NPEs, the Market for Patents and Follow-on Innovation. Evidence from Patent Transfers at the USPTO*

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Abstract

We provide original evidence on the role of Non-Practicing Entities (NPEs) for follow-on innovation by looking at the transfers of USPTO patents involving these entities over the period 1990-2016. Our evidence is threefold. First, NPEs build selected patent portfolios and contribute relevantly and increasingly to patent transfers in the United States. Second, their impact on follow-on innovation around the acquired assets is, on average, negative. We estimate a post-transfer reduction in forward citations received by patents transferred to NPEs of ~3%. Third, heterogeneous NPE business models co-exist, with different implications for innovation. NPEs that build valuable patent portfolios do not harm (or are even beneficial to) follow-on innovation around the acquired patents. Similar evidence applies to NPEs that sell large portions of their patent portfolios to producing companies. By contrast, the negative effect is driven by specific NPEs, i.e. those that operate opportunistically and build weak patent portfolios. Lastly, we contribute the debate on the functioning of the market for technology. On average, transfers between producing companies are associated with an increased use of the patent. However, this is not the case in high-tech domains. This suggests that the transfer of high-tech patents is largely motivated by strategic reasons.

Keywords: Patent Market; Non-practicing entities; Patent litigation; Patent trolls; Patent sales; Patent citations

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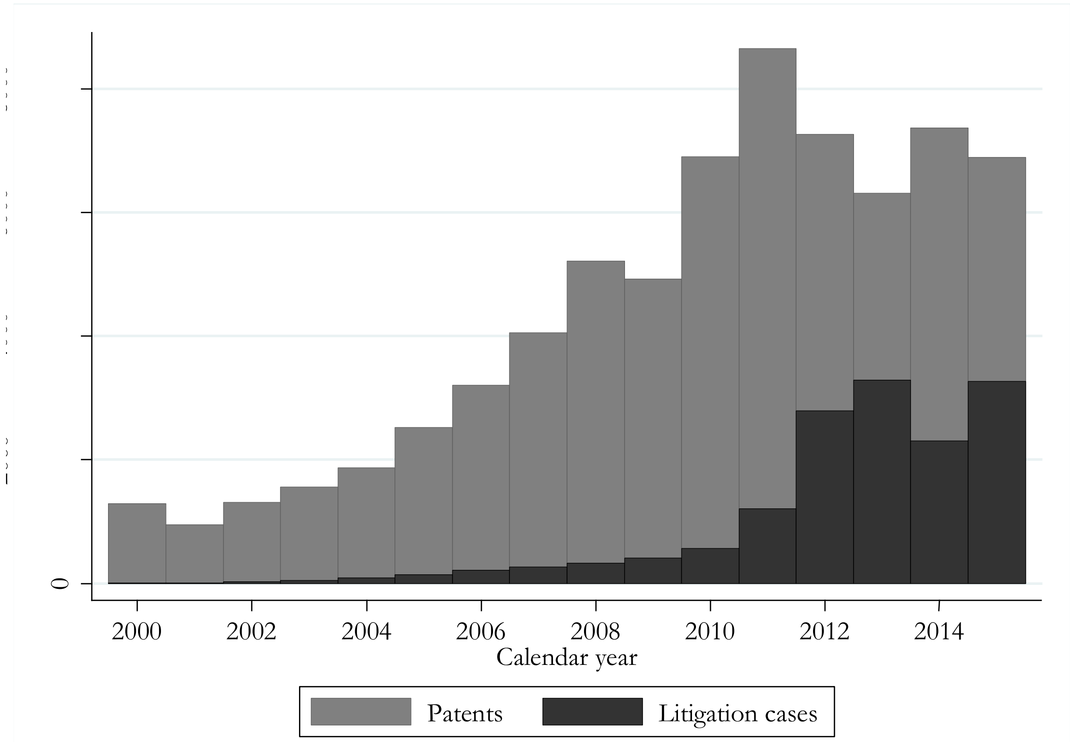
1. Introduction

Markets for technology have expanded rapidly over the last 20 years or so. According to Ocean Tomo (Elsten and Hill, 2017), the value of intangible assets (mostly consisting of Intellectual Property – IP – rights) has continued to grow in the last fifty years. It represented 84% of the S&P 500 market capitalization in 2015, in contrast with 68% in 1995 and just 17% in 1975. Once considered as a mere tool to protect inventions, patents have now become marketable assets that can be acquired, held, licensed and sold strategically (Papst, 2012; Serrano and Ziedonis, 2018). Due to increased opportunities for monetization, the way in which patent rights are exploited has changed dramatically, as has their management and governance. Specialized IP businesses have developed quickly, with non-practicing entities (NPEs) leading the way (Hagiu and Yoffe, 2013; Scott Morton and Shapiro, 2014). NPEs are actors that acquire patents from a variety of sources and employ them primarily to obtain license fees and revenue, sometimes by asserting them against accused infringers (Chien, 2008; FTC, 2016).

A widespread opinion among scholars and practitioners is that the NPE phenomenon should be a cause of concern for policy-makers and stakeholders (Cohen *et al.*, 2016; Lemley and Feldman, 2016) or even *"the most significant problem facing the patent system today"* (Lemley, 2006, p.2). Over the past decade, the patent system has experienced a soaring number of litigation cases initiated by NPEs, especially in the United States. Recent studies estimate that the NPE business in the United States is worth some $30 billion in settlements and licensing fees annually (Bessen and Meurer, 2013). Not surprisingly, the debate has become heated on the economic role that these companies play in the market for patents and on their impact on innovation. In reaction to the proliferation of patent lawsuits initiated by NPEs, the US Congress has introduced several bills aimed at regulating the process of patent licensing and assertion more finely. The new *Inter-Partes Reviews* implemented by the 2011 American Invent Act and a number of subsequent US Supreme Court decisions over issues such as patentable subject matter, attorney fees and 'forum shopping' have aimed to curtail the NPE activity (Fusco, 2016). The widespread use of the expression "patent trolls" when referring to NPEs reflects the negative mood surrounding their activity (Chien, 2008).

To study whether NPEs really harm innovation, most of the extant evidence relies on patent litigation data. While relevant and informative, this approach has its drawbacks. First, it targets one specific aspect of NPE enforcement activity (i.e., cases that end in court), while not considering those that settle out of court and do not become public. In fact, "these visible actions are just the tip of the iceberg" (Scott Morton and Shapiro, 2014). Instead of going through litigation, NPEs are indeed more likely to prefer to set royalty demands strategically below litigation costs, so to make the decision to settle an obvious one (Leslie, 2008). In other words, litigation is just the downstream (visible) part of NPE's assertion activity. Second and possibly more relevantly, litigation data largely ignore the benefits that NPEs may bring to the patent ecosystem (Schwartz and Kesen, 2014; Steensma *et al.*, 2016). Notably, some NPEs have expertise as intermediaries and "middleman" in the market, and they may reduce the distance between technology producers that are willing to sell assets and users that are willing to acquire. When acquiring patents for whichever reason, NPEs also create demand for technology and boost liquidity. These aspects increase market efficiency and incentives to innovate.

Figure 1. Number of NPE-owned patents and NPE-initiated litigation cases in US (2000-2015)



Notes: The number of patents sums both filed and acquired US granted patents (with filing year between filed 1990 and 2010) by NPEs. The number of patent litigation cases (Source: Darts-IP) sums cases initiated (infringement actions only) by NPEs in US District Courts.

This paper complements the extant literature focusing on the upstream NPE activity: patent acquisitions. Our contribution provides original evidence pertaining to the effect of NPE patent acquisitions on follow-on innovation around the technologies that are purchased. The analysis is conducted at the patent level on US granted utility patents filed in 1990-2010. We build an original database of NPE patent filings and transfers at the US Patent and Trademark Office (USPTO). This database is enriched with information on litigation initiated by NPEs in US District Courts (provided by Darts-IP). We combine these two sources to quantify the NPE presence in the US and to qualify different NPE business models. Figure 1 illustrates the number of patents owned (filed or acquired) and the number of litigation cases initiated by NPEs over the period 2000-2015. Both increased sharply in recent years. NPEs filed or acquired some 7,000 patents in 2015, almost three times the amount in 2005. Similarly, NPEs brought 3,766 patent lawsuits in 2015, more than 28 times the 2005 level. This supports awareness of the phenomenon and the representative nature of the US market for appreciating the effect of NPEs on innovation.

To assess the impact of NPEs on follow-on innovation, we look at the pattern of citations received by patents filed by practicing entities (PEs) and subsequently acquired by NPEs. Forward citations are an indicator of the use of the protected technology by innovating and producing companies: patents frequently-cited are patents that constitute important prior art for further related technological improvements; conversely, patents that stop being cited are patents whose technological utility is reduced. To study the impact of NPE patent acquisition on downstream innovation, we compare the number of citations received by the patents acquired by NPEs, before and after the transfer to those received by practicing entities (PEs) or non-transferred patents with similar characteristics. We interpret any reduction in the number of post-transfer citations as indicative of a transfer-induced hold-up on the patent, which pushes downstream firms to invest away from the technology covered by the transferred patent (Scott Morton and Shapiro, 2014).

Our main finding is that, on average, NPE acquisitions significantly reduce the number of post-transfer citations by around 2.1%, relative to non-transferred patents, and by around 2.9% relative to patents transferred to PEs. Our paper also contributes to the debate on the functioning of the market for technology (Agrawal *et al.*, 2015; Arora *et al.*, 2001). Patent transfers lead to more effective use of the acquired technology when the buyer is a PE, suggesting that access to external knowledge drives patent acquisition decisions (Desyllas and Hughes, 2010; Karim and Mitchell, 2000). This is not the case for high-tech patents, however. This suggests that the transfer of high-tech patents is largely motivated by strategic reasons, whether defensive – i.e. preventing patent litigation – or offensive, such as raising costs for competitors (Scott Morton and Shapiro, 2014; Hall and Ziedonis, 2001; Blind *et al.*, 2009; Noel and Schankerman, 2013). Finally, we provide evidence that heterogeneity in the NPE business model matters when explaining the average negative effect of NPE patent acquisitions on follow-on innovation. NPEs that sell large portions of their patent portfolios (i.e., intermediaries) and NPEs that monetize valuable patents (i.e., NPEs that build their portfolios mainly by acquiring higher-quality patents) have a neutral or even beneficial effect on downstream innovation.

The rest of the paper is organized as follows. Section 2 develops the theoretical background. Section 3 describes the data. Section 4 proposes the empirical strategy. Section 5 present our empirical results on the effect of NPE-patent acquisition on follow-on innovation. Section 6 show evidence of when and how NPEs benefit or harm innovation. Section 7 concludes.

2. Theoretical background

2.1 Market for patents

Technology products are increasingly sophisticated, with combinations of multiple features and functions. This requires ad-hoc patent protection against infringers and competitors (Steensma *et al.*, 2016). Patentable discovery and its commercialization are increasingly being pursued by different organizations; intellectual property (IP) rights and technology (invention) often diverge with patents since entities other than the patent owner can reinvent the technology that underlies those rights (Fischer and Ringler, 2014).

