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Non-Practicing Entities and their patent acquisition activity in Europe

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Abstract

This paper investigates the expansion of non-practicing entities (NPEs), a widely-discussed subject in both academic and public policy circles, particularly in the United States. There is a prevalent belief that Europe is less exposed to NPEs due to a robust patent system, increased enforcement costs, and smaller damage awards. However, by using a newly compiled database of NPE patent applications at the European Patent Office (EPO), this study reveals a growing presence of NPE activity in Europe, with ownership of nearly 20,000 EPO patents, predominantly in the field of Electrical Engineering. Furthermore, the paper contributes to the existing literature by examining the heterogeneity of the NPE business model and its correlation with the characteristics and utilization of targeted patents. The econometric analysis presented in this study yields three significant findings. Firstly, NPEs with a higher inclination for litigation (referred to as "Litigation" NPEs) acquire patents with elevated infringement risk but comparable technological quality to those obtained by practicing entities. Secondly, patent aggregators (identified as "Portfolio" NPEs) and technology companies (termed "Technology" NPEs) acquire patents of superior quality compared to those secured by practicing entities. Thirdly, patent acquisitions by "Litigation" NPEs and "Portfolio" NPEs result in a decrease in the subsequent utilization of protected technologies.

Keywords: Non-Practicing Entities, patenting activity, patent litigation, patent quality, European patent market

JEL: O31; O34; D23

1 Introduction

The sharp rise in patent applications observed in the last three decades indicates a significant shift towards an economy that relies more and more on intellectual property rights (IPRs). IPRs have a widespread influence on our society, and intangible assets, particularly patents and trade secrets, represent the most valuable element of a company's market value (Elsten and Hill, 2017). Intangible assets are crucial, as leading industries heavily depend on knowledge and proprietary innovations. However, in today's knowledge-driven economy, the utilization of patents has evolved far beyond their original purpose of promoting and rewarding innovative development, especially in the field of Information and Communication Technology (ICT). In this sector, patents are increasingly being employed as strategic tools by various companies (Blind, 2021). This environment has created lucrative opportunities for new intermediaries in the technology market that can capitalize on these developments (Hagiu and Yoffie, 2013). Among them, non-practicing entities (NPEs)—firms whose business model is focused on using patents either to extract licensing fees or to enforce them against alleged infringers to obtain damages or settlement payments (Golden, 2007; Lemley and Shapiro, 2007; Chien, 2008)—have emerged as key actors (Feldman and Ewing, 2012). Their growing active presence in the patent market has sparked a debate about their impact on business performance and innovation. The primary question revolves around whether NPEs, through the threat of litigation, extract unjustified rents from innovators or, instead, they might function as efficient intermediaries in the market, facilitating technology transfer and the development of new products.

To date, the interest in NPE activities has been largely US-centered, where NPEs have been subject to patent law reforms and Supreme Court rulings. In contrast, European policymakers have shown relatively less concern towards NPEs, and only a few studies have thoroughly examined their activities in the European context. Notably, Fusco (2013) stands out as the inaugural empirical inquiry into NPE activities in Europe, meriting recognition for its pioneering contribution. Fusco (2013) shows that NPEs were already present in Europe in the early 2000s, even if their activity was modest compared to the US. Love et al. (2016) analyze patent infringement lawsuits filed in the UK in the years 2000-2013 and in three large regional courts in Germany in the years 2000-2008. They find that litigation initiated by NPEs account for approximately 9% of the cases examined. Moreover, their analysis shows a notable surge of NPE cases in Germany during the study's recent years, culminating in a remarkable peak of over 30% in 2008. Lastly, Thumm et al. (2016) study the impact of NPEs on innovation in Europe by interviewing selected groups of academics, industry experts and representatives from NPEs operating in Europe in the ICT field. They find that most patents asserted in Europe originated from large practicing firms operating in the Telecommunication sector, and they identify in the lack of patent ownership transparency one of the key success factors of the NPE business model in Europe.

These studies agree on a relatively low presence of NPEs in Europe compared to the US. They attribute this discrepancy to a range of factors including, but not limited to, the superior standards upheld by the European

Patent System, reduced costs associated with litigation, greater access to financial resources, and the application of the "English rule", which entails awarding attorney's fees to the successful litigant. Nevertheless, it is worth to acknowledge two notable constraints that limit the scope of these studies. First, they analyze mostly NPE activities that become visible through litigation or provide non-systematic descriptive evidence of the presence of NPEs in the ICT industry. Second, the examined timeframe predates the recent amalgamation of judicial rulings and legislative modifications in the US, which have undeniably eroded certain vital mechanisms accessible to NPEs for capitalizing on their patents.[1] However, in the last decade large patent portfolio acquisitions by NPEs in Europe have made headlines in the media. For example, Inside Secure (now Verimatrix), a French semiconductor (now software) company, licensed out in 2012 its entire near field communication (NFC) patent portfolio to France Brevets, a French state-owned NPE; Technicolor, a French media and entertainment company, sold its Patent Licensing Business to Interdigital in 2019, a US-based NPE active in the telecommunication industry.[2] Finally, a significant number of European product companies have also refocused their business strategy and moved one-step closer to the IP monetization business, which is becoming an important source of revenues.[3]

The first contribution of this paper is to assess the presence of NPEs in Europe in a more comprehensive and precise manner than it has been done so far in the literature, and to extend the period of analysis to more recent years. For this purpose, we build a brand-new database of patent applications filed at the European Patent Office (EPO) where NPEs appear to be the last patent owner. Precisely, we rely on an extensive list of more than 600 groups and 3,508 related subsidiaries defined as NPEs by experts in the patent litigation and licensing field (Clarivate-Darts-IP and Allied Security Trust). Our analysis shows that the presence of NPEs in Europe is far from being negligible. Indeed, we find that NPEs own almost 20,000 patents filed at the EPO. When restricting the sample to patents transacted over the period 2010-2020, we identify around 7,000 patents acquired by NPEs (corresponding to 3% of transacted patents). Moreover, we show that NPEs are particularly active in the Electrical Engineering field, where they acquired around 9% of the transacted patents.

Our second contribution entails delving into the patent acquisition strategies employed by NPEs through a detailed examination of the characteristics of the patents they acquire. Specifically, we juxtapose the patents acquired by the identified NPEs against a random selection of patents acquired by practicing entities in the same technological classes and years. Contrary to studies that rely only on specific samples of patents acquired

[1] For example, Love et al. (2016) see in the continent's fee-shifting regimes one of the main reasons explaining the low attractiveness of Europe for patent monetization compared to the US, where fee awards are rare (though permitted by statute). NPEs deciding whether to file suit in Europe must consider the very real possibility that they will not only fail to win damages and recoup their own legal fees, but also that they will have to pay the accused infringer at least a large portion of the cost of defense. However, this difference has disappeared after Octane Fitness. LLC v. ICON Health & Fitness, LLC (2014) Supreme Court decision that relaxed the standard for awarding fees in patent suits.

[2] Interdigital has acquired more than twenty thousand global patent applications from Technicolor for a total deal of $475 million (including an upfront payment of $150 million and 42.5% of the future royalties from Interdigital's licensing activities in the Consumer Electronics field). See: https://www.technicolor.com/news/ technicolor-agrees-sell-interdigital-its-patent-licensing-business.

[3] Ericsson and Nokia have created dedicated business licensing units and subsidiaries in order to monetize their patent portfolio. See, for example, companies like Unwired Planet, PanOptis, Core Wireless and Vringo/FORM Holding.

by large and known NPEs (e.g. Fischer and Henkel, 2012; Leiponen and Delcamp, 2019), our data allow for a wider and more systematic identification and analysis of the activity of NPEs, by including subsidiaries and small entities that often escape the media's attention. Our empirical analysis shows that, in many respects, NPEs differ significantly from practicing entities with respect to the characteristics of the patents they acquire. In particular, OLS and Logit estimates show that NPEs target patents of relatively high technological quality (as proxied by the number of forward citations).

