigated patents in years 6 to 15 after patent application. The patents in our dataset that were acquired by NPEs and that have such an exposure time frame have on average 2.30 forward citations per year in this time frame.

[21] To see how much the (traded) patents in our sample differ from "average" patents, we randomly drew 1176 patents, matched to our sample by year. For these patents, we find an average logarithmic number of 1.24 forward citations, compared to an average logarithmic number of 1.65 forward citations for patents acquired by practicing firms (first control group) and 2.40 for patents acquired by trolls (all differences are significant on the .1% level). That is, on average patents acquired by trolls differ from "average" patents in the logarithmic number of forward citations nearly three times as much as patents acquired by other firms do.

[22] "Generality" measures to what extent the citations that the focal patent receives are spread over technology subclasses. With N subclasses (4-digit IPC classes in our calculation) and s_{ik} denoting the share of patent i's citations that come from subclass k, it is defined as $1 - \sum_{1}^{N} s_{ik}^2$ (e.g., Serrano, 2010).

[23] Our simple concentration measure, computed in the same fashion as the triples indicator, represents the share of patents held by the top four patent applicants per technology field.

[24] We used the number of patents applied for by the inventing firm as a proxy for firm size.

Table 5
Model estimations.

	Model 1a		Model 1b		Model 1c		Model 1d	
Estimator	Logit		Probit		Rare events logit		Sample selection probit	
Variable	Coefficients	Marginal effects	Coefficients	Marginal effects	Coefficients	Marginal effects	Coefficients	Marginal effects
Number of assigned IPC sections	.381***	.063***	.216***	.066***	.367***	.0001959***	.172***	.026**
	(.095)	(.016)	(.052)	(.016)	(.094)	(.00005)	(.052)	(.010)
Number of triples in technology field	.0268***	.004***	.016***	.005***	.026***	.0000138***	.017***	.003***
	(.00005)	(.001)	(.002)	(.001)	(.004)	(.00000)	(.002)	(.001)
Logarithmic number of forward citation	.528***	.087***	.304***	.092***	.509***	.000272***	.322***	.049***
	(.092)	(.013)	(.044)	(.013)	(.077)	(.00005)	(.040)	(.010)
Number of backward references	−.0125	−.002*	−.008*	−.002*	−.012*	−.0000065*	−.006*	−.001*
	(.006)	(.001)	(.003)	(.001)	(.005)	(.00000)	(.003)	(.001)
Number of nonpatent-literature backward references	.008	.001	.006	.002	.008	.0000040	.006	.001
	(.009)	(.001)	(.003)	(.002)	(.008)	(.00000)	(.005)	(.001)
Number of family members	−.073**	−.012**	−.044**	−.013**	−.069**	−.0000371**	−.039**	−.006**
	(.027)	(.004)	(.014)	(.004)	(.025)	(.00001)	(.013)	(.002)
Number of claims	.0113*	.002*	.007*	.002*	.011*	.0000058*	.007*	.001*
	(.005)	(.001)	(.003)	(.001)	(.005)	(.00000)	(.003)	(.0004)
Time between filing of priority application and acquisition	.0001	.000001	.00002	.000001	.00006	.0000003	.00009*	.000001*
	(.0001)	(.00001)	(.00004)	(.00001)	(.00006)	(.00000)	(.00004)	(.00001)
Patent granted before acquisition	−.941*	−.190*	−.532*	−.186*	−.913*	−.0007551*	.−.121	−.019
	(.592)	(.099)	(.231)	(.089)	(.413)	(.0005)	(.249)	(.043)
Number of patent applications in technology field	.0001	.00001	.0004	.00001	.0001	.0000005	.001*	.00001*
	(.0001)	(.00001)	(.0005)	(.00001)	(.0001)	(.00000)	(.00005)	(.00001)
IPC section dummies included	chi² (5) = 69.72 p < .001		chi² (5) = 70.70 p < .001		chi² (5) = 63.96 p < .001		chi² (5) = 44.02 p < .001	
Application year dummies included	chi² (16) = 61.14 p < .001		chi² (16) = 38.58 p < 001		chi² (16) = 34.64 p = .005		chi² (16) = 41.76 p < .001	
Constant	−4.954***		−2.667***		−14.565***		−3.602***	
	(.853)		(.409)		(1.737)		(.409)	
LR/McFadden's Pseudo R^2	288.16/.3840		351.64/.3702					
Observations	1176 (392 NPEs' patents/784 practicing firms' patents)							

Note: Robust standard errors are in parentheses.
* p < .1
** p < .01
*** p < .001

Table 6
Robustness checks.