The existence of well-developed technology markets allows innovative firms to specialize and facilitates the diffusion of existing knowledge. This is important for developing efficient market structures (Galasso *et al.*, 2013). Patent licenses and patent sales are the main tools to transfer rights to technology, although the latter have received less attention from scholars than the former.[1] However, only patent acquisitions typically transfer the legal exclusion rights to the recipient.[2] Partially due to increasing availability of new data on patent transactions, especially in the US (Graham *et al.*, 2018), scholars have recently recognized the relevance of the secondary market for patents (Akcigit *et al.*, 2016; Galasso *et al.*, 2013; Hochberg *et al.*, 2014; Khun, 2016; Serrano 2010). The recent evidence based on data from USPTO shows that a significant proportion of patents are in fact transferred, suggesting that the benefits of trade are considerable and that residual control rights play an important role in the market (Serrano, 2010).

There are two main reasons that explain why a firm may be willing to acquire a patented technology: i) when it needs the *underlying technology* to produce and develop specific products or ii) when it needs the *patent asset* to exploit its legal exclusion rights.

[1] See, e.g., Agrawal *et al.* (2015), Arora and Ceccagnoli (2006); Cockburn *et al.* (2010).

[2] A patent license does not transfer the right to sue to the recipient, but rather the right to not be sued by the patent owner, except when "all substantive rights" associated with the patent are also transferred to the license holder (Kuhn, 2016).

In the first case, the acquirer – usually a firm operating in the same technology field as the seller (Lamoreaux and Sokoloff, 1999) – can use the underlying technology to profit from innovation by offering products or services. Moreover, when the patents are acquired along with the firm, the buyer can reconfigure the technological resources (Desyllas and Hughes, 2010; Karim and Mitchell, 2000), capture important synergies in the process (Chondrakis, 2016; Grimpe and Hussinger, 2014), or even consolidate ownership of substitute technologies and enhance market power (Scott Morton and Shapiro, 2014). However, patent buyers and sellers frequently have a hard time finding each other, because searching for and identifying potential partners requires considerable time, effort and skills. In addition, both sellers and buyers often have difficulties measuring the value of the deal and negotiating the terms of licensing agreements efficiently (Khan, 2013; Steensma *et al.*, 2016). These costs create business opportunities for NPEs, which may be seen as an alternative mechanism to bilateral negotiations for allocating IPRs, especially when the value of a single patent depends on whether it is combined with other patents and when its commercial application is broad (Steensma *et al.*, 2016).

In the second case, the object of the acquisition is not the technology, but the right to exploit the IP asset. Patents are in fact tradable rights that can be acquired and sold strategically (Papst, 2013). Companies may use patents for a variety of strategic reasons, ranging from blocking competitors from using the underlying technology or avoiding being prevented from innovating by rivals, to signaling to the market the firm's technological competences, for cross-licensing agreements and for monetizing the patent assets (Blind *et al.*, 2009; Walsh *et al.*, 2016). In particular, companies may be interested in acquiring patent assets to enforce their exclusion right against alleged infringers and to seek royalties on other, closely related patents in their own portfolios. They may also trade patents strategically in order to evade a commitment to license on reasonable terms or to remove the ability of a patent defendant to counterattack (Scott Morton and Shapiro, 2014). Costs associated with the identification of potential infringers and the resolution of contractual disputes in court can be economized through specialization and scale, favoring the emergence of new and specialized intermediaries, such as NPEs.

2.1 NPEs in the patent market

Whichever the reason for trading a patent (internal use of underlying technology or strategic use of the IP right), NPEs may play a role.

In general terms, the NPE business model involves filing and, primarily, purchasing patents (sometimes in large numbers) to obtain revenues by licensing and asserting them without conventional business lines (Scott Morton and Shapiro, 2014). This definition encompasses both firms that act mainly as independent distributors and patent brokers (acquiring patents from inventors and licensing the rights to commercializing entities) and firms that assert patents as their primary business model. In both cases, NPEs invest in IP assets that allow them to exploit their comparative efficiency advantage in deploying and enforcing patents (Steensma *et al.*, 2016). On the one hand, NPEs may gather and exploit the information necessary to match the technologies they acquire to a specific industrial and commercial use. On the other hand, they may exploit their capabilities in enforcing the acquired patents, identifying potential infringers, negotiating licensing agreements with them, monitoring their behavior, and litigating before court in order to reach a settlement or favourable judgement. Depending on their business models, NPEs may reduce frictions in the patent market or, on the contrary, may exploit and exacerbate them (Penin, 2012).

As intermediaries, NPEs may clearly improve the efficiency of the market for technologies by reducing the information asymmetries that characterize both sides of the market. This should boost innovation. NPEs may identify undervalued patents and invest time and resources in finding other firms that are interested in them (McDonough, 2006). In addition, they may match the supply of diverse technologies from multiple providers to the demand of multiple potential acquirers, reducing the number of transactions otherwise necessary especially when innovation requires the access to multiple fragments of knowledge (high complementarity) and has several commercial applications (Steensma *et al.*, 2016). Finally, NPEs also economize the transaction costs that arise when inventors and commercializing entities need to measure and price the traded invention, simplifying the purchasing process.

As "patent enforcers", NPE activity may also be an efficient mechanism for technology transfer and the creation of new products. Efficient enforcement activities do allow end-inventors to obtain remuneration otherwise precluded to them (McDonough, 2006). However, they may also rents through patent litigation, benefitting from and exploiting the information frictions that characterize the patent system: the lack of transparent patent ownership and unclear patent boundaries (Anderson, 2015; Bessen and Meurer, 2005; Feldman, 2014; Lemley and Shapiro, 2006; Meurer and Menell, 2013). In this case, NPEs profit from the non-transparency of the patent system. They often accumulate patents through shell companies. The use of separate affiliates to acquire and monetize patents may reflect different types of agreement with separate patent sellers, making it easier to segregate revenues originating from different sources (FTC, 2006). At the same time, the diffuse use of affiliates makes it difficult for potential licensees to identify the actual ownership of the patents they need (Scott Morton and Shapiro, 2014).[3] This is a typical marker of "Large Litigation NPEs" which frequently control a multitude of small affiliates to hold patent portfolios as they are acquired (FTC, 2016). NPEs may then wait years, hiding the patents until the use by the alleged infringer becomes more widespread.[4] Practicing firms should do broad patent clearances and subsequently license in all the IP they need to develop their products or invent around them. However, because of the amount of patents issued and the lack of transparency of the patent market, such patent clearances are burdensome (Macdonald, 2004). Moreover, even when a manufacturer does know that it might be infringing a given patent, it may start to produce if the patent owner is considered "non-litigious" (for example when the patent owner is a competitor and a cross-licensing agreement has been signed), not knowing that the patent(s) may have been transferred at some point to another entity (Reitzig *et al.*, 2007). This creates room for NPEs to enter the patent market and negotiate licensing agreements once specific technologies have already been adopted (ex-post licensing). Unclear patent boundaries also make it difficult for practicing entities to decide if a patent reads on a product or not (Bessen and Meurer, 2008). A patent might in fact be infringed inadvertently, even though the infringer was aware of it.

The comparative advantages of NPEs vis-à-vis practicing entities are not limited to the possibility to exploit the information frictions in the patent system more effectively. Because of specialization in patent monetization, NPEs might easily reach a minimum efficient scale in patent assertion, which is precluded to small PEs (Steensma *et al.*, 2016).[5] NPEs may thus purchase hundreds of patents for monetization purposes, exploiting economies of scale more easily than practicing entities. Therefore, individuals and small inventors willing to monetize their patents might partner with NPEs because of the high costs associated with litigation (especially in cases of defeat in court) and due to a lack of resources, time or know-how (Lanjouw and Schankerman, 2004).[6] Moreover, without practicing the invention, NPEs are not exposed to the threat of injunction or exclusion.

[3] Moreover, the use of affiliates and shell companies may allow an NPE to protect affiliated business interests from countersuits, creditors or other claims if one entity should be fail, or simply lose a litigation campaign (FTC, 2016).

[4] A common tactic used by NPEs, before the American Inventors Protection Act (1999, amended in 2002), was to delay the issuance and the publication of a patent for a long time in order to stay "under water" for long periods and "emerge" and surprise the market several years after the filing (Liang, 2010).

[5] Even when manufacturing companies do enter the business of patent monetization, this business is likely to represent a small share of their product and service commercialization revenue. For example, Ericsson's revenue from IP rights licensing is less than 5% of total revenue (Q2, 2019).
https://www.ericsson.com/4a09c9/assets/local/investors/documents/financial-reports-and-filings/interim-reports-archive/2019/6month19-en.pdf

[6] For example, France Brevets, the sovereign patent fund established by the French government, has the mission of helping small and medium French companies and public research centers to monetize their patent portfolios. In 2011, France Brevets signed an agreement with Inside Secure, a French company specialized in secure transactions, for the exclusive license of 70 NFC (near field communication) patents. Two years later, France Brevets filed patent infringement lawsuits against HTC and LG in the US and in Germany for using two patents (US 6700551; US 7665664) that were granted to Inside Secure in 2004 and 2010. LG decided to settle in 2014, while HTC did not, but lost the patent litigation case in 2015.

Since NPEs do not depend on the final product market, conventional market remedies (i.e. cross licenses) are ineffective in preventing NPEs from pursuing holdup strategies (Lu, 2012). On the contrary, the prospect of an injunction or exclusion can make patent litigation highly unattractive to practicing firms, influencing the negotiated outcome.[7] This is particularly true for complex technologies and, in general, for all inventions in the information technology sector in which many patents are possibly associated with a single product and, more particularly, when manufacturers have already invested irreversible technology-specific capital (Lemley and Shapiro, 2006). NPEs thus have a strong incentive to design large and credible "outsized" threats.

2.3 Extant Evidence

Do NPEs affect innovation? The rise of NPEs has sparked a debate as to their value and impact on innovation. However, the internal mechanisms of NPEs are largely enigmatic as NPEs operate in secrecy, making it harder for researchers to access data on their direct business transactions.

The extant literature has mainly focused on the direct impact of NPEs on targeted firms in terms of additional licensing and extra litigation costs to be sustained, while the indirect consequences on the market for innovation, taken as a whole, have not been deeply investigated. One shortcoming of the extant evidence is that it is based mainly on patent litigation data. Litigation data have been used by a number of legal scholars and economists (1) to find evidence of "opportunistic" behavior by NPEs and (2) to evaluate the impact of litigation on R&D investments and sales of innovating companies targeted by NPEs.