Finally, we investigate possible heterogeneity due to diverse business models among NPEs, contributing extant literature in two ways. First, we build upon Leiponen and Delcamp (2019) and we develop a taxonomy of NPEs based on two dimensions: (1) the propensity of NPEs to acquire (rather than to file) patents, and (2) their patent litigation intensity.[4] Depending on the relative position in the distribution, each NPE is assigned to one of the following three categories: "Technology" (if the NPE portfolio consists mostly of filed patents, rather than acquired patents), "Litigation" (if the NPE portfolio consists mostly of acquired patents that are used relatively often in litigation activities), "Portfolio" (if the NPE portfolio consists mostly of acquired patents that are rarely used in litigation activities). Second, our study delves into the effect of NPE patent acquisitions on innovation, exploring both the attributes of the acquired patents and how these patents are utilized. We interpret a negative correlation between the number of forward citations received by acquired patents after the transaction and the likelihood that the patent buyer is an NPE as a signal of the reduced use of the patent after transfer (Abrams et al., 2019; Orsatti and Sterzi, 2023). Our empirical analysis shows that the heterogeneity observed among NPE business models is correlated with distinctive approaches employed in the acquisition of patents. In particular, we find that "Litigation" NPEs acquire patents at high risk of infringement, but of similar technological quality if compared with patents acquired by practicing companies. This is not the case of other types of NPEs that, instead, acquire highly cited patents. Furthermore, our econometric results point out a heterogeneous correlation of patent acquisition strategies with follow-on innovation across NPE business models. In particular, we observe that the number of citations drops significantly, in after-transfer periods, only for patents acquired by "Litigation" NPEs. This suggests that both the use of these technologies and the overall level of innovation around them reduce when more aggressive NPEs enter the market for technology through the means of patent acquisition.

The remainder of the paper is organized as follows. Section 2 discusses the literature background. In Section 3, we describe the methodology used to build the database of NPE patents filed at the EPO, and we report the key figures of the database, listing the most active NPEs and their main sources of patents. In Section 4, we analyze NPEs' patent acquisitions, by investigating the difference between patents acquired by NPEs and those acquired by PEs. In Section 5, we test whether NPE licensing models correlate with the characteristics of the acquired patents and downstream innovation. Section 6 concludes.

[4] For this purpose, we complement data on patent acquisitions with patent litigation data.

2 Background and research questions

Is the patent enforcement activity pursued by NPEs an efficient mechanism for technology transfer and innovation? Or, instead, is it merely a means of raising funds under the threat of litigation, constituting a hidden cost for innovators and thus reducing incentives to carry out R&D? The positive view is that NPEs reduce matching costs, help the enforcement of patent rights and inject liquidity. Therefore, as intermediaries in the patent market, they positively contribute to making the secondary market for inventions more efficient. Opponents argue, instead, that NPEs exploit frictions in the market for patents to extract unjustified rents: an 'unwanted tax' that leads to inefficient extra costs and deadweight loss.

From a theoretical point of view both arguments are sound and on the empirical ground the results are not conclusive, depending on the type of data used and on the definition of NPEs adopted. Most of extant evidence on the direct and indirect impact of NPEs on targeted firms and their licensing strategies is based on data on litigation cases. In this respect, some studies find that NPEs significantly increase costs for targeted firms, resulting in a reduction of their R&D investments (Tucker, 2014; Cohen et al., 2019; Mezzanotti, 2021). Chen et al. (2023) show that the response of technology peers to litigation risk from NPEs involves ramping up R&D investments in order to create alternative technologies, but also that this boost in R&D efforts leads to a gradual decrease in the value of resulting patents. Other studies find that NPEs make use of weak patents to engage in frivolous litigation (Lu, 2012; Feng and Jaravel, 2020), and that they often behave opportunistically by providing incomplete information regarding patent ownership, obfuscating the extent of their rights and gaming the system (Menell and Meurer, 2013; Morton and Shapiro, 2013; Feldman, 2014; Sterzi, 2021; Sterzi et al., 2021). By contrast, other empirical analyses suggest that NPEs litigate patents of similar or higher quality than practicing companies, concluding that they do not engage in frivolous litigation (Shrestha, 2010; Risch, 2012) but, rather, increase liquidity and the efficiency of the patent market (Haber and Werfel, 2016). For example, Chari et al. (2022) find that PAE brokerage helps small inventors to monetize their patented inventions, even if this favors only incremental innovations.

The shortcoming of relying only on patent litigation data to investigate the effects of NPE activities is that this type of data provides only partial monitoring of the presence of NPEs in the patent market (Morton and Shapiro, 2013; Lemley et al., 2018): anecdotal evidence suggests that NPEs go through litigation only when they are forced to do so, while they prefer to set royalty demands strategically below litigation costs in order to force defendants to settle (Leslie, 2008; Morton and Shapiro, 2013).

Only a few papers focus directly on patent filings and acquisitions involving NPEs. Fischer and Henkel (2012) analyze the characteristics of a sample of 392 US patents acquired by a few large and known NPEs between 1997 and 2006. Their findings suggest that the probability that a patent will be acquired by an NPE, rather than by a practicing company, increases with both the scope and the technological quality of the patent.

Sterzi et al. (2021) investigate the business model of small NPEs registered as dormant companies in the UK and find that their portfolios consist of patents that are at a higher risk of being infringed than the average, and that are acquired with the purpose of starting litigation campaigns. However, contrary to Fischer and Henkel (2012), Sterzi et al. (2021) find that NPE patents are not cited more frequently than the average. This suggests that empirical findings on patent quality are influenced by both the definition of patent quality and the sample used in the analysis.

The results of extant studies do not provide conclusive evidence about the characteristics of the patents targeted by NPEs and about whether these patents are systematically different from the patents targeted by PEs. We therefore propose the following two research questions:

RQ-1a: Does the probability of a patent acquisition by an NPE increase with the technological quality of the targeted patent (and, consequently, with its probability of being upheld in court and of being enforceable)?

RQ-1b: Does the probability of a patent acquisition by an NPE increase with the scope of the targeted patent and, consequently, with its probability of being infringed upon?

The NPE business model revolves around the acquisition and utilization of patents for generating income through licensing and enforcement, rather than through traditional business operations (Morton and Shapiro, 2013). This definition encompasses different types of firms that invest in IP assets to leverage their efficiency advantage in deploying and enforcing patents (Steensma et al., 2016). Due to data constraints, most of extant studies have focused only on a small subset of NPEs, mainly large and well-known NPEs, and mainly those that aggressively assert patents in court. This has prevented from investigating the heterogeneity of NPE business models with respect to the characteristics and use of the patents they target. NPEs consist, in fact, of multiple types of entities with different licensing models.

Following Federal Trade Commission (2016) and Leiponen and Delcamp (2019), there are at least three main different NPE business models. First, some NPEs may strategically exploit the loopholes of the patent system, by shielding the inventor should she lose a court action (Sterzi et al., 2021)[5] and engage in aggressive patent assertion activities (Kiebzak et al., 2016). We refer to this type of entities as “Litigation” NPEs. Secondly, some NPEs may play a classic intermediary function in the secondary market for technology, facilitating patent licensing and technology transfer (Papst, 2012; Steensma et al., 2016). We refer to this type of entities as “Portfolio” NPEs. Thirdly, some NPEs can also actively perform R&D and commercialize their own inventions via licensing and patent assertion (Reitzig et al., 2010; Leiponen and Delcamp, 2019). We refer to this last type of entities as “Technology” NPEs.[6] These three types of NPEs target and manage patents in different

[5] For example, in Germany, under Section 144 of the Patent Act, individuals facing financial constraints can ask for a reduction in court and attorney fees if they are unable to afford them.