Estimator: Sample selection probit	Model 2 Only NPE type 1	Model 3 Without Rembrandt	Model 4 Application year matched control group	Model 5 IPC matched control group
Number of assigned IPC sections	.250***	.140**	.200***	.165***
	(.062)	(.052)	(.046)	(.044)
Number of triples in technology field	.015***	.016***	.019***	.002
	(.003)	(.002)	(.002)	(.002)
Logarithmic number of forward citation	.295***	.337***	.296***	.304***
	(.048)	(.043)	(.045)	(.040)
Number of backward references	−.008*	−.004	−.007*	−.003
	(.004)	(.003)	(.003)	(.003)
Number of nonpatent-literature backward references	.005	.008	.012*	.007*
	(.006)	(.005)	(.005)	(.004)
Number of family members	−.041**	−.033*	−.050***	−.019
	(.015)	(.013)	(.013)	(.013)
Number of claims	.007*	.006*	.005*	.005*
	(.003)	(.003)	(.003)	(.002)
Time between filing of priority application and acquisition	.0001	.0001*	.0001	.0003***
	(.0001)	(.0001)	(.0001)	(.00005)
Patent granted before acquisition	.032	−.417	−.296	.222
	(.364)	(.272)	(.254)	(.184)
Number of patent applications in technology field	.0001*	−.00003	.0001*	−.0001
	(.0001)	(.0001)	(.0001)	(.0001)
IPC section dummies included	chi^2 (5) = 41.58	chi^2 (5) = 61.10	chi^2 (5) = 77.03	chi^2 (5) = 1.91
	$p < .001$	$p < .001$	$p < .001$	$p = .862$
Application year dummies included	chi^2 (16) = 723.17	chi^2 (16) = 276.32	chi^2 (16) = 8.51	chi^2 (16) = 46.21
	$p < .001$	$p < .001$	$p = .932$	$p < .001$
Constant	−3.589***	−3.309***	−2.543***	−3.202***
	(.679)	(.423)	(.362)	(.401)
Observations	959 (319 NPEs' patents/640 practicing firms' patents)	861 (287 NPEs' patents/574 practicing firms' patents)	1176 (392 NPEs' patents/784 practicing firms' patents)	1176 (392 NPEs' patents/784 practicing firms' patents)

Note: Robust standard errors are in parentheses.
* $p < .1$
** $p < .01$
*** $p < .001$

of the technology field and thus the cost of substituting for the underlying invention; and the higher the patent's technological quality and thus its likelihood of being upheld in court and of being enforceable. A comparison of sample means between NPE-acquired patents and the control groups yields analogous results, with NPE-acquired patents being, on average, significantly more difficult to substitute and more likely to be upheld in court. These characteristics are clearly desirable for the NPE business model, and our results thus show that NPEs successfully focus on patents most suitable for their business. Yet, the finding that higher legal stability of traded patents increases their probability of being acquired by an NPE rather than a practicing firm, and the analogous result for sample means, are highly remarkable as they contradict the common notion of NPEs exploiting patents of dubious quality.

Our empirical analysis thus supports recent theoretical work arguing that the NPE business model will be sustainable in the long run (Henkel and Reitzig, 2007). Legal countermeasures may help to limit the payoffs that NPEs can achieve, and may, in particular, prevent gigantic settlement sums as paid by Research In Motion to NTP (see Footnote 2). However, the potentially high cost of substituting an invention once it is incorporated into a complex product will continue to provide leverage to NPEs, 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 NPE 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.

5.2. NPEs and markets for technology

Beyond the topic of NPEs, 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 (Arora et al., 2001; Lamoreaux and Sokoloff, 1999). 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 (Arora and Ceccagnoli, 2006; Gans et al., 2008; Lamoreaux and Sokoloff, 1999). In fact, transactions on markets for technology are mostly measured by observing patent licenses (Gambardella et al., 2007) or patent sales (Lamoreaux and Sokoloff, 1999; Serrano, 2010). However, transactions that involve NPEs are false positives in these statistics. Neither as buyers or licensees, nor as sellers or licensors of patents, are NPEs interested in the knowledge about the technology that a patent covers. Transactions involving NPEs thus take place on the market for patents, but not on the market for technologies. Even if NPEs enforce high-quality patents, they are, by the definition of their business model, no technology intermediaries. 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 NPEs 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.[25] 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*. Note that these inefficiencies do not affect an NPE's patent procurement activities since the latter take place on the market for patents, not on the market for technology.