About the first point, extant evidence is mixed. On the one side, some authors suggest that NPEs behave opportunistically. Feldman and Frondorf (2015) survey the in-house legal staff of 50 product companies characterized by initial public offerings (IPOs) between 2007 and 2012. They find that 40% of respondents had received patent demands at the time of their IPOs, with those demands coming mainly from NPEs. Cohen *et al.* (2019) find that cash availability is the principal determinant of litigation targeting by NPEs, while this is not true for small inventors and producing companies. Love (2013) finds that NPEs litigate their patents late in the patent life, waiting until a lucrative industry has developed before filing suit. Finally, Feng and Jaravel (2016) find that NPEs

[7] This explains the increasing partnerships between large practicing entities and NPEs. The former have an incentive to assign their patents to NPEs for monetization purposes without risking their reputation or the possibility of counterclaims. According to our data on US patent transactions, we observe the increasing importance of large companies as a source of NPE patents. Before 2010, patents acquired from large companies represented less than 10% of the total patents acquired by NPEs, while after 2010 this share increased to more than 30%.

purchase more patents that are "more obvious and contain vaguer claims", suggesting that they acquire patents for the sole purpose of litigation. On the other side, recent works also provide some evidence that NPEs are not (mainly) involved in frivolous litigation and, interestingly, do not seem to assert low-quality patents. For example, Risch (2012) analyzes the patents asserted by the ten most-litigious NPEs in the US and found them to be qualitatively similar to those asserted by producing companies. Similarly, focusing on patents acquired (instead of patents litigated) by NPEs, Fischer and Henkel (2012) and Leiponen and Delcamp (2018) find evidence suggesting that NPEs do acquire patents of high technological quality.

On the second point, extant studies substantially agree that the (litigation and licensing) costs for targeted firms are high and that reductions in R&D and other investments are substantial (Cohen *et al.*, 2019). For example, Tucker (2014) conducts a case study into how the actions of Acacia Research Corporation, a well-known NPE, have affected technology sales of US firms in the field of medical imaging technology. The author finds that sales of products protected by patents affected by litigation with Acacia diminished considerably as a consequence of a reduction in incremental product innovation during the period of litigation. Similarly, Bessen *et al.* (2011), analyzing defendant stock market events around the filing of patent lawsuits involving an NPE over the period 1990-2010, find that these lawsuits were associated with half a trillion dollars of lost wealth to defendants.

Although NPEs do increase costs for targeted firms, it is possible that they may serve as tax collectors for inventors from whom patents have been bought. Payments from innovative companies might not be considered a reduction in R&D efforts if they are counterbalanced by significant transfers to the original inventors. Early evidence in this regard is mixed. Bessen and Meurer (2013) use survey evidence on US companies and find that NPEs pass-through to end inventors (Royalties + Patent Acquisition) only 5% of the revenues obtained from defendants. Conversely, Schwartz and Kesan (2014) report that in 2011 Acacia (the largest publicly traded NPE in the United States) paid more in royalties to inventors than it did to their patent attorneys.

In this paper, we investigate the effect of NPEs on follow-on innovation, according to a new, original perspective. By looking at patent transfers, we test empirically the effect of a patent transfer to an NPE on the further use of the acquired technology. If NPEs behave mainly as patent intermediaries, we expect to see them finding a better positioning for technologies acquired in the market and enhancing their usage. On the contrary, if the NPE business consists mainly in collecting rents from producing companies through the threat of legal actions, we expect the opposite. If the latter is the dominant case, NPEs do not target technologies for their intrinsic value but for the enforcement possibilities they offer; in the absence of intermediary actions, this should depress the innovation activity around such technologies, reducing their further use.

3. Data

We conduct our analysis on an original database of patent transfers we produced by merging three main data sources. The first source is Darts-IP[8], which provides an extensive list of NPEs together with their shell companies. Using Darts-IP data, we also collect information on patent lawsuits initiated by NPEs in the US between 2000 and 2012. The second source of information is the Patent Assignment Database (2017 version), that we use to track patent transfers in the US (Graham *et al.*, 2015). The third source of information is the combination of *PatentsView* and the *OECD Patent Quality Indicators database* that we use to collect information on patent characteristics and patent citations. Our final database covers patent transfers occurring over the period 1994-2014. We consider granted utility patents filed at the USPTO in the years 1990-2010 by PEs in all technologies.[9] We measure the impact of patent transfers to NPEs (and PEs) on follow-on innovation by means of patent citations. Citation data cover the period 1990-2016.

3.1 The NPE list

We define NPEs as independent organizations (legal entities) that own or purchase patents filed by or granted to other companies or individual inventors without the intent of developing, producing and/or commercializing the related products or processes. In most cases, these firms do not conduct any R&D activity. Universities, academic institutions and sole inventors/individuals are excluded.[10]

To individuate active NPEs, we rely on the list provided by Darts-IP. Together with the information on the name of the single NPE, Darts-IP also gathers information on NPE group-tree structures.[11] This information serves to assemble as many patents as possible under their unique real NPE owner. Some NPEs are known for perpetrating strategic patent purchasing

[8] https://www.darts-ip.com/
[9] We exclude patents applied for by individuals, universities, hospitals, government or other public institutions and non-for-profit organizations.
[10] Wisconsin Alumni Research Foundation is an example of an academic institution that initiated several patent suits. For this reason it is often labeled as NPE. However, due to its academic nature, we decide to exclude them from our analysis.
[11] Darts-IP verifies the ownership, when possible, using company reports and other sources.

operated by shell companies so as to hide the real identity behind the patent transfer (Feldman, 2014). Extending the list of shell companies with reference to the NPE groups is therefore indispensable for obtaining a reliable estimate of the NPE presence in the patent market. As a further step in this direction, we complement the list of NPE shell companies and subsidiaries provided by Darts-IP making use of information retrieved from various web resources (PatentFreedom, IP-Checkups, PlainSite).

The final list of active NPEs is made up of 373 unique groups and 3,851 subsidiaries.[12] With respect to the 1994-2014 period considered for tracking patent transfers, we individuate 199 NPE groups acquiring at least one US patent. The methods applied to track patent transfers and to individuate NPE-acquired patents are described below.

3.2 Patent transfers

To track patent transfers at the USPTO, we rely on the Patent Assignment Database (PAD – 2017 version). US granted utility patents applied for in 1990-2010 in all technologies constitute our analysis sample.

As explained in Marco *et al.* (2015), PAD records assignments of an assignor's interest in patent applications and issued patents. This provides legal notice to the public of the assignment. As the authors stress: "*An assignment of assignor's interest* […] *is a transfer by an assignor of its right, title, and interest in a patent or patent application to an assignee.* [… T]*he assignment transfers to another a party's entire ownership interest or a percentage of that party's ownership interest in the patent or application. Valid assignments indicate ownership to establish standing to bring suit against infringers*" [pp. 5 and 6].[13]

We therefore track patent transfers exploiting the information contained in the 'assignment' data file.[14] More precisely, between the several types of conveyance reported in the file, we select the 'assignment of assignor's interest' conveyance.[15] For each isolated record, we then look at the 'assignee' and 'assignor' files to retrieve information on the buyer and seller respectively. The two files report information on the names of the entities registered. We apply semantic algorithms to clean and standardize those names, both within and between files. More precisely, we conduct a

[12] 3,851 unique company names are attached to these corresponding 373 NPE groups.
[13] See also Graham *et al.* (2018) for a detailed description of PAD.
[14] A drawback of the data is that the federal recording of a change of ownership (entire or partial) is not mandatory. However, both patent statute and federal regulations provide some incentive for recording. For a discussion about assignment recording requirements see Marco *et al.* (2015).
[15] We do not consider mergers and acquisitions. Moreover, we exclude all the first assignments that refer to inventor-applicant formal assignment cases. All further assignments referring to 'change of name', 'change of address', etc. have been excluded.

three-step standardizing and matching procedure between the two files. The first two steps serve to clean and standardize names within each file. The final step is the matching between the two to harmonize them. After standardizing and harmonizing assignee and assignor names, we rebuild the ownership tree attached to each patent recorded in the original assignment database.

The number of patents filed between 1990 and 2010 for which we are able to measure all the variables used to conduct the analysis (and that constitute our starting sample) is 2,807,127. We individuate 619,795 transferred patents (~22% of the sample) over the period 1990-2016.[16] Of them, 75.6% (i.e. 468,814 patents) have been transferred only once over their lifecycle. Table 1 summarizes the distribution of the number of transfers per patent we individuate in PAD for our sample of interest. For the subsample of high-tech patents[17], the share of transferred patents is ~26%, significantly higher than the average. This signals for a particular dynamism of ownership changes in high-tech sectors.

TABLE 1. Distribution of transfers per patent

# of transfers	Freq.	Percent	Cum.
Never transferred	2,187,332	77.92	77.92
1 transfer	468,814	16.70	94.62
2 transfers	116,122	4.14	98.76
3 transfers	27,362	0.97	99.73
4 or more transfers	7,497	0.27	100.00
Total	2,807,127	100.00	

Note: patents filed in 1990-2010; transfers occurred in 1990-2016. Source: Author's elaboration from PAD (2017 version).

3.3 The NPE-PAD database

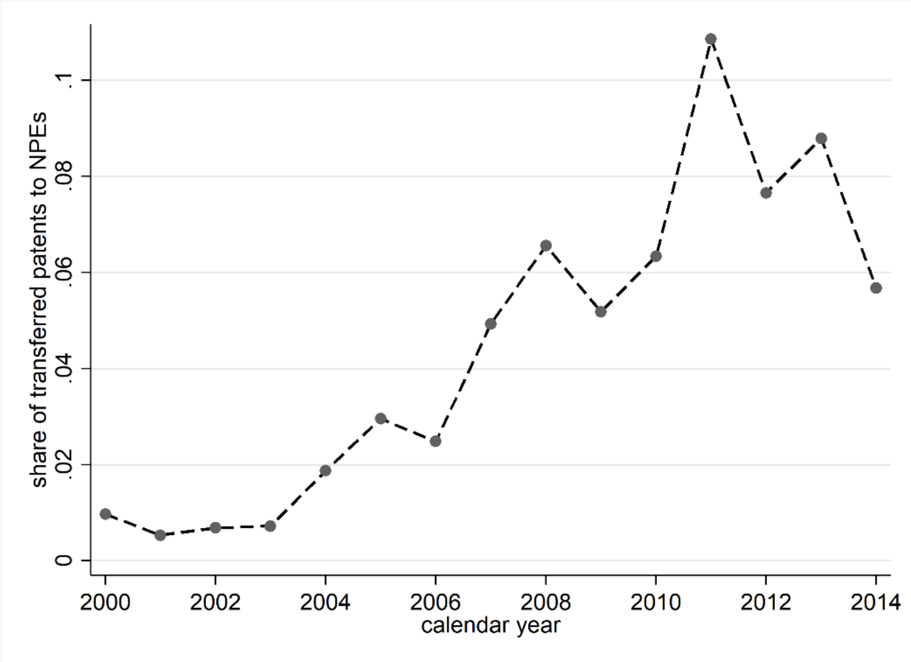
To identify patents assigned to NPEs, we perform a semantic matching between entity names included in the aforementioned NPE list and assignee names recorded in PAD. We perform a

[16] A pioneering work on patent transfers at the USPTO is Serrano (2010). On the sample of utility patents granted in 1983-2001 at the USPTO, the author finds that 13.5% of them have been transferred at least once over the period 1983-2001. To test the robustness of the methods we implemented to individuate patent transfers at the USPTO, we calculate the share of transferred patents replicating the sample used by Serrano (2010). According to our methodology, the share of utility patents granted in 1983-2001 that have been transferred at least once over the period 1983-2001 is 13.02%.