[6] In Section 5.1 we describe the empirical approach used to allocate each NPE to one of the three business models.

ways. Leiponen and Delcamp (2019) is the first attempt in the direction of underlining the importance of deepening this heterogeneity. Precisely, they analyze the features and implications of the patent licensing business models and they show that licensing companies exhibit strong heterogeneity with respect to the strategies they adopt in the patent market and in the legal arena. However, the analysis proposed by Leiponen and Delcamp (2019) relies on a relatively small sample of well-known licensing companies (15 companies). This raises issues of representativeness. Moreover, the authors do not provide evidence of the different use of the patents targeted by the different types of NPEs and, therefore, on their indirect impact on downstream innovation. About this last point, only a few studies delve into the analysis of the effects of NPEs' patent acquisitions on downstream innovation, and none of them makes a precise distinction between the various NPE business models. Abrams et al. (2019), among a series of theoretical and empirical analyses on NPE activities, document also a significant citation drop in after transfer periods of NPE-acquired patents. However, the main limitation of their empirical analysis is that it refers to the patent portfolio of only one single large NPE. Orsatti and Sterzi (2023) use an original database of US patents reporting patent acquisitions made by an extensive list of active NPEs (546 groups). They document two main empirical facts: first, patent assertion entities build large patent portfolios and contribute significantly to patent transfers in the US; second, their impact on follow-on innovation is, on average, negative. Moreover, they distinguish between large patent aggregators and small patent assertion entities, and they show that the estimated negative effect on follow-on innovation is mainly driven by patent acquisitions performed by large patent aggregators.

In this paper, we leverage an extensive list of more than 600 groups and 3,508 related subsidiaries defined as NPEs by experts in the patent litigation and licensing field (Clarivate-Darts-IP and Allied Security Trust) to appreciate the heterogeneity of their business model with respect to the characteristics and use they make of the patents they target in the market. Precisely, we ask the following two main research questions that did not receive much attention by previous studies:

RQ-2a: Are diverse patent acquisition strategies indicative of distinct business models employed by NPEs?

RQ-2b Are different NPE business models associated with different impact on downstream innovation?

3 Data

To assess the presence of NPEs in Europe and to investigate their patent acquisition strategies, we use and combine data from three different sources. First, we rely on two extensive proprietary lists of NPE names provided by Clarivate Darts-IP and AST.[7] Second, we employ the Bureau van Dijk's Orbis Intellectual Property Database (ORBIS IP) to retrieve information on European patents currently owned by business

[7] Please visit https://clarivate.com/darts-ip and https://www.ast.com/ for information about Clarivate Darts-IP and AST, respectively.

entities, distinguishing between first filings and acquired patents.[8] Third, we collect information on patent characteristics from the OECD Patent Quality Database, 2021 Version (Squicciarini et al., 2013) and PATSTAT (Version October 2019).

Furthermore, we complete our data collection with information on patent litigation cases initiated by NPEs in Europe, provided by Clarivate Darts-IP, in order to characterize NPE business models. Precisely, we collect information on EPO patents used in infringement actions initiated by NPEs in the six largest European jurisdictions (i.e. Germany, the UK, France, Italy, Spain and the Netherlands).

3.1 List of NPE names

In order to identify patent holders that are NPEs, we rely on an extensive list provided by Clarivate Darts-IP and AST.[9] The list includes all NPE groups, together with their subsidiaries. We double-check the list of NPEs names in order to exclude universities (and individuals), defensive patent aggregators (such as, for example, RPX), and we obtain an initial list of NPEs that consists of 652 NPE groups and 3,508 related subsidiaries.

The advantage of relying on the Clarivate Darts-IP and AST list of NPEs is twofold: first, NPEs have been identified as such by a group of IP specialists; second, it also includes small NPEs and subsidiaries ignored by previous studies and whose omission can lead to a substantial underestimation of the presence of NPEs in the patent market.

NPEs are defined by Clarivate Darts-IP as legal entities that "own or purchase patents filed by or granted to other companies or individual inventors without the intent of producing and/or commercializing the related products or processes".[10] This broad definition includes heterogeneous and, in some cases, too-distant business models. For this reason, with the aim of appreciating this heterogeneity, we further differentiate (in Section 6) NPEs into three categories: (i) *Portfolio NPEs*, that aggregate patent portfolios and negotiate licensing agreements; (ii) *Litigation NPEs*, that acquire patents frequently used in litigation activities; (iii) *Technology NPEs*, that mainly develop and commercialize their own patents.

3.2 NPE patent applications

In a second step, we rely on ORBIS IP to collect patent applications where NPEs appear to be the last owners of EPO and European patents. We thus perform a company name search on ORBIS IP for every single NPE group contained in the list of NPE names, together with their respective subsidiaries. The goal is to collect all

[8] The ORBIS IP database is a commercial database that provides economic and administrative data for more than 360 million companies and information on approximately 115 million patents worldwide, including publication information, ownership, industry, history of transfer, and opposition.
[9] We consider all NPE names from Clarivate Darts-IP and NPE groups from AST with more than 45 purchased US patents, corresponding to the top 90% of NPEs listed by patent portfolio size.
[10] A similar definition is also used by AST.

patent applications where an NPE turns out to be the last owner.[11] We limit our search strategy to patent applications filed at the EPO and in the following European national patent offices: Germany, France, Italy, Spain, the UK and the Netherlands. This cross-reference search between the initial list of 652 NPE group names and the ORBIS IP database leads us to identify 188 NPE groups that are the last owners of 31,713 patent documents (expired patents included). The most targeted patent office is the EPO, with 19,213 patent applications. In the subsequent analysis, we thus focus only on EP patents. However, NPEs also acquire a significant number of patents in Germany (where they result to be the last owners of 7,810 patents) while their presence in other patent offices is less relevant (see Table A2 in Appendix).

Together with the patent number, we collect extensive patent ownership data, along with details on patent acquisitions and transfers. Reconstructing patent ownership history can be challenging, and this is especially true for European patents. As pointed out by Ciaramella et al. (2017), identifying with precision the patents owned by NPEs, both at national patent offices and at the EPO, is a complex task for at least two main reasons. First, the EPO does not record patent reassignments after the patent is granted. Second, each national patent office operates according to a different legal framework with regard to both the obligation to register changes in patent ownership and to the categorization of these patents, with the effect that some NPEs keep the transactions secret and avoid registering the ownership change with the patent office (Sterzi et al., 2021). However, ORBIS IP makes up for the first shortcoming, as it gathers information from diversified data providers and sources, and applies the ownership changes to the entire patent family whenever this information is available.[12] This means that, after the granting, we do observe a transfer related to an EPO patent whenever in its patent family a patent has been transferred, and its transaction has been recorded at the national patent office.[13]

As we focus on patent acquisitions, in order to remove false transactions, we exclude transactions that ORBIS IP identifies as “Intra-company” and “Others”. In addition, we also develop an algorithm to further remove residual incorrect transactions, given that sometimes ORBIS IP does not accurately identify intra-company transactions, or that the information on the transaction type is missing.[14]

In summary, our database contains all patent applications filed at the EPO whose last owner is an NPE. These patents come with their complete ownership history and information concerning their specific features, such as the relative technological field of application and quality characteristics.

[11] The match has been performed automatically by ORBIS IP but we checked manually the accuracy of the match.

[12] The possibility of exploiting patent transaction details is a recent implementation in ORBIS IP (https://www. bvdinfo.com).

[13] To reassure the reader about the quality of the data, we have taken 30 random patents from our list of NPE- acquired patents and we have checked whether the same reassignments were reported on Google Patent Search. We observed a discrepancy in only two cases.

[14] Section 7.1 in the Appendix describes the process of identification of patent transfers.

3.3 The NPE-EPO database: Key figures

3.3.1 Quantifying the presence of NPEs in Europe

Our final dataset consists of 19,213 patent applications ("patents" hereafter) filed at the EPO. These patents specifically belong to NPEs, and we identify a total of 176 NPEs that hold at least one patent.[15] Since a patent can be owned simultaneously by more than one NPE, our database includes 19,323 NPE-patent pairs.