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. The existence of NPEs in particular, signals such inefficiencies. In contrast, in cases where infringement is deliberate, the occurrence of NPEs might help to fix another inefficiency of the patent system; namely, the difficulty for financially constrained patent holders 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, but only made visible by NPEs. The important research question of whether NPEs are per se welfare enhancing or decreasing cannot be answered with our dataset and is an important avenue of further research.

5.3. Management implications

Our analysis has a number of management implications. In order to avoid being sued and pressed for license payments by NPEs, practicing firms have to find ways to impede the NPE business. As Henkel and Reitzig (2007) 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 NPEs to acquire patents. This is not an easy task, since—as we discussed in Section 2.4—NPEs have a higher valuation than practicing firms of patents that are suitable for the NPE business. To overcome this problem, practicing firms will have to cooperate with each other in acquiring patents before NPEs 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 or the foundation of RPX corporation in 2008).

5.4. Limitations and opportunities for future research

First, our method of identifying NPEs via Internet-based search biases the set of NPEs 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 NPEs must be interpreted with some care. However, since we do observe a strong increase around the year 2002, and hence 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, NPEs may choose to have some acquired patents reassigned at the USPTO 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 NPE 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.

Third, we used patent reassignment data to study NPEs' patent acquisition criteria. While we excluded reassignments due to mergers, these data include patent purchases as well as reassignments due to transfers of company parts along with their patents. If the NPE group consisted of patent purchases while the control group was dominated by firm transfers the two groups were potentially not comparable. To understand our data in more detail we drew a random sample of 15% of patents in our control group and spent considerable resources to try to identify whether the patents were reassigned due to a patent sale or due to a company sale. We found that 20% of patent reassignments were patent-only transfers and 40% were company transfers. The remaining 40% could not be identified; it seems plausible, though, that the majority of these are patent-only transfers since information on company sales is much easier to find. Furthermore, analyzing the NPE patents matched to our sample patents we found that also 27% of these were acquired along with the complete company. Hence both groups contain patents that were transferred along with a firm transfer, while indeed the control group seems to consist of a lower share of pure patent transfers than the control group. To

[25] 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.

understand the consequences of this data limitation we conducted t-tests of key patent characteristics (forward citations, triples, ipc classes) between the individually sold control patents and their matched NPE patents. As for the overall sample, we find that the control patents obtained significantly fewer forward citations (log: 1.84 vs. 2.65, $p = .049$) and lie in less dense technology fields (17.1 vs. 70.1, $p < .001$) than the NPE patents, while the number of assigned IPC classes does not differ significantly (1.87 vs. 1.83). These results, admittedly based on a small sample, make us more confident that the data limitation does not drive our results.

Fourth, we cannot rule out that the forward citations that patents receive are endogenous to the acquisition by NPEs. However, if indeed this should be the case then such patents should receive fewer citations upon acquisition, since we would except that practicing entities built to a lower degree on the respective patent. Hence, any effect in this direction makes the observation of more forward citations for NPE patents more conservative.

Fifth, not all acquired patents might be litigated. As NPEs should only acquire patents that are beneficial for their business model, our approach should reveal patent characteristics most favorable for the NPE business model, whether they are litigated or not. In the end, this "limitation" is immanent to our study as we study NPE behavior on markets for patents before patent litigation.

An interesting avenue of further research on NPEs is to delve deeper into the processes of how these firms procure patents. Anecdotal evidence holds that NPEs 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 the NPEs' business model. Furthermore, we offered only a first glimpse on NPEs' patent sources. It is still an open question if NPEs 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 NPEs acquire patents of higher quality than practicing firms do. Is the commonly held belief that NPEs 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 NPEs that acquire patents and NPEs that enforce their own patents differ in this respect? Third, what triggers the switch of practicing entities to an NPE business model and what does the transition process look like? 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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