[17] The definition of high-technology patents proposed by Eurostat uses specific subclasses of the International Patent Classification (IPC) as defined in the trilateral statistical report of the EPO, JPO and USPTO. The following (macro) technical fields are defined as high technology: Computer and automated business equipment; Microorganism and genetic engineering; Aviation; Communications technology; Semiconductors; Lasers. The list of sub-classes and their definition is provided by Eurostat at http://ec.europa.eu/eurostat/cache/metadata/Annexes/pat_esms_an2.pdf.

probabilistic matching using the RECLINK Stata algorithm (Blasnik, 2007), which allows for a minimum amount of discrepancy between applicant and NPE names to be matched.[18]

Figure 2. The NPE contribution to patent transfers



Notes: The figure plots the share of patent transferred to NPEs over the total number of transferred patents over the period 2000-2014. We consider all granted utility patents filed at the USPTO between 1990 and 2000.

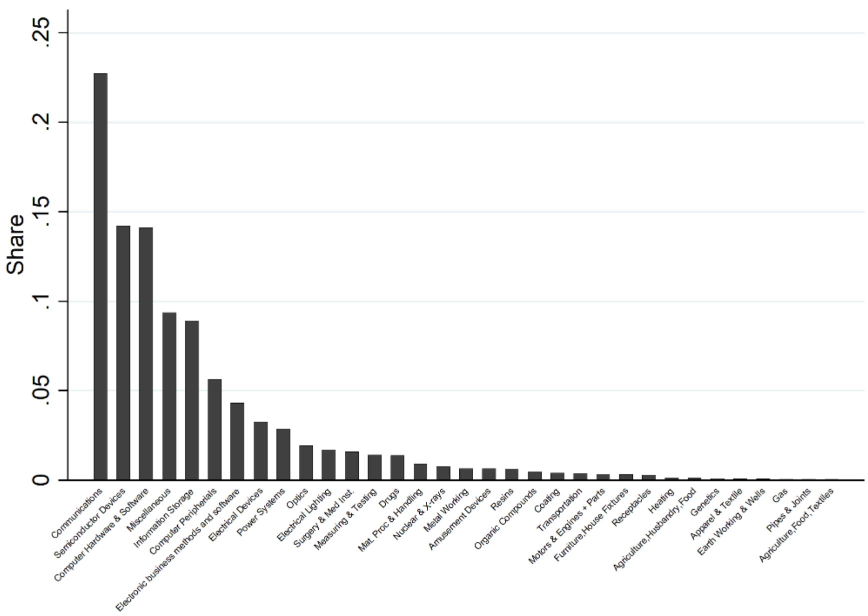
The matching method leads to the identification of 69,071 patents applied for in 1990-2010 in which at least one NPE is listed as the owner of the IP right in the patent lifecycle (i.e., either as first applicant or as patent assignor), representing around 2.5% of the entire basket of patents filed in 1990-2010 at the USPTO by companies (either PEs or NPEs). The number of patents purchased by NPEs from PEs is 38,044, representing around 6.2% of transferred patents first filed by PEs in our sample. The contribution of NPEs as patent buyers to patent transfers in the US increased sharply from the early 2000s onwards, as shown by Figure 2, reaching the remarkable peak of more than one in ten in 2010.[19] In terms of first filing, NPEs filed 31,027 patents over the period 1990-

[18] We set the algorithm score at 0.95. This threshold was chosen by visually comparing applicant names with NPE names on a random sub-sample of 100 cases. For robustness checks we also perform, respectively, exact matching and we allow the algorithm to vary according to different thresholds (i.e., 0.90 and 0.99): the results do not change significantly when varying algorithm precision, and are available upon request by the authors.
[19] Table A1 in the Appendix reports the Top-20 NPEs by number of acquired patents filed at the USPTO in 1990-2010.

2010. Of these, 5,561 (around 18%) were subsequently transferred to PEs. This last statistic tells us that the role of NPEs as patent intermediaries is far from negligible.

NPEs operate mainly in the ICT industry and, in general, in "complex" technologies, i.e. technologies in which a new product or process is composed of numerous separately patentable elements, leading to the fragmentation of the relevant IP ownership (Kingston, 2001). This is confirmed by our data. In fact, the three most representative technological fields in which NPEs file or acquire patents are Communications (22.7%), Semiconductor devices (14.2%) and Computer hardware and software (14.1%).[20] Overall, more than half of the NPE patent portfolio belongs to these three domains (Figure 3), confirming previous evidence that NPEs largely target information and communication technologies.

Figure 3. NPE by technological field



Notes: The figure plots the distribution of NPE patents across technological fields. We consider granted utility patents filed at the USPTO between 1990 and 2010 either firstly applied or acquired by NPEs. For acquisitions the timespan considered is 1990-2014. Technological fields are retrieved from the NBER classification (Source: PatentsView).

[20] In the descriptive analysis, we classify the technological fields according to NBER patent categories (Source: PatentsView).

Table 2 compares the characteristics of patents transferred to NPEs to those of the other patents granted in the three technological domains in which NPEs are most active (i.e. Communications, Semiconductor devices and Computer hardware and software). On average, NPE-purchased patents appear to be more cited in the early phase of their lifecycle (i.e., during the three-year window after filing), to be more original[21] and to contain claims than other patents. Moreover, when compared to the set of patents transferred to PEs, patents transferred to NPEs are also older (1.7 years) on average at the time of the transfer.[22] All the mean differences are statistically significant at the 1% level. Overall, the descriptive statistics suggest that higher quality and originality, as well as the maturity of the technology, drive transfers to NPEs.

Table 2. Patent characteristics by category

	Originality	**Citations (3 years)**	**Claims**	**Age at 1st transfer**
NPE purchased	0.764 (N=13,579)	4.819 (N=13,579)	21.430 (N=13,579)	9.249 (N=13,579)
Other	0.748 (N=659,332)	3.035 (N=659,332)	18.535 (N=659,332)	7.545 (N=168,344)

Note. The table shows the average characteristics of patents in the following technological fields: Communications, Semiconductor devices and Computer hardware and software. The group "NPE purchased" is composed of patents filed by PEs and successively transferred to NPEs. The group "Other" consist of all the other patents (non-transferred and transferred to entities different from NPEs). The age at the transfer is computed as the difference between the year of the filing and the year of the 1st transfer; for the group "Other", the statistics is computed for patents transferred to entities different than NPEs. Mean differences are statistically significant at the 99% confidence level.

3.4 Litigation data

The last block of information on NPEs comes from litigation data. We collect information on patent litigation cases initiated by NPEs (i.e., cases in which NPEs were plaintiffs) in US Courts over the period 2000-2012. [23] The total number of unique litigation cases is 7,519. Figure 4 shows the number of new NPE-initiated litigation cases by year. While the rate of growth is remarkable over the period 2005-2010 (with a 41% average year growth), there was a real boom in 2011 and 2012, with 1,495 and 3,383 new initiated litigation cases respectively.

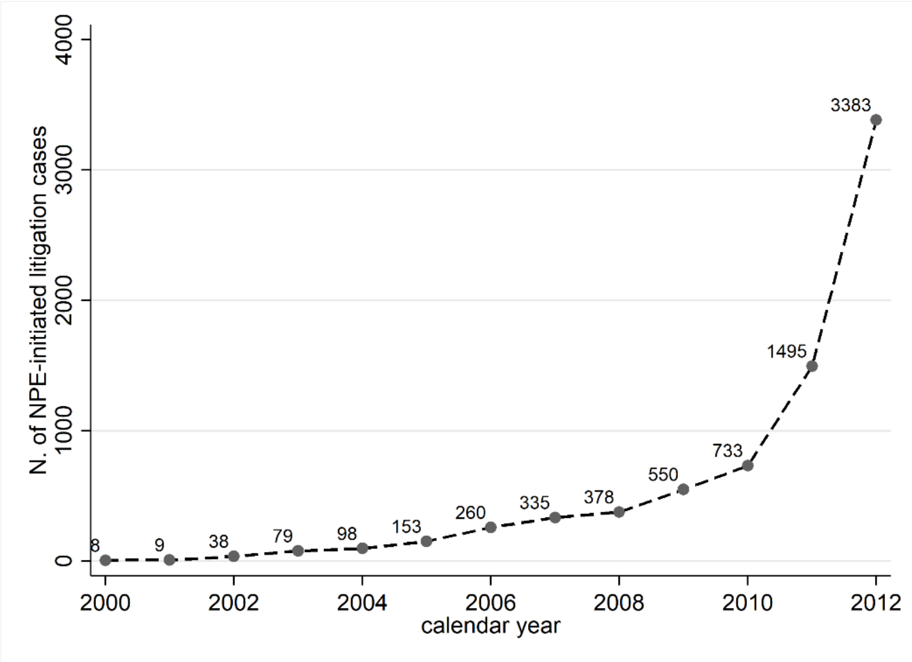
[21] Patent originality refers to the breadth of the technology fields on which a patent relies (Squicciarini *et al.*, 2013). It is defined as $Originality_p = 1 - \sum_j^{n_p} s_{pj}^2$, where s_{pj} is the percentage of citations made by patent p to patent class j out of the n_j IPC 8-digit patent codes contained in the patents cited by patent p. The information is retrieved from the "OECD Patent Quality Indicators database, July 2019".

[22] Patent age at the transfer is measured as the number of years elapses since filing.

[23] All types of actions have been considered, including infringement cases and invalidity actions.

We individuate 82 Courts in which NPEs are active. Their litigation activity is strongly concentrated in four Courts that account for more than 62% of all NPE initiated cases. These Courts are the Texas Eastern District Court (by far the most representative Court, accounting for around 30% of NPE cases), the Delaware District Court (14.7%), the Illinois Northern District Court (9.3%) and the California Northern District Court (8.3%). Overall, 40.1% of NPEs use Texas Eastern District Court as a venue for patent litigation. The total number of patents litigated by NPEs is 2,853, with a median of 3 litigation cases per patent (the maximum is 214 different litigation cases in which the same patent was used to sue alleged infringers).

Figure 4. NPE new litigation cases by year



Notes: The figure plots the number of new litigation cases initiated by NPEs in US District Courts over the period 2000-2012. All types of actions have been considered, including infringement cases and invalidity actions.

4. Empirical strategy

4.1 Measuring Follow-On Innovation

To investigate the effect of NPE patent acquisitions on follow-on innovation, we compare the difference in the number of citations received by patents transferred to NPEs between pre and post transfer periods with the same difference shown by the rest of patents filed in 1990-2010 at the USPTO (either never transferred or transferred to PEs).

We consider patent citations both as an indicator of patent exploitation and a measure of technological quality. We argue that the number of forward citations signals the usefulness of the protected technology for further innovation (De Rassenfosse and Jaffe, 2018). Patent citations are reported in the patent document, provide a legal delimitation of the property right scope and identify the antecedents upon which the invention stands. Scholars have made wide use of the information contained in patent citations to track knowledge flows (Jaffe *et al.*, 1993; Jaffe and Trajtenberg, 1999; Maurseth and Verspagen, 2002; Bottazzi and Peri, 2003; Bacchiocchi and Montobbio, 2010; Montobbio and Sterzi, 2011).[24] In this respect, a citation from one patent to another indicates that (an important) portion of the technological content protected by the latter constitutes prior art for the former. Controlling for the patent age and the technology, patents that stop being cited are very likely to be no longer used in further innovation activities. Conversely, a large number of citations received indicates that the patented invention is relevant for present and future R&D (Trajtenberg, 1990; Fischer and Leidinger, 2014).