Consistent with prior research, most patents held by NPEs are concentrated in the ICT sector. Based on the macro IPC patent classification (WIPO, 2020), which consists of eight classes, Electricity (60%) and Physics (23%) emerge as the two predominant technological domains in which NPEs are active.[16]

It is worth to notice that in this paper we focus on European patents, which do not always cover European inventions. In fact, some of the identified patents owned by NPEs can be part of international families in which the same invention has also been patented outside Europe. We observe that about 50% of the patents filed in the last decade have no inventors residing in Europe (see Figure A1 in Appendix). Furthermore, in some cases the original application is not an application filed at the EPO: in our data, 26.6% of NPE-patents have a US priority application.

Our data also show that about 60% of identified NPE patents were first filed, rather than acquired, by NPEs. This can be explained by three factors. First, our definition of NPEs includes entities that invest in R&D. Second, in certain instances, NPEs might acquire companies that continue to operate as subsidiaries within the NPE group. In such cases, the NPEs may decide not to register at the patent office the change of ownership of the patents of the acquired firm. Consequently, these acquired companies still appear as the current owners of the patents in our database. As a result, we categorize these patents as initially filed by NPEs since we identify the acquired companies as subsidiaries of NPEs. Third, some patents are in families where the priority is a US patent application. In this case, it is likely that the NPE acquired the US patent prior to its extension to the EPO.

Figure 1 shows the total number of EPO patents where an NPE is the last owner by calendar year. This corresponds to either the transaction year if the patent changed ownership to an NPE, or to the priority year if the patent was filed by an NPE. Although we observe that the majority of NPE patent portfolios consists of patents directly filed by NPEs, since 2010 the number of patents acquired by NPEs has increased significantly, while the number of first filings has remained stable, indicating an increasing attention of NPEs towards the European patent market.

By focusing only on transacted patents in the years 2010-2019,[17] we identify 6,727 patents acquired by

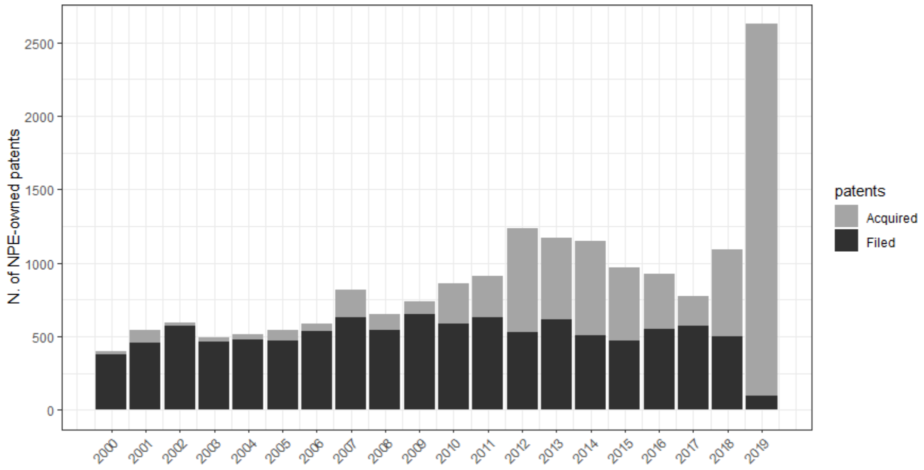
[15] Twelve NPEs in our list do not hold any EPO patents in their portfolios, but only patents granted by national European patent offices. For a comprehensive account of the selection process used to finalize the analysis of 176 NPE groups, please refer to Section 7.1 in Appendix.

[16] Table A3 in Appendix reports, for each macro technological area, the number and the share of EPO patents owned by NPEs.

[17] We anticipate here a result based on the data regarding all transactions of EP patents that we present in Section 5.

NPEs, which correspond to about 3% of all transacted patents in the same period.[18] By further restricting the sample to the Electrical Engineering field,[19] our data show that NPEs acquire about 8.7% of the transacted patents, with peaks above 15% in 2014 and 2019 (see Figure A2 in Appendix).

Figure 1: Distribution of NPE-owned EPO patents: number of filed and acquired patents by calendar year



The figure plots the distribution of EPO NPE-owned patents by calendar year, which correspond to the acquisition year for acquired patents (in light gray) and to the priority year for filed patents (in dark gray).

3.3.2 Identifying Top NPEs and the sources of their patents

The NPE patenting activity in Europe is largely driven by a few large groups: the CR4 concentration index is approximately 50% and the 10 largest NPEs account for over 75% of the total. Table 1 displays the top 30 NPEs by patent portfolio size, reporting for each NPE the percentage of litigated patents in the portfolio.[20]

The significant concentration can be largely attributed to Interdigital's acquisition of the Technicolor patent portfolio (as discussed in Section 2). Other NPEs with large portfolios (more than 1,000 EPO patents) are Dolby Laboratories, Xperi, Provenance Asset Management, and Intellectual Ventures.

NPEs enter the European patent market in different ways. While some NPEs—as it is the case, for example, of Yeda R&D Company—build their portfolios (almost) exclusively on first filings, other NPEs—such as Form Holdings, France Brevets and PanOptis Holdings—acquire most of their patents in the secondary market.

[18] Using similar data on NPEs and looking at the US context since the early 2000s we find that the number of patents filed at the USPTO between 1990 and 2010 and purchased by NPEs between 2000 and 2015 is 31,484, around 4% of all US patents filed and transacted over the same time span.

[19] The Electrical Engineering field includes the following sectors: Electrical machinery, apparatus, energy; Audio-visual technology; Telecommunications; Digital communications; Basic communication processes; Computer technology; IT methods for management; Semiconductors.

[20] In what follows, since a patent application can be owned by more than one NPE group at the same time (for example, we identify in our database 14 patent applications simultaneously owned by both Acacia Research and Optimum Power Technology, 51 patents owned by both Inception Holdings and PanOptis, 8 patents owned by both Sonrai Memory and Gerald Padian, 36 patents owned by both Tq Delta and Techquity Capital Management, and one patent owned by both Finjan and Fortress Investment Group) our unit of analysis will be the patent-NPE group pair.

Table 1: Top 30 NPEs per patent portfolio size (EPO): number of patents in portfolio, share over total patents belonging to NPEs, and proportion of litigated patents in each NPE portfolio

	NPE Group	Tot. portfolio	% over tot.	Cum. of portfolio	% Cum.	% acquired	% litigated
1	Interdigital	5,569	28.82 %	5,569	28.82 %	39.74 %	0.00 %
2	Dolby Laboratories	1,545	8.00 %	7,114	36.82 %	10.87 %	0.13 %
3	Xperi	1,406	7.28 %	8,520	44.09 %	36.49 %	0.57 %
4	Provenance Asset Group	1,192	6.17 %	9,712	50.26 %	78.86 %	0.00 %
5	Intellectual Ventures	1,072	5.55 %	10,784	55.81 %	51.77 %	0.56 %
6	Michael Gleissner	1,062	5.50 %	11,846	61.31 %	17.51 %	0.00 %
7	Yeda R&D Company	934	4.83 %	12,780	66.14 %	1.39 %	0.21 %
8	Panoptis Holdings	821	4.25 %	13,601	70.39 %	82.22 %	0.97 %
9	Quarterhill (Wilan)	569	2.94 %	14,170	73.33 %	55.36 %	0.53 %
10	Rambus	503	2.60 %	14,673	75.94 %	14.12 %	0.00 %
11	Mosaid Technologies	470	2.43 %	15,143	78.37 %	54.04 %	1.49 %
12	Universal Display	455	2.35 %	15,598	80.72 %	36.04 %	0.00 %
13	Sisvel	317	1.64 %	15,915	82.36 %	74.13 %	3.15 %
14	Global Oled Technology	284	1.47 %	16,199	83.83 %	51.06 %	0.00 %
15	Pendrell	234	1.21 %	16,433	85.04 %	52.14 %	0.00 %
16	Ipcom	195	1.01 %	16,628	86.05 %	48.72 %	8.21 %
17	Innovative Sonic	189	0.98 %	16,817	87.03 %	12.17 %	0.00 %
18	Rockstar Consortium	163	0.84 %	16,980	87.87 %	92.64 %	0.00 %
19	Virginia Tech IP	160	0.83 %	17,140	88.70 %	8.75 %	0.00 %
20	France Brevets	124	0.64 %	17,264	89.34 %	84.68 %	2.42 %
21	Flagship Ventures 2004 Fund	121	0.63 %	17,385	89.97 %	0.83 %	0.00 %
22	Acacia Research	104	0.54 %	17,489	90.51 %	29.81 %	6.73 %
23	Intellectual Discovery	100	0.52 %	17,589	91.03 %	67.00 %	0.00 %
24	Fractus	88	0.46 %	17,677	91.48 %	3.41 %	1.14 %
25	Gerald Padian	81	0.42 %	17,758	91.90 %	96.30 %	0.00 %
26	Invue Security Products	71	0.37 %	17,829	92.27 %	4.23 %	0.00 %
27	Form Holdings	69	0.36 %	17,898	92.63 %	91.30 %	5.80 %
28	Seven Networks	68	0.35 %	17,966	92.98 %	14.71 %	0.00 %
29	Uniloc	61	0.32 %	18,027	93.29 %	19.67 %	3.28 %
30	Key Patent Innovations	59	0.31 %	18,086	93.60 %	45.76 %	0.00 %
Total		18,086	-	-	-	-	-