As discussed above, NPEs target specific technologies. This particular behavior affects the probability of a transfer, its timing and hence the citation pattern of transferred patents. To provide a reliable identification, we therefore perform matching methods that allow us to replicate a quasi-natural experiment as closer as possible, minimizing the number of (observable) confounding factors that might affect our empirical setting. The next subsection introduces the matching methods applied and describes the econometric strategy.

4.2 Econometric models

To study the impact of patent acquisitions on follow-on innovation we first design a diff-in-diff panel research framework with patents that experience a change of ownership as the treated group and never transferred patents as the control group (Section 4.2.1). Importantly, we split the treated group into (1) patents transferred to PEs (PE), and (2) patents transferred to NPEs (NPE) and we assign to each of them a distinct group of control patents. Our first goal is to capture the effect of the transfer event on forward citation received by the transferred invention and to test whether the effect differs with the type of buyer (NPE/PE). In order to better control for selection, we then compare NPE-acquired patents to PE-acquired patents (Section 4.2.2). For the purpose of our analysis, we focus on first transfers.[25]

[24] Griliches (1998) and Breschi *et al.* (2005) provide path-breaking and renowned surveys on the topic.
[25] To assess the robustness of the results presented in Section 5 we exclude patents traded multiple times over their life-cycle from our analysis. The results of this robustness test are reported in Section 5.3.

4.2.1 The effect of patent transfers (1): comparing transferred- to never-transferred patents

A patent transfer is a two-sided deal. On the one hand, the seller's characteristics explain the decision to transfer a patent. On the other hand, demand for patents is not homogeneous, with several entities that are willing to buy patent assets for different reasons. The largest part of these aspects is not observable, making it hard if not impossible to solve selection issues (i.e. finding the right specification that replicates a natural experiment indispensable to guarantee full exogeneity of the transfer event).

To minimize selection issues, we apply matching methods. Matching methods seek to replicate a randomized experiment in which the matched and the control patents do not differ systematically on observable characteristics that predict a change of ownership. More precisely, we match the two groups of transferred patents (NPE and PE) with non-transferred patents on an index, the propensity score, of several variables affecting the likelihood of observing a transfer. In this exercise, we implicitly assume that all the variables explaining a patent transfer are observed and included in the model, so that we can construct two unbiased counterfactuals of non-transferred patents for the two groups of traded patents (conditional independence assumption). Among these observable characteristics, we include: the patent filing year; the technology category classifying the patent (IPC at three digits level); the number of citations received in the four-year time window elapsing from the filing;[26] the level of patent originality, capturing the knowledge diversification and its importance for innovation (Trajtenberg *et al.*, 1997); the number of backward citations, which signal inventions of an incremental nature (Lanjouw and Schankerman, 2001); the number of patent claims, which reflects the expected economic value of a patent (Lanjouw and Schankerman, 2001, 2004); team size (number of inventors listed in the patent document), which is usually correlated with the quality of the patent (Wuchty *et al.*, 2007); a dummy variable for patent co-application (i.e. more than one PE as the patent owner); and the patent portfolio size of the first applicant (i.e., the first applicant's stock of patents).[27] Since we focus on first transfers, this last variable accounts for the size of the potential seller – an important determinant of the transfer.[28]

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[26] The choice of measuring citations in the first four years from the filing is due to the fact that transferred patents diverge the most from never-transferred patents in terms of citation growth precisely during those years. Ensuring that the citation rate in the early phase of a patent lifecycle does not diverge significantly between groups of patents makes the assumption of a parallel citation trend before the transfer event reliable. Due to this choice, we exclude those patents that change ownership before the fourth year since filing from the empirical analysis.

[27] The patent stock is calculated applying the Perpetual Inventory Method with a 15% annual decay rate. For co-applied patents we assign the maximum stock between first applicants.

[28] Serrano (2010) highlights that "there is a substantial difference in the rates of transfer across type of patentees, with individual private inventor and small innovators selling respectively 16.2% and 17.5% of their patents. Meanwhile, large innovators and government agencies have the lowest rates of transfer with 10.5% and 4.1% of their respective patents". This difference is even larger when the author accounts for patent quality.

The propensity score is then calculated from the fitted values of a probit model where the dependent variable is the probability of a patent being transferred (either to a PE or to an NPE). We force the matching to be exact on three dimensions: the filing year, the technological field (three digits IPC) and the number of citations in the four years after the filing. For the rest of the variables we adopt the nearest-neighbor algorithm, setting a caliper threshold to 0.01. The choice of a low caliper threshold imposes a tiny tolerance level on the maximum propensity score distance also for the variables that do not exactly match. It therefore further minimizes potential biases due to systematic differences in the vector of variables, avoiding bad matches (Caliendo and Kopeinig, 2008). The method returns a 1:1 matching where, for both groups, the related control patents distribute identically across cohorts, technological fields and citations (in the four years after the filing), while as close as possible on the other dimensions.

After the matching, the first sample is composed of 337,783 patents transferred to PEs (~99.5% of the original sample of patents transferred to PEs) and the matched never-transferred patents. The second sample includes 18,235 patents transferred to NPEs (~99.8% of the original sample of patents transferred to PEs) and the related matched never-transferred patents. We then assign a *'placebo transfer event'* in the same year as the ownership change registered for the corresponding treated patent to each control patent, i.e. we create a fictitious counterfactual situation for the two groups of transferred patents.

These final restricted samples are then used for estimating the following (conditional) difference-in-differences (CDD) models where the treatment is the transfer (real or placebo) and the treated groups are the groups of patents transferred, respectively, to PEs (Equation 1) or to NPEs (Equation 2):

[Equation 1]

$$CIT_{it} = \beta_1 \times POST_{it} + \beta_2 \times POST_{it} \times PE_i + \sum_{j=1}^{20} \gamma_j \, AGE_j + \alpha_i + \varepsilon_{it}$$

[Equation 2]

$$CIT_{it} = \beta_1 \times POST_{it} + \beta_2 \times POST_{it} \times NPE_i + \sum_{j=1}^{20} \gamma_j \, AGE_j + \alpha_i + \varepsilon_{it}$$

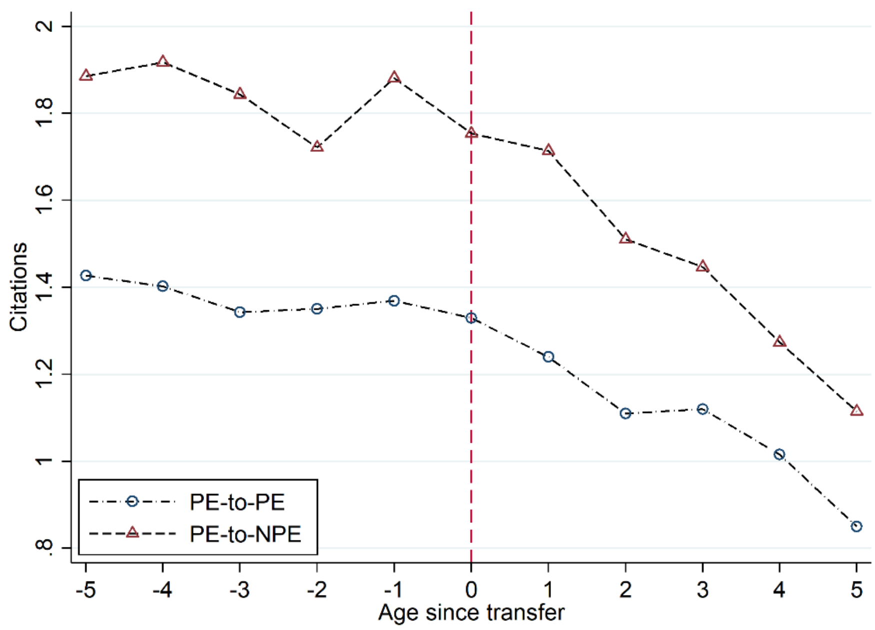
where CIT_{it} is the number of citations received by patent i in year t. We take the log (plus one) of the number of citations to have the dependent variable distributed more closely to normality. $POST_{it}$ is an indicator of the post-transfer period for both transferred and placebo patents: it takes value one from the year of the transfer on. Its coefficient, β_1, captures the obsolescence of the protected technology. Since a patent is transferred on average in the mature phase of its lifecycle, β_1 is expected to be negative. The $POST_{it} \times PE_i$ and $POST_{it} \times NPE_i$ interactions are the two diff-in-diff indicators in the two models. They measure the effect of the transfer on citations when the buyer is a PE and an NPE, respectively. Their effect is captured by β_2. In the former model, a positive sign suggests that, on average, a patent transfer helps to reduce the initial misallocation of patents, with buyers fitting the content of the protected technology better than sellers to innovate further around it. Conversely, a negative sign most likely suggests that, on average, patents change ownership mainly for strategic reasons (Hall and Ziedonis, 2001; Blind *et al.*, 2009; Noel and Schankerman, 2013; Scott Morton and Shapiro, 2014), as often happens in the case of complex technologies (Bessen, 2003; Orsenigo and Sterzi, 2010), reducing the rate of innovation around the transferred asset. Since in the second model we compare citations received by NPE-acquired patents with citations received by placebo patents, the interpretation changes. If NPEs mainly acquire patents either to facilitate matching between sellers and potential buyers (i.e. if they play as intermediaries in the market) or to efficiently exploit their legal specialization in assertion activities, we expect to observe a positive β_2 coefficient. Conversely, if NPEs on average exacerbate market frictions due to aggressive and inefficient assertion activities (i.e. if they act as "patent trolls"), we would expect a negative and significant sign. Finally, in both models we include patent age dummies (AGE_j) and patent fixed effects (α_i). The former capture citation dynamics associated with the age of the patent that are common across technologies. The latter captures time-invariant, unobservable characteristics at the patent level. ε_{it} is the error term.

4.2.2 The effect of NPE patent acquisitions (2): comparing NPE-acquired patents to PE-acquired patents

While the analyses described so far lead us to interpret the role of NPE from a comprehensive perspective, we acknowledge that they come at the cost of not entirely solving endogeneity issues. The patent transfer is indeed an endogenous event since we cannot properly control for seller's and buyer's strategies. Moreover, NPEs target patents that systematically differ from PE targets. Therefore, with the framework proposed in Section 4.2.1 we cannot reject the hypothesis that NPE acquisitions affect follow-on innovation the same way PE acquisitions do. In other word, to provide a more comprehensive evidence of the phenomenon under scrutiny, we compare patents transferred to NPEs with (almost) identical patents transferred to PEs. In what follows, we thus restrict our focus to the subset of transferred patents and we look at the age profile of citations around the transfer event for the two groups of purchasing entities (i.e. PEs and NPEs).

As first descriptive evidence, Figure 5 plots the two citation profiles (for NPE- and PE-acquired patents, respectively) over a ten-year window around the transfer event. In order to compare similar patents, we take the group of NPE-acquired patents as benchmark and we perform a 1:1 exact matching on the patent filing year, the IPC 3 digits classifying the technology and the patent age at the transfer (in years) with the group of PE-acquired patents. This matching method allows to compare patents broadly targeted by NPEs with patents traded in the market between producing companies that belong to the same technology and cohort, and change ownership at the same age.

Figure 5. Age profile of citations since the patent transfer



Note: The figure plots the age profile of citations in a ten-year window around the first transfer for the two groups of transferred patents (i.e. transferred to PEs and transferred to NPEs). We consider all the patents filed in 1990-2010 at the USPTO. We perform a 1:1 exact match between the sample of patents transferred to NPEs (20,550 patents) and the sample of never transferred patents on the year of filing, the technology and the age at the transfer.

The figure shows that NPEs target highly-cited patents at the time of the transfer (around 1.7 citations on average). Conversely, patents transferred to PEs are on average less cited (around 1.3 citations in the year of the transfer). The slightly declining citation trend is similar and (almost) parallel between the two groups over the five years before the transfer. This is due to the fact that traded patents change ownership in an advanced phase of their lifecycle on average (around 9 years since filing). While the two pre-transfer citation profiles look alike before the transfer, an evident convergence takes place after, with patents transferred to NPEs falling faster in citations than patents transferred to PEs. More precisely, the absolute difference in citations between the two groups is around .43 at the time of the transfer (age 0 in the figure).[29] It drops to around .26 in the fifth year after the transfer (age 5 in the figure). In other words, an accelerated drop in citations seems to characterize patents whose buyer in an NPE, reducing the citations gap the two groups show before and at the time of the transfer.

The descriptive exercise performed so far is informative of two main things: 1) NPEs systematically target highly cited patents, 2) the average citation profile of NPE-acquired patents converge towards the citation profile of PE-acquired patents in the after transfer period (while this is not the case before the transfer).

Since we want to reduce confounding factors as much as we can in order to capture the 'pure' effect of NPE patent acquisitions on follow-on innovation around traded patents, we refine the matching proposed above. We therefore implement a further matching strategy that replicates in its method the one adopted for matching transferred with placebo patents, but with an important difference. Since both NPE and PE patents are actually traded, we exploit two further dimensions that explain the transfer. The first is the age of the patent at the moment of the first transfer, the second is the total number of citations received by the focal patent in the period from the filing to the first transfer. Importantly, the latter guarantees that the pre-transfer citation pattern is on average the same across groups of transferred patents. We force the algorithm to exact matching also on those variables, as well as on the patent filing year (cohort) and the technology class. For the rest of the variables we adopt the nearest-neighbor algorithm, setting a caliper threshold to 0.01.

Altogether, the algorithm guarantees that two types of patents are transferred exactly in the same year, at the same age and in the same technological field, they received the same number of citations since the filing year, and that they show similar characteristics on the other dimensions (i.e. originality, number of backward citations, number of claims, number of inventors, seller's stock of patents and co-application). The only observable difference is therefore the type of entity that purchases the patent.

We then estimate the following diff-in-diff specification on the subsample of matched transferred patents with OLS:

[29] The difference in citations between groups is around .45 five years before the transfer (age -5 in the figure).

[Equation 3]

$$CIT_{it} = \beta_1 \times POST_{it} + \beta_2 \times POST_{it} \times NPE_i + \sum_{j=1}^{20} \gamma_j AGE_j + \tau_i + \varepsilon_{it}$$

where CIT_{it} is the (log plus one transformed) number of citations received by patent i in year t.[30] $POST_{it}$ is an indicator of the post-transfer period: it takes value one from the year of the transfer on. Its coefficient, β_1, captures the average rate of post-transfer citations for PEs with respect to the pre-transfer period. Since a patent is transferred on average in the mature phase of its lifecycle, β_1 is expected to be negative. The negative magnitude of β_1 might be either amplified or attenuated by the transfer event itself. On the one hand, if the transfer is driven by strategic reasons we do expect to observe a larger negative coefficient. Conversely, we do expect a smaller negative coefficient if the decision to buy is driven by technological reasons that reduce the initial misallocation of the patent. As discussed when presenting Equation 1, the former case is more likely to verify in high-tech domains, while the latter in more traditional, low-tech ones. The interactions $POST_{it} \times NPE_i$ is our diff-in-diff indicator of interest. It measures the difference in the pre/post transfer citation differences between the two groups of patents due to the NPE activity. The NPE effect on follow-on innovation is captured by β_2. Lastly, we include age and patent fixed effects, as we do in Equation 1 and Equation 2.

Once assessed the average effect of NPEs on follow-on innovation (Section 5), we perform several heterogeneity tests to investigate the differential role of different NPE businesses (Section 6). To start with, we focus on NPEs whose business conceives patent intermediation. On the other side, we look at the effect on follow-on innovation when patents are acquired by 'opportunistic' NPEs.

5. Baseline results

In this section, we present the results of the empirical approaches proposed above. Section 5.1 presents the baseline evaluation of the impact of the patent acquisition on follow-on innovation. We provide evidence about the effect of the transfer when the buyer is, respectively, a producing company or an NPE in two separated estimates (Equations 1 and 2). In Section 5.2, we restrict our focus to transferred patents and we investigate differences between citations received by patents

[30] In appendix we show OLS results when the dependent variable is in level (Table A2), and when we estimate negative binomial models (Table A3).

transferred to NPEs and citations received by patents transferred to PEs. In Section 5.3 we discuss the robustness tests performed.

5.1 The effect of patent transfers (1): comparing transferred- to never-transferred patents

We start by presenting our results with the models presented and specified in Section 4.2.2. In this first step of the analysis, we make use of two reduced samples: the first sample is composed of patents transferred to PEs and their matched (placebo) patents, selected among the never-transferred patents; the second sample is composed of patents transferred to NPEs and their matched (placebo) patents, selected among the never-transferred patents. In the former case, we estimate the effect of the transfer only on the subsample of patents transferred to PEs and corresponding placebo patents, while in the latter we do the opposite, looking only at the subsample of patents targeted by NPEs.

Table 4 reports the results. When we focus on the subsample of patents targeted by PEs (Panel A, column I), our results show a positive and significant coefficient for the diff-in-diff interaction $POST \times PE$. This means that, compared to placebo patents that do not change ownership over their lifecycle, patents transferred to producing companies are used more efficiently in the post-transfer period. The average number of citations increases significantly by 0.25% relative to non-transferred patents. Although positive, the effect is not substantial. This could be explained by the heterogeneous use of patents across technologies and industries.

In industries characterized by complex technologies and, in general, in high-tech domains, patent acquisitions are mainly driven by strategic reasons. To test this possible heterogeneity across technologies, we further estimate the same model by splitting the sample between high-tech (Column II) and low-tech patents (Column III): the results show that the effect on citations of the patent transfer is negative and significant for high-tech patents, while it is positive and significant for more traditional (low-tech) domains. In the latter case, patent transfers seem to reduce the initial misallocation of the patent. In the former, reasons that go beyond technological advances around the protected technology drive purchasing decisions.

In Panel B, columns IV, V and VI we estimate the effect of the transfer when the buyer is an NPE. Results show a negative and significant coefficient of the diff-in-diff interaction $POST \times NPE$. The transfer to NPEs reduces the technological usage of the patent with respect to the counterfactual situation in which the patent does not change ownership over its lifecycle. The decrease is estimated in around -2.1%. To test for a different effect across technologies, we estimate the same model on the sample of high-tech patents (column V) and on the sample of low-tech patents (column VI). While the difference between the two subsamples is significant when acquisitions from PEs are considered, this is not the case for NPE-acquired patents. Both low-tech and high-tech patent samples confirm the overall evidence. The coefficient for the interaction $POST \times NPE$ is indeed negative and significant in both cases. Precisely, it stands at -2% for low-tech patents, while it slightly increases to -2.3% for high-tech patents.

Table 4. CDD model (transferred vs placebo patents)

	Panel A: PE – placebo		
	All sectors (Equation 1)	High-Tech (Equation 1)	Low-Tech (Equation 1)
	I	II	III
post	-0.044***	-0.049***	-0.036***
	(0.00086)	(0.0014)	(0.0011)
post x PE	0.0025**	-0.0040**	0.0067***
	(0.0010)	(0.0016)	(0.0013)
Patent FE	yes	yes	yes
Age FE	yes	yes	yes
Observations	11264274	4475133	6789141
Adjusted R^2	0.482	0.517	0.452

	Panel B: NPE – placebo		
	All sectors (Equation 2)	High-Tech (Equation 2)	Low-Tech (Equation 2)
	III	IV	V
post	-0.026***	-0.015***	-0.049***
	(0.0038)	(0.0046)	(0.0068)
post x NPE	-0.021***	-0.020***	-0.023***
	(0.0044)	(0.0053)	(0.0079)
Patent FE	yes	yes	yes
Age FE	yes	yes	yes
Observations	586371	408023	178348
Adjusted R^2	0.524	0.537	0.489

The sample used to estimate models in Panel A is composed of patents transferred to PEs and matched (placebo) never-transferred patents. The sample used to estimate models in Panel B is composed of patents transferred to NPEs and matched (placebo) never-transferred patents. Standard errors, clustered at the patent level, are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Altogether, these results provide three main insights. First, the transfer between producing companies fosters a more efficient allocation of patented technologies in traditional sectors (low-tech sector): patents transferred in the market increase their (technological) usage with respect to similar patents that do not change ownership. Second, the average patent transfer in the high-tech sector is not associated with an increase in use of the patent, suggesting that strategic considerations drive patent acquisitions (Morton Scott and Shapiro, 2014). Third, when the buyer is an NPE, the patent transfer is associated with a reduction in the number of citations. Patents targeted by NPEs receive fewer citations than similar never-transferred patents after the transfer occurs.

5.2 The effect of patent transfers (2): comparing NPE-acquired patents to PE-acquired patents

In this subsection, we restrict the analysis to the sample of transferred patents. The analysis performed and discussed so far allows us to estimate the effect of the transfer on patent citations differentiating between the two types of buyer separately (i.e. NPEs and PEs). However, NPEs target patents that systematically differ from PE targets. This exercise also helps in further alleviating endogeneity issues due to the transfer itself.

Estimates of Equation 3 are reported in Table 5. Column I presents the results for all technologies. The coefficient for the diff-in-diff indicator $POST_{it} \times NPE_i$ is negative and significant. Its magnitude is -.029. This means that the average patent transferred to NPEs significantly drops in post-transfer citations by around 2.9% with respect to the average control patent that changes ownership between producing companies.