The sample consists of 19,323 pairs of EPO patent applications and 176 NPE groups.

Table 2: Top 30 NPE transactions per number of EPO patents

	Vendor Company	**Vendor country**	**Acquirer Company (NPE Group)**	**Acquirer country**	**N. EPO transacted patents**
1	Technicolor	FR	Interdigital	US	2,002
2	Alcatel Lucent	FR	Provenance Asset Group	US	557
3	Ericsson	SE	Panoptis Holdings	US	431
4	Nokia	FI	Mosaid Technologies	CA	201
5	United Video Properties	US	Xperi	US	160
6	Eastman Kodak Company	US	Global Oled Technology	US	145
7	Alcatel	FR	Provenance Asset Group	US	114
8	Nortel Networks	CA	Rockstar Consortium	CA	111
9	Lucent Technologies	US	Provenance Asset Group	US	104
10	Matsushita Electric Industrial	JP	Panoptis Holdings	US	103
11	Robert Bosch	DE	Ipcom	DE	87
12	Nokia	FI	Provenance Asset Group	US	86
13	Siemens	DE	Quarterhill Aka Wilan	CA	86
14	Basf	DE	Universal Display	US	67
15	Orange	FR	Sisvel	IT	67
16	Philips	NL	Pendrell	US	65
17	Fujifilm Corporation	JP	Universal Display	US	64
18	Nokia	FI	Form Holdings	US	60
19	Rovi Guides	US	Xperi	US	59
20	Daewoo Electronics	KR	Quarterhill Aka Wilan	CA	58
21	Ericsson	SE	Interdigital	US	51
22	Nokia	FI	Provenance Asset Group	US	50
23	Ericsson	SE	Panoptis Holdings	US	47
24	Nxp	NL	Intellectual Ventures	US	45
25	Infineon Technologies	DE	Quarterhill Aka Wilan	CA	43
26	Nokia	FI	Sisvel	IT	43
27	Daewoo Electronics	KR	Quarterhill Aka Wilan	CA	41
28	Starsight Telecast	US	Xperi	US	39
29	Verimatrix	FR	Rambus	US	39
30	Micron Technology	US	Round Rock Research	US	37
Total		-	-	-	5,062

The sample consists of 7,607 patent applications acquired by 176 NPE groups. If a patent is jointly owned by two NPEs, it is counted twice.

Our data on patent acquisitions show that NPEs tend to buy relevant stacks of patents mainly from large firms that sell considerable portions of their patent portfolios (Table 2 reports the top 30 EPO patent transactions with an NPE as the acquirer).

Contrary to common thinking, small firms and individual inventors represent only a tiny share of vendors. Furthermore, most of the transactions concern European companies selling their patents to North American NPEs, mainly US-based.[21]

Lastly, we observe a significant heterogeneity in the propensity to litigate in Europe. Some NPEs—such as IPCom, Acacia Research Company and Form Holdings—litigate their patents with relative high intensity (more than 5% of their portfolio consists of patents asserted in infringement cases). Other NPEs, instead, do not litigate at all in Europe. This could be because their patent acquisitions are too recent or because their business model diverges substantially from the mainstream view of NPEs as aggressive entities constantly involved in patent litigation.

4 Quality and breadth of NPE-acquired patents

In this section, we investigate NPE patent acquisition strategies, with the aim of shedding light on research questions 1a and 1b proposed in Section 2. We focus on the subset of transacted patents and we complement our database of NPE patent acquisitions by including patents acquired by entities other than NPEs that we label as practicing entities (PEs). Data on patent transactions are from ORBIS IP and have been further cleaned in order to remove false transactions, that is, intra-company transactions and changes of name.[22] For each patent history, we consider only the most recent acquisition. We then restrict the analysis to patents filed between 1995 and 2015 and transacted between 2010 and 2020, which corresponds to the period in which NPEs acquire most of their patents.[23] Our final dataset comprises 203,927 transacted patents, of which 6,378 are patents acquired and currently owned by NPEs (3.1% of all transacted patents in our sample). NPEs are mostly active in Electrical Engineering, where they acquired 5,859 patents (8.8% of all patents traded in that field over the period analyzed).

A key issue when it comes to NPE patent acquisitions and litigation is patent quality because their impact on innovation significantly changes if they target low-quality rather than promising and high-quality technologies. We thus focus on the two following patent characteristics: patent quality and patent breadth. We proxy patent quality with the number of forward citations (calculated over 5-year time windows since publication), and patent breadth with patent scope, measured by the number of four-digit International Patent Classification (IPC) classes assigned to the invention (Lerner, 1994). Precisely, our two variables of interest are:

[21] Table 2 also shows that, occasionally, the transactions identified in our sample are not proper market transactions, but merely changes in company names that our algorithm is unable to capture, such as the case of Rovi Guides transferring to Xperi 59 EPO patents.

[22] For a detailed description of the intra-company transactions and the identification of name changes, see Appendix 7.1.1.

[23] We exclude patents filed later than 2015 because we use the number of forward citations received in a five-year window after patent publication as a proxy of the technological quality of the protected invention.

1. *Five-year Citations*: the number of times a given patent is cited by other patent documents in the five years after its publication. Patent citations are included in the patent document to delimit the scope of the property right. At the EPO, citations are added by both the patent applicant and the patent examiner during the examination process. Known as "forward citations", citations received by a patent imply that the invention protected by the patent is being used for the creation of new inventions. Hence, it is common to consider a patent that receives a large number of citations to be of high technological quality. Forward citation counts presented here take into account patent equivalents (patent documents protecting the same invention at several patent offices).

2. *Patent Scope*: the number of distinct four-digit sub-classes of the International Patent Classifications (IPC). Broad-scope patents are more likely to be infringed and litigated (Merges and Nelson, 1990; Lerner, 1994) and can be exploited for rent-seeking purposes by NPEs (Fischer and Henkel, 2012; Sterzi et al., 2021).

Other patent characteristics are also expected to correlate with the probability of an NPE patent acquisition. Therefore, we include the following control variables in the empirical analysis:

- *Age* measures the age (in years) of the patent from filing to acquisition. NPEs buy patents for reasons different than producing companies; for example, they acquire from inventors who failed to exploit and monetize their inventions, or target technologies that are no longer useful for developing or commercializing new products. Consequently, NPEs are expected to acquire patents later in their patent life compared to practicing entities.

- *Family size* is computed as the number of patent offices in which the same invention obtained a patent grant. This variable controls for the possibility that the original invention is protected also in patent offices other than EPO. Since most of NPEs in the sample are not European, Family size is expected to be positively correlated with NPE patent acquisition.

- *Claims* is the number of patent claims. It is a proxy of the legal sustainability of the patent (Lanjouw and Schankerman, 1999; Reitzig, 2003), since a patent with a large number of claims has, on average, a greater chance of at least one claim surviving an invalidation procedure. Since NPEs acquire patents that can be frequently challenged in courts, this variable is expected to be positively correlated with NPE patent acquisition.

- *Backward citations* is computed as the number of patent citations made by the focal patent. This variable measures the number of protected technologies the focal patent relies on in terms of prior art (Sampat and Ziedonis, 2004; Ziedonis, 2004).[24]

[24] The number of backward citations has also been used as a measure of the scope of the patent (e.g. Harhoff et al., 2003). However, this correlation vanishes as we include the variable "patent scope" in the regression analysis.

- *Non-Patent Literature citations* (NPL dummy) indicates whether the focal patent cites non- patent literature (e.g. scientific publications). It is considered a proxy for the proximity of the patent to science (Meyer, 2000; Narin, 1987; Narin et al., 1987).
- Moreover, we include (i) filing year dummies, to control for cohort effects, and (ii) technology dummies to control for technology-specific effects.[25]

Table 3: Summary statistics (mean values)

	Practicing Entity (PE)	NPE	Mean difference	P-value
Age	8.80	10.87	-2.07	0.00
5-Year Citations	1.03	1.45	-0.42	0.00
Patent Scope	1.92	1.84	0.08	0.00
Family Size	6.47	6.35	0.12	0.05
Claims	13.37	14.19	-0.82	0.00
Backward Citations	6.65	4.50	2.15	0.00
NPL (dummy)	0.30	0.47	-0.18	0.00
Electrical Engineering	0.31	0.92	-0.61	0.00
Observations	203,927	63,788		

The sample consists of EPO patent applications filed 1995-2015 and acquired by either NPEs or PEs over the period 2010-2020. Only the last recorded transaction is accounted in the statistics; p-values are computed from the two-sample t-test statistics for differences in means.

Table 3 reports the summary statistics of the variables used in the analysis, distinguishing between patents acquired by NPEs and patents acquired by PEs, along with the mean differences between these two groups and the p-values of the corresponding t-test statistics. We observe significant differences between the two groups for all variables used, confirming the findings reported in extant studies (Fischer and Henkel, 2012; Leiponen and Delcamp, 2019).

On average, patents acquired by NPEs receive more citations than patents acquired by PEs in the first five years since publication (five-year Citations). However, the former show fewer possible technological fields of application (Patent Scope) than the latter. Moreover, NPE-acquired patents are on average older (Age), closer to science (NPL dummy), have fewer family members (Family Size) and cite fewer extant patents (Backward Citations). We also find significant differences with respect to technology field and cohort between the two groups of acquired patents. Precisely, NPEs acquire 92% of their patents in Electrical Engineering (only 31% for PEs), and NPE-acquired patents are, on average, two years older than patents acquired by PEs.

[25] We follow the WIPO taxonomy and consider 35 unique technology fields.

4.1 Econometric analysis

Differences in the patent quality reported in Table 3 might reflect distribution differences between the two groups across technological domains and years of filing and acquisition. In order to address this issue, we estimate a series of linear probability models (LPMs) and logit models, where the dependent variable takes value 1 when the patent is acquired by an NPE, 0 when it is acquired by a PE. We report the results of this analysis in Table 4.

Since our dependent variable is strongly unbalanced (i.e. the share of NPE-acquired patents in the sample is about 3%), logit models should be preferred over LPMs. Moreover, in order to better deal with the potential problem of low-frequency or rare events in matched samples affecting the standard maximum likelihood estimation (King and Zeng, 2001), we follow three additional strategies. First, in Column 3 we estimate the model only for patents in Electrical Engineering, where NPEs acquire about 9% of all transacted patents. Second, in Columns 4 and 5 we match the sample of patents acquired by NPEs with two distinct control groups of patents acquired by PEs. Precisely, in Model 4 each NPE-acquired patent is randomly matched to a control group of at most two patents acquired by PEs that are classified in the same technological field (WIPO 35 classes) and filed in the same year. In Model 5 we impose the additional condition that the patents in the control groups must be acquired in the same year as those acquired by NPEs to enter the sample. The advantage of relying on matched control groups of patents is that it also decreases the influence of potential confounding factors, as we control not only for the linear terms of the covariates, but also for any arbitrary combination of them. Third, we estimate rare events logit models with the Firth logit approach, which is a penalized likelihood method taking into account the low shares of 1 in the outcome variable (Firth, 1993).[26]

Finally, since in our analysis we focus only on transacted patent applications, our econometric results might suffer from selection bias if the probability of being transacted differs between patents attractive to NPEs and those attractive to PEs. To control for this possible bias, we follow Fischer and Henkel (2012) and estimate a selection equation to compare transacted and non-transacted patent applications (Heckman, 1979). Precisely, for every transacted patent resulting from the previous matching procedure (where every NPE-acquired patent was matched to a PE-acquired patent in the same technological field, transferred and filed in the same year, corresponding to the sample reported in Column 5, Table 4), we randomly select up to three non-transacted patents in the same technological field, filed in the same year and active (i.e. pending or granted) in the year of transaction of the matched transacted patent. Then, for each transacted patent, the instrument included in the selection equation (but excluded from the outcome equation) is a dummy that is equal to 1 if the patent was already granted at the time that it was acquired, and 0 otherwise; for the patent in the control group, the same dummy is equal to 1 if it was granted when its matched patent was acquired. The rationale of this instrument is that this variable should have an influence on the probability of the patent being transacted (selection

[26] Results are available upon request from the authors.

equation), as the patent grant reduces the uncertainty about the value of the legal right (Gans et al., 2008), but it should not have any influence on the type of buyer (outcome equation) since NPEs can also use patents that are still pending to seek settlement payments (Fischer and Henkel, 2012).

Table 4: NPE-patent acquisition. Baseline estimation (marginal effects)

	(1) LPM-OLS	(2) LOGIT	(3) LOGIT Electrical Eng.	(4) LOGIT Matched Sample 1	(5) LOGIT Matched Sample 2	(6) Sample Selection PROBIT
Age	0.0022***	0.0020***	0.0068***	0.0168***	-0.0010	0.0013
	(0.0001)	(0.0001)	(0.0004)	(0.0012)	(0.0014)	(0.0009)
5-year Citations (ln)	0.0037***	0.0022***	0.0061***	0.0196***	0.0143**	0.0123***
	(0.0007)	(0.0006)	(0.0017)	(0.0052)	(0.0058)	(0.0036)
Patent scope (ln)	0.0011	-0.0001	-0.0072**	-0.0011	0.0030	0.0023
	(0.0011)	(0.0012)	(0.0036)	(0.0113)	(0.0124)	(0.0076)
Family size (ln)	0.0099***	0.0121***	0.0404***	0.1050***	0.1052***	0.0839***
	(0.0006)	(0.0008)	(0.0023)	(0.0072)	(0.0081)	(0.0066)
Claims (ln)	0.0001	0.0006	0.0023	0.0121**	0.0146**	0.0012
	(0.0006)	(0.0006)	(0.0017)	(0.0054)	(0.0058)	(0.0038)
Backward Citations (ln)	-0.0074***	-0.0060***	-0.0177***	-0.0484***	-0.0358***	-0.0183***
	(0.0007)	(0.0007)	(0.0020)	(0.0065)	(0.0070)	(0.0049)
NPL (dummy)	0.0122***	0.0062***	0.0138***	0.0463***	0.0594***	0.0403***
	(0.0012)	(0.0008)	(0.0024)	(0.0074)	(0.0081)	(0.0058)
Observations	190,357	190,357	61,847	18,176	15,054	54,941
R^2 (Pseudo R^2)	0.0952	(0.2777)	(0.1222)	(0.0302)	(0.0188)	

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The dependent variable takes value 1 if the patent buyer is an NPE, 0 if the buyer is a PE. All variables—except patent Age and the dummy NPL—are augmented by 1 and log-transformed. The constant term in the models is included but not reported. Marginal effects are computed at the mean values. In Model (4) each patent acquired by an NPE is randomly matched to a control group of (up to two) patents acquired by practicing companies that are classified in the same technology field (WIPO 35 classes) and have been filed in the same year. In model (5) we impose the additional condition that the control patents must be acquired in the same years as patents acquired by NPEs. Model (6) reports the estimated marginal effects from the sample selection probit; 15,054 selected patents, 39,887 non-selected patents; estimated coefficients of the selection equation are reported in Appendix, Table A4.