Table 5. CDD model (NPE-acquired vs PE-acquired patents)

	All sectors	High-Tech	Low-Tech
	(Equation 3)	(Equation 3)	(Equation 3)
	I	II	III
post	-0.045***	-0.049***	-0.032***
	(0.0040)	(0.0047)	(0.0076)
post x NPE	-0.029***	-0.022***	-0.050***
	(0.0046)	(0.0053)	(0.0088)
Patent FE	yes	yes	yes
Age FE	yes	yes	yes
Observations	577826	429308	148518
Adjusted R^2	0.539	0.549	0.505

Standard errors, clustered at the patent level, are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

We then replicate the same analysis on the subsample of high-tech and low-tech patents, respectively. Column II presents the results on high-tech patents. As discussed above, high-tech domains are characterized by a higher incidence of strategic patent acquisitions. We in fact estimate an average negative effect of the transfer for high-tech patents when the buyer is a PE (Table 4, column II). This leads us to assume that the negative effect of NPEs on citations is smaller for high-tech patents than the average effect we estimate when pooling together all technologies. This intuition is confirmed by the coefficient for the diff-in-diff interaction $POST \times NPE$ that now stands at -.022. Conversely, the arguments discussed about low-tech domains lead to an opposite expectation: the negative effect of NPE acquisitions is likely to be higher for low-tech patents. Column III presents our estimates for this set of technologies. The diff-in-diff coefficient is now the highest in absolute terms, -5%. This means that, on average, low-tech patents acquired by NPEs receive around 5% less citations in the post-transfer period than low-tech control patents traded between producing companies.

The evidence presented in Table 5 suggests that NPEs harm follow-on innovation. Focusing on patents targeted by NPEs, the average transfer to NPEs leads to a lower use of the protected technology with respect to the case in which the transfer is between PEs. This negative impact on follow-on innovation around NPE-purchased patents is larger in low-tech domains. To investigate which kind of NPEs drive these results, we then explore the NPE business model heterogeneity.

5.3 *Robustness tests*

In this subsection we present a series of robustness tests. Since our analysis focuses on patent first-transfers, we first re-estimate the models reported in Tables 5 on the subsample of patents that do not change ownership multiple times over their lifecycle (and related controls). This test serves to exclude that the evidence discussed in Section 5.2 is driven by multiple acquisitions of the same patents. Table 6 reports the results of this test, confirming the main findings. Column I reports the results obtained on the sample where all technologies are considered. The coefficient for the interaction $POST \times NPE$ is negative and significant. Its magnitude is -.035, slightly higher that the coefficient estimated in Table 5, column I. In columns II and III we restrict the sample to high-tech and low-tech patents respectively. In both subsamples we estimate a negative and significant coefficient which is in line with what estimated in Table 5, columns II and III. More precisely, we estimate a negative effect of NPE patent acquisition of ~-2.8% for high-tech patents and of ~-5.1% for low-tech patents.

TABLE 6. Robustness I: Exclusion of multiple-traded patents

	All sectors	High-Tech	Low-Tech
	(Equation 3) I	(Equation 3) II	(Equation 3) III
post	-0.060***	-0.067***	-0.042***
	(0.0045)	(0.0053)	(0.0084)
post x NPE	-0.035***	-0.028***	-0.051***
	(0.0052)	(0.0061)	(0.0100)
Patent FE	yes	yes	yes
Age FE	yes	yes	yes
Observations	434247	321284	112963
Adjusted R^2	0.539	0.550	0.501

Standard errors, clustered at the patent level, are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Second, we perform a falsification (or placebo) test taking as benchmark the group of PE-acquired patents used as control patents to estimate Equation 3. More precisely, we consider those patents as 'fake' treated patents and we run a 1:1 matching with other PE-acquired patents replicating the matching method applied to generate the sample used to estimate Equation 3. The rationale of this test is straightforward: as the false treatment group is not receiving the treatment (i.e. these patents are not transferred to NPEs), a non-significant coefficient for the DD estimator would suggest that the control group and the treated group do not follow different citation trends in the absence of the treatment. If the contrary verifies, this would suggest that the focal DD estimator is biased. In other words, this test serves to validate the DD coefficient estimated with Equation 3. Table 7 reports the results. Column I reports the results obtained on the sample where all technologies are pooled together. In columns II and III we restrict the sample to high-tech and low-tech patents respectively. The coefficient of interest for the diff-in-diff indicator $POST \times fakeNPE$ is not statistically significant across models, confirming that the 'fake' treated group and the control group do not follow different citation paths in the post-transfer period. Altogether, this robustness test supports a causal interpretation of the coefficient estimated with Equation 3, confirming that, when acquired by NPEs, transferred patents drops in citations with respect to the counterfactual situation of a transfer involving PEs as buyers.

TABLE 7. Robustness II: Falsification tests

	All sectors	High-Tech	Low-Tech
	(Equation 3) I	(Equation 3) II	(Equation 3) III
post	-0.075***	-0.086***	-0.066***
	(0.0039)	(0.0065)	(0.0049)
post x fakeNPE	0.0072	0.0074	0.0073
	(0.0044)	(0.0072)	(0.0055)
Patent FE	yes	yes	yes
Age FE	yes	yes	yes
Observations	569730	423311	146419
Adjusted R^2	0.518	0.550	0.489

Standard errors, clustered at the patent level, are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6. NPE business models

NPEs are characterized by heterogeneous business models. As discussed in Section 2, some NPEs operate as independent distributors and patent brokers. They acquire patents from inventors and license or (re)sell the relative intellectual rights to commercializing entities. NPEs as intermediaries are likely to reduce information asymmetries, to increase liquidity and, in turns, to foster innovation. Others specialize in assertion activities. While patent enforcement specialization might theoretically benefit the patent system restoring efficiency through necessary enforcement activities, this is not the case if it is driven by opportunistic behavior and systematic exploitation of legal inefficiencies (Lemley and Shapiro, 2006). To better understand which kind of NPE business model is harmful for follow-on innovation, we exploit a combination of patent and litigation data.

6.1 Intermediation

To begin with, we look at the business of intermediation. Especially when innovation has a several number of commercial applications or requires the access to multiple fragments of knowledge controlled by diverse patent owners (typical of technology sectors), NPEs might efficiently allocate IP rights and increase the use of the technology they acquire (Steensma *et al.*, 2016). We cannot directly measure whether patents acquired by NPEs were actually licensed out, since this information is rarely disclosed. However, by relying on patent reassignment data, we assume that NPEs act as intermediary whenever they re-sell patents they previously acquired in the market. For each NPE, the share of sold patents is computed with respect to the total number of acquired patents. We define *intermediary* the group of NPEs that falls in the top quartile of the distribution of the share of NPE-acquired patents sold to PEs, and we build the dummy variable $INTER_i$ accordingly. We therefore augment Equation 3 with the triple interaction $POST_{it} \times NPE_i \times INTER_i$ and we estimate the following model:

[Equation 4]

$$CIT_{it} = \beta_1 \times POST_{it} + \beta_2 \times POST_{it} \times NPE_i + \beta_3 \times POST_{it} \times NPE_i \times INTER_i + \sum_{j=1}^{20} \gamma_j \, AGE_j + \tau_i + \varepsilon_{it}$$

The interaction $POST_{it} \times NPE_i \times INTER_i$ measures the additional effect of the transfer to *intermediary* NPEs. The diff-in-diff-in-diffs, captured by β_3, is expected to be positive.

According to the FTC 2016 Study, NPEs with large patent portfolios ("*Portfolio*" NPEs) are often involved in this kind of business. Through large patent acquisitions, they may exploit economies of scale and patent complementarities (Scott Morton and Shapiro, 2014; Steensma et al., 2016). Moreover, because of the higher visibility, *portfolio* NPEs may also easily reach out to a large network of contacts and offering a portfolio license. Therefore, they may easily intermediate between technology suppliers and manufacturers (FTC, 2016). At the same time, through large patent acquisition they also establish reputation, important for seeking high royalties and licensing out their technologies without having to sue alleged infringers. Not surprisingly, large patent aggregators litigate only a small fraction of their patents.[31]

We define *portfolio* NPEs those entities in the top 25% of the distribution of the number of (acquired) patents. They are responsible for ~89% of all NPE patent acquisitions. To test whether their impact on follow-on innovation is different with respect to other (smaller) NPEs, we estimate the following model:

[Equation 5]

$$CIT_{it} = \beta_1 \times POST_{it} + \beta_2 \times POST_{it} \times NPE_i + \beta_3 \times POST_{it} \times NPE_i \times PORTFOLIO_i + \sum_{j=1}^{20} \gamma_j \, AGE_j + \tau_i + \varepsilon_{it}$$

[31] For example, Intellectual Ventures, the larger NPE in our sample, litigated less than 1% of its patent portfolio in 2000-2012. Among the top 20 larger NPEs, only ACACIA litigated more than 10% of its patent portfolio. On average, NPEs in our sample litigated ~4.3% of their patent portfolios.

6.2 Opportunistic behavior

NPEs have been accused to bring nuisance lawsuits when no infringement has occurred, seeking quick, lucrative settlements on frivolous patents (Cohen *et al.*, 2019). A common NPE practice is to systematically target specific courts to maximize the probability of a favorable judgment. This practice, called *'forum shopping'*, was made possible by the US law (28 U.S.C. – 14000[b]) that provided two options for a patent lawsuit venue: 1) the defendant residence and 2) any jurisdiction in which the sued defendant is alleged to commit infringement and maintains its established place of business (Liang, 2010). Before recent US Supreme Court decisions (TC Heartland LLC v. Kraft Foods Group Brands LLC, 2017), the defendant residence was intended to include districts where the corporation was licensed to do business or was doing business-in addition to districts where it was incorporated (Bone, 2017). The Court most targeted by NPEs is the Eastern District Court of Texas, accounting for more than 40% of NPE-initiated cases over 2007-2017 and showing the highest NPE success rate (Ansell *et al.*, 2018). Conversely, only 7% of PE-initiated cases are instead litigated in the Eastern District Court of Texas (Cohen *et al.*, 2019). One reason is that, especially during the 2000s, the juries of the Eastern District Court of Texas were perceived as being distrustful of large corporations and friendlier toward patent holders (Liang, 2010).[32] As a matter of evidence, NPEs showed a 52% success rate in Texas Eastern District during the decade ending in 2017, against an average of 28% for other Courts (Ansell *et al.*, 2018). The choice to initiate a lawsuit in the Eastern District Court of Texas is seen as an opportunistic strategy (Cohen *et al.*, 2019) because some of the patent holders only pretend to have activities in an area that has "*a meager population and is home to neither major business nor metropolitan areas*" (Taylor, 2006 p. 570).

Around 40% of NPEs in our sample assert patents at least once in the Eastern District Court of Texas. We flag them as *opportunistic* NPEs, generating the ad-hoc dummy variable $TEXAS_i$, and we estimate a triple difference model augmenting Equation 3 with the interaction $POST_{it} \times NPE_i \times TEXAS_i$. Formally, the model takes the following form:

[Equation 6]

$$CIT_{it} = \beta_1 \times POST_{it} + \beta_2 \times POST_{it} \times NPE_i + \beta_3 \times POST_{it} \times NPE_i \times TEXAS_i + \sum_{j=1}^{20} \gamma_j AGE_j + \tau_i + \varepsilon_{it}$$

[32] Other reasons, for example the fact that the Court was one of the US fastest rocket dockets, may explain the high number of litigation initiated by NPEs in the Eastern District Court of Texas. For a further discussion, see Liang (2010).

The interaction $POST_{it} \times NPE_i \times TEXAS_i$ measures the additional effect of the transfer to NPEs due to NPEs that initiated at least one infringement action in the Eastern District Court of Texas. The diff-in-diff-in-diffs, captured by β_3, is expected to be negative.

Another way to identify *opportunistic* NPEs is to look at the characteristics of the patents they purchase. NPEs that behave opportunistically in court have been in fact accused to buy (and assert) low-quality patents (Allison *et al.*, 2017; Feng and Jaravel, 2016). Since litigation costs are often larger than potential infringer's expected costs when weak patents are involved, *"the defendant might settle to avoid the nuisance of mounting a defense"* (Bessen and Meurer, 2005, pag.16). This makes profitable the opportunistic NPE patents assertion business. On the contrary, as our descriptive statistics suggest (Table 2), NPEs often target valuable patents for the purpose of reducing transaction costs (Steensma *et al.*, 2016). The two models co-exist, and different implications on follow-on innovation are expected. We rely on the average originality of the NPE patent portfolios to identify those NPEs that mainly acquire low-quality patents.[33] We consider low-quality patents those that are in the bottom quartile of the distribution of patent originality in the population of all USPTO patents filed in 1990-2010. For each NPE we then compute the share of low-quality patents in its portfolio. We define *opportunistic* NPEs the group of NPEs that falls in the top quartile of the distribution of this share (i.e. NPEs with the lowest average portfolio originality), and we build the dummy variable $WEAK\_ORIG_i$ accordingly. We then estimate the following model:

[Equation 7]

$$CIT_{it} = \beta_1 \times POST_{it} + \beta_2 \times POST_{it} \times NPE_i + \beta_3 \times POST_{it} \times NPE_i \times WEAK\_ORIG_i + \sum_{j=1}^{20} \gamma_j \, AGE_j + \tau_i + \varepsilon_{it}$$

6.3 Results

Table 8 reports the estimation results of models 4-7. Columns I and II focus on Equations 4 and 5, respectively. Our results suggest that patents transferred to *intermediary* NPEs receive on average

[33] We also measure patent quality using the number of citations each patent has received up to the transfer and the number of patent claims. Both measures show an additional negative effect of the transfer to NPEs when they acquire weak patent portfolios. However, the effect is significant only in the first case. The number of claims is however often used as a proxy of the profitability of the invention, rather than to proxy technological quality (Lanjouw and Schankerman, 2004; Tong & Frame, 1994), leading to higher damage awards if infringement is found (Mazzeo *et al.*, 2013).

2% more citations than patents transferred to other NPEs after the transfer. Moreover, their citation rate does not significantly differ from the citation rate of patents transferred to PEs.[34]

However, large (*portfolio*) NPEs are associated with a reduction in the number of citations with respect to other NPEs. Contrary to what expected, the negative effect of the transfer to NPEs found in the previous section is mainly driven by these large companies that acquire thousands of patents. We propose several explanations to this result. First, large patent acquisitions are relatively more profitable when patents are not particularly valuable, due to possibility to exploit economies of scale and patent complementarities (Scott Morton and Shapiro, 2014). Second, large NPEs may be seen as a credible threat when they buy in the patent market, discouraging operating companies from innovating. Third, contrary to large companies, small companies (or non-known subsidiaries of *portfolio* NPEs) are not visible and recognized until they start to assert patents.[35]

Table 8. NPE business model

	Intermediation		*Opportunistic behavior*	
	Equation 4 I	Equation 5 II	Equation 6 III	Equation 7 IV
post	-0.045***	-0.045***	-0.045***	-0.045***
	(0.0040)	(0.0040)	(0.0040)	(0.0040)
post x NPE	-0.033***	-0.0058	-0.019***	0.027**
	(0.0048)	(0.012)	(0.0069)	(0.011)
post x NPE x INTER	0.020**			
	(0.0090)			
post x NPE x LARGE		-0.026**		
		(0.012)		
post x NPE x TEXAS			-0.014*	
			(0.0073)	
post x NPE x WEAK_ORIG				-0.064***
				(0.011)
Patent FE	yes	yes	yes	yes
Age FE	yes	yes	yes	yes
Observations	577826	577826	577826	577826
Adjusted R^2	0.539	0.539	0.539	0.539

[34] The overall difference in differences with respect to PE-acquired patents (-1.3%) is not statistically significant for *Intermediary* NPEs (p-value=0.15).

[35] We provide evidence that the effect of the transfer to not yet visible NPEs (i.e. NPEs that did not yet initiated any infringement case) is not statistically different than the average transfer to PEs. Results are available upon request by the authors.

Standard errors, clustered at the patent level, are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The results for *opportunistic* NPEs are in line with expectations. Columns II, IV and V reports the results of the estimates of Equations 6-8. The negative impact of the transfer to NPEs on follow-on innovation is mainly driven by *opportunistic* NPEs (patent trolls). Our results suggest that patents transferred to NPEs that litigate in Texas Eastern District receive 1.4% fewer citations per year after the transferred, compared to patents transferred to other NPEs (Column III). We also find that NPEs that mainly acquire lower-quality patents (when the quality is proxied with patent originality) are associated with a reduction of 6.4% in number of citations post transfer with respect to NPEs acquiring higher-quality patents (Column IV). More interestingly, the transfer to NPEs that acquire on average higher quality patents is associated with an increase of the number of post transfer citations, even with respect similar patents transferred to PEs.

7. Conclusions

The proliferation of NPEs has become a topic of intense academic and policy debate. On the one hand, critics suggest that the NPE enforcement model imposes costs that are disproportionate to the value of protected technologies, while their litigation targets – in most cases operating companies – have fewer defensive options since NPEs neither produce goods nor perform R&D. As a result, NPEs are responsible for a deadweight loss to the economy by discouraging operating companies from innovating. On the other hand, advocates of the NPE business stress that their patents are often stronger than those held by operating companies and that they serve as intermediaries in the markets for technologies.

We contributed to the debate by providing new evidence based on patent transfers at the USPTO involving NPEs. Our main findings point to a negative impact of NPEs on follow-on innovation around targeted technologies. Patent citations decrease by around 3% for patents that are transferred to NPEs, relative to similar patents that are transferred to PEs. This evidence is robust across specifications. NPE-acquired patents also see their citations dropping at a similar rate when compared with placebo never-transferred patents. Importantly, this effect is driven by specific NPEs, namely those that operate opportunistically and build low-quality patent portfolios. Conversely, NPEs that build valuable patent portfolios do not harm follow-on innovation around the acquired patents or are even beneficial to it. Similar evidence applies to NPEs that sell large portions of their patent portfolios to producing companies (i.e. patent intermediaries). Lastly, we contribute to the debate on the functioning of the market for technology. While overall associated positively with more efficient use of the purchased technology, acquisition deals in high-tech domains do not necessarily foster innovation. This suggests that the transfer of high-tech patents is largely motivated by strategic reasons.

An interesting venue of further research is to analyze whether NPEs pass-through to end-inventors efficiently. Anecdotal evidence holds that NPEs pocket high royalties and settlement amounts received and pass little to end-inventors. However available evidence on this mechanism is too little to support generalizable conclusions.

Finally, our results point out significant heterogeneity among different NPEs. NPEs harm innovation when they behave opportunistically by repeatedly acquiring low-quality patents and initiate litigation in 'friendly' courts. Accordingly, policy attention should go beyond the PE versus NPE distinction, targeting market frictions that make profitable opportunistic behavior in IP monetization rather than specific businesses. In this sense, recent reforms introduced by the US Congress (in particular, the *2011 American Invent Act*) and the more recent US Supreme Court decisions discouraging the so called 'forum shopping' practices (e.g. *TC Heartland LLC v. Kraft Foods Group Brands LLC, 2017*) go in this direction. A further recommended step is to foster the overall transparency around patent ownerships and against strategic hiding of patent acquisitions, making post-litigation strategies less attractive.

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APPENDIX

Table A1. TOP-20 NPEs by patent acquisition size

Ranking	NPE name	N. acquired patents	Share	cum
1.	INTELLECTUAL VENTURES	14,996	.394	.394
2.	QUARTERHILL (AKA WILAN)	5,220	.137	.531
3.	ROCKSTAR CONSORTIUM	3,192	.084	.615
4.	ROUND ROCK RESEARCH	1,795	.047	.662
5.	PANOPTIS HOLDINGS	1,780	.047	.709
6.	ACACIA RESEARCH GROUP	1,272	.033	.743
7.	CONVERSANT INTELLECTUAL PROPERTY MANAGEMENT (AKA MOSAID)	1,056	.028	.770
8.	IP BRIDGE	985	.026	.796
9.	XPERI	890	.023	.820
10.	INTELLECTUAL DISCOVERY	694	.018	.838
11.	PENDRELL .	541	.014	.852
12.	TIVO CORP.	476	.013	.864
13.	UNIVERSAL DISPLAY	362	.010	.874
14.	INTERDIGITAL	300	.008	.882
15.	ZAHID RAHIMTOOLA	264	.007	.889
16.	RAMBUS	249	.007	.895
17.	SISVEL	182	.005	.900
18.	IND TECHNOLOGY RESEARCH INSTITUTE	179	.005	.905
19.	GRAPHICS PROPERTIES	172	.005	.909
20.	NORMAN IP HOLDINGS	168	.004	.914

Note: The table reports the top 20 NPEs by number of patents purchased from producing companies over the period 1990-2014. Patents considered are all granted utility patents filed by producing companies at the USPTO in 1990-2010. Top 20 account for 91.4% of the total (38,044 purchased patents). These figure do not include patents filed by NPEs.

Table A2. CDD model (NPE-acquired vs PE-acquired patents): OLS

[Dependent variable: Number of citations]

	All sectors	High-Tech	Low-Tech
	(Equation 3)	(Equation 3)	(Equation 3)
	I	II	III
post	-0.25***	-0.27***	-0.18***
	(0.029)	(0.034)	(0.054)
post x NPE	-0.085***	-0.066*	-0.13**
	(0.030)	(0.035)	(0.059)
Patent FE	yes	yes	yes
Age FE	yes	yes	yes
Observations	577826	429308	148518
Adjusted R^2	0.506	0.513	0.479

Standard errors, clustered at the patent level, are reported in parentheses. $^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Table A3. CDD model (NPE-acquired vs PE-acquired patents): Negative Binomial

[Dependent variable: Number of citations]

	All sectors	High-Tech	Low-Tech
	(Equation 3)	(Equation 3)	(Equation 3)
	I	II	III
post	-0.11***	-0.13***	-0.044***
	(0.0075)	(0.0086)	(0.015)
post x NPE	-0.017**	0.0100	-0.098***
	(0.0081)	(0.0094)	(0.016)
Patent FE	yes	yes	yes
Age FE	yes	yes	yes
Observations	577826	429308	148518
Adjusted R^2	0.506	0.513	0.479

Standard errors, clustered at the patent level, are reported in parentheses. $^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$