Table 4 reports the baseline results of our analysis, expressed as marginal effects at the mean values. With a few exceptions, results are consistent across models. In particular, the probability of a patent acquisition by an NPE increases with the technological patent quality, proxied by the log-transformed number of five-year forward citations: marginal effects reported in Model 2 show that for a 1% increase in the number of forward citations, the probability of a patent being acquired by an NPE (rather than acquired by a practicing company) increases by 0.2%. Conversely, Patent scope does not correlate with the probability of an NPE patent acquisition. This result is not consistent with extant literature (Fischer and Henkel, 2012; Sterzi et al., 2021). One reason for this result might be the heterogeneous sample of NPEs used in our analysis, which encompasses not only litigious NPEs (as commonly studied) but also patent aggregators and technology companies. We investigate the business model heterogeneity of NPEs in Section 5.

When we use the matched sample, in which we impose the condition that both NPE-acquired and PE-acquired patents belong to the same technology (i.e. same WIPO 35 class), to the same cohort (i.e. same year of first filing) and are transacted in the same year (Column 5), we estimate stronger marginal effects of patent technological quality (0.014) than before. Lastly, the sample selection probit model[27] (Column 6) yields qualitatively the same results as the Logit models based on matched samples.[28]

Overall, the coefficient for technological patent quality is positive and significant, although it is found to be lower than in Fischer and Henkel (2012), where the estimated marginal effect is almost three times larger than in our sample (0.049). We thus answer positively to RQ-1a. However, with respect to RQ-1b, our results suggest that the probability of an acquisition by an NPE does not necessarily increase with patent scope.

4.2 Robustness checks

Results reported in Table 4 suggest that on average NPEs target patents with higher intrinsic technological quality compared to practicing companies, when quality is proxied by the number of citations received by the patent in a fixed five-year window since publication. This result points to a positive role played by NPEs in the patent market. However, NPEs are often accused of buying old technologies that are no longer useful for developing new inventions and commercializing new products. In this respect, the number of citations a patent receives at the beginning of its life might not be indicative of the actual usefulness of the invention at the time of acquisition.

In this section, we thus investigate whether NPEs target patents that are highly used at the time of the acquisition. We consider a citation received by a patent in a given year as evidence that the knowledge embodied in the patent has been exploited somehow to generate a recent invention.

Therefore, the higher the number of citations received around the patent acquisition, the higher the present usefulness of the patent for other innovators at the time it changes ownership. We proxy the usefulness of the patent at the time of the acquisition with the number of citations received in the two (or, alternatively, three) years before the transaction.[29] Data on patent citations are from PATSTAT.[30] While fixed windows of five-years since publication proxy for the intrinsic technological quality of a protected technology, the number of citations computed close to the transaction date captures the extent to which the patent is used *at the time of the acquisition*.

Results are reported in Table 5 and are based on the matched sample where patents acquired by NPEs are exactly matched to patents acquired by practicing companies on (i) technological field, (ii) filing year, and (iii)

[27] We use the STATA command "Heckprobit".
[28] Results of the selection equation are reported in the Appendix in Table A4.
[29] To compute the number of citations received before the transaction, we restrict the analysis to patents transacted at least three years after filing.
[30] Since we use the October 2019 version of PATSTAT, we exclude patents transacted after 2018 from the analysis. We consider only EP-to-EP citations.

transfer year.

Table 5: NPE-patent acquisition. Patent quality (marginal effects)

	(1) LOGIT Matched Sample 2 Age>2	(2) LOGIT Matched Sample 2 Age>2	(3) LOGIT Matched Sample 2 Age>2
Age	-0.0014	0.0013	0.0011
	(0.0022)	(0.0023)	(0.0022)
5-year Citations (ln)	0.0196***		
	(0.0044)		
2-yr Cit. before acquisition (ln)		0.0384***	
		(0.0074)	
3-yr Cit. before acquisition (ln)			0.0330***
			(0.0062)
Patent scope (ln)	0.0199	0.0199	0.0197
	(0.0144)	(0.0144)	(0.0144)
Family size (ln)	0.1195***	0.1192***	0.1189***
	(0.0096)	(0.0095)	(0.0096)
Claims (ln)	0.0370***	0.0384***	0.0377***
	(0.0068)	(0.0067)	(0.0067)
Backward Citations (ln)	-0.0036	-0.0038	-0.0041
	(0.0085)	(0.0085)	(0.0085)
NPL (dummy)	0.0668***	0.0674***	0.0674***
	(0.0096)	(0.0096)	(0.0096)
Observations	10,497	10,497	10,497
Pseudo R^2	0.0255	0.0260	0.0261

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The sample is the same used in Table 4, Column 5, where each patent acquired by an NPE is randomly matched to a control group of (up to two) patents acquired by practicing companies that are classified in the same technology field (WIPO 35 classes), have been filed in the same year (i.e. patents in the same cohort) and have been acquired in the same year. The only difference is that we consider only transactions occurring at least three years after the filing date. The variable "2-yr Cit. before acquisition" refers to the number of citations received in the two years before the acquisition year, while the variable "3-yr Cit. before acquisition" refers to the total number of citations received in the three years before the acquisition year. Data on forward citations are from PATSTAT, version October 2019 (therefore, we excluded patents that changed ownership after 2018). The dependent variable takes value one if the patent buyer is an NPE, zero if the buyer is a PE. All variables—except patent Age and the dummy NPL—are augmented by one and log-transformed. The constant term is not reported. Marginal effects are computed at the mean values.

Logit results show that patents acquired by NPEs receive a higher number of citations than patents acquired by PEs not only in the first five years since filing (model 1), but also in the two (model 2) or three years (model 3) before the transfer. The estimated marginal effect of the number of citations in the two or three years before the transaction is about 0.038, meaning that, for a 1% increase in the number of forward citations, the probability of a patent being acquired by an NPE (rather than a PE) increases by 3.8%. This suggests that NPEs on average target high-quality patents that are actively used around the time of the acquisition.

5 NPE business model heterogeneity

Overall, our results point to a positive role of NPEs in the patent market as they acquire, on average, highly cited patents. How do our results reconcile with other studies that find NPEs acquiring and asserting weak patents? We argue that the mixed empirical evidence on the impact of NPEs on innovation can be explained by the different definitions and samples of NPEs used in extant studies. With few exceptions, most of the literature has considered NPEs as a homogeneous group. However, NPEs encompass various types of entities with distinct business models, all of which share the common trait of not practicing their patents.

We build upon previous studies to propose a taxonomy of NPEs, and we use this taxonomy to analyze the NPE heterogeneity with respect to the characteristics and use of targeted patents.

5.1 NPE taxonomy

Extant studies have reported evidence of a fit between NPEs business models and their patent acquisition strategies. For example, Leiponen and Delcamp (2019) analyze the characteristics of four types of NPE licensing models: independent patent licensing companies, patent aggregators, technology development firms, and NPEs affiliated with practicing companies. They find high heterogeneity in terms of propensity to litigate, and in the age and the quality of acquired patents. In our analysis, we extend their work by relying on a larger sample of NPEs and proposing a taxonomy based on two main observable dimensions: (i) the proportion of litigated patents and (ii) the proportion of acquired patents in their patent portfolio. We thus distinguish three types of NPEs based on their relative position in with respect to these dimensions. In particular, we argue that a high litigation rate is associated with NPEs that are particularly aggressive and litigious (*Litigation NPEs*).[31] Among non-litigious NPEs, we then distinguish between *Technology NPEs*, whose patent portfolios are largely built on patents filed (rather than acquired)—these NPEs invest in R&D and develop and commercialize their own patents—and *Portfolio NPEs* that, on the contrary, aggregate different extant patent portfolios. Our definitions of *Litigation NPEs*, *Portfolio NPEs* and *Technology NPEs* closely correspond, respectively, to the three categories "Independent licensing companies", "Patent aggregators" and "Technology development firm" proposed by Leiponen and Delcamp (2019).

We assign the 176 NPEs in our sample to one of the three types of business models described above depending on their relative position in the distribution of the two variables considered. Figure 2 provides a graphical visualization of the NPE taxonomy proposed, according to the percentage of litigated patents (x-axis) and the percentage of acquired patents (y-axis). The lines forming the quadrant are drawn according to the average values of the two variables (2.47% and 32.52%, respectively). We therefore distinguish between:

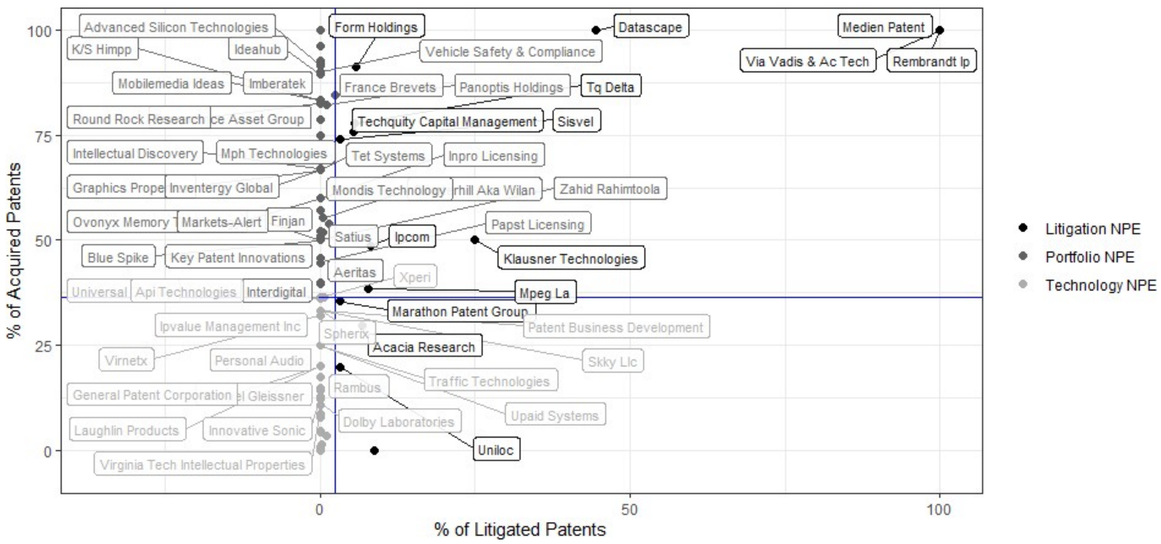
- *Litigation NPEs*: NPEs with a percentage of litigated patents in their portfolio exceeding the average (2.46%). They populate the right-hand side of Figure 2.
- *Portfolio NPEs*: NPEs with a percentage of acquired patents in the portfolio exceeding the average

[31] If it is not true that all aggressive NPEs need to litigate a high share of their patents, it is difficult to consider not aggressive those that litigate intensively in court. Data on licenses would be particularly useful to detect aggressive NPEs that do not litigate their patents at high rates, but unfortunately this information is confidential in most of the cases.

(36.32%) and with a percentage of litigated patents lower than the average. They populate the top left side of Figure 2.

- *Technology NPEs*: residual category including NPEs with a percentage of both acquired and litigated patents below the average. They populate the bottom left side of Figure 2.

Figure 2: NPEs' taxonomy by acquisition and litigation propensity



The vertical line and the horizontal line are drawn, respectively, at the mean of the percentage of litigated patents in portfolio on the x-axis and at the mean of the percentage of acquired patents in portfolio on the y-axis. Mean of the percentage of litigated patents = 2.47. Mean of the percentage of acquired patents = 36.52.

Table 6: Top five NPEs per acquired patents by type of business model

	NPE Group	N. acquired patents	N. patents in portfolio	NPE Type
1	Sisvel	235	317	Litigation NPE
2	Ipcom	95	195	Litigation NPE
3	Form Holdings	63	69	Litigation NPE
4	Acacia Research	31	104	Litigation NPE
5	Techquity Capital Management	28	37	Litigation NPE
6	Interdigital	2,213	5,569	Portfolio NPE
7	Provenance Asset Group	939	1,192	Portfolio NPE
8	Panoptis Holdings	675	821	Portfolio NPE
9	Intellectual Ventures	555	1,072	Portfolio NPE
10	Quarterhill Aka Wilan	315	569	Portfolio NPE
11	Xperi	513	1,406	Technology NPE
12	Michael Gleissner	186	1,062	Technology NPE
13	Dolby Laboratories	168	1,545	Technology NPE
14	Universal Display	164	455	Technology NPE
15	Rambus	71	503	Technology NPE

The table shows the five largest NPEs by number of acquired patents for each type of NPE.

Table 6 reports the names of the five largest NPEs, by type of business model and size of patent portfolio.

Table 7 reports the number of NPEs, the total number of patents in the portfolio and the total number of acquired patents, by type of business model.

Table 7: Total number of patents, number of acquired patents and number of NPEs by NPE type

NPE Type	N. patents	N. acquired patents	N. NPEs per type	Average portfolio size
Litigation NPE	916	235	15	61.07
Portfolio NPE	11,123	2,213	62	179.40
Technology NPE	7,284	168	99	73.60
All NPEs	19,323	2,616	176	109.79

The table shows the number of patents, the number of NPE groups and the average portfolio size by NPE type.

As discussed in Section 2, we investigate whether different NPE business models are correlated with different patent acquisition strategies (RQ-2a), and whether different NPE business models exhibit heterogeneous associations with follow-on innovation around targeted patents (RQ-2b).

5.2 NPE business model and patent acquisition strategies

With respect to RQ-2a, extant studies stress that NPEs that assert patents as their core business target mainly weak patents that protect technologies no longer useful neither to develop new inventions nor to commercialize related products. Therefore, it is likely that *Litigation NPEs* target patents with a high probability of being infringed, while technological quality plays a less important role in the choice of the patent to purchase (or even a negative role when high-quality patents are particularly expensive). Conversely, *Technology NPEs* differ from the other types of NPEs in the way they have access to technological capabilities. In particular, since *Technology NPEs* file a large share of their patents (instead of acquiring patents in the market) it is likely that they target high-quality patents to complement their patent portfolios (Leiponen and Delcamp, 2019). Similarly, NPEs that aggregate patent portfolios without aggressively litigating in courts (*Portfolio NPEs*) are expected to target valuable patents, since their main business consists in maximizing licensing fees.

Our goal is to estimate the probability that a patent will be acquired by one of the three types of NPEs, rather than acquired by a PE. Therefore, we estimate a Multinomial Logit model whose reference category is a PE patent acquisition. Table 8 reports the estimated coefficients (and associated standard errors in parenthesis) calculated as relative risk ratios (RRR). An estimated RRR > 1 for a variable of interest indicates that the risk of an NPE category acquiring a patent compared to the risk of a PE acquiring a patent (the reference group) increases as the variable of interest increases. An estimated RRR < 1 indicates the opposite. The sample used to perform this analysis is the same of Table 5, formed by matched pairs of NPE-acquired and PE-acquired patents (control group) on filing year, transaction year and technology.

Referring to Model 1, we estimate a positive and significant coefficient of technological quality for *Technology NPEs* and for *Portfolio NPEs*. Precisely, the RRR for a one-unit increase in the number of citations (computed in the 5-year window since filing) is 1.12 when the patent is acquired by a *Technology NPE,* and 1.11 when it is acquired by a *Portfolio NPE*. This means that these two types of NPEs are more likely to target patents more cited than patents targeted by PEs. We estimate similar coefficients for the number of citations received by the patent at the time of its acquisition (2-yr and 3-yr Cit. before acquisition): both *Technology NPEs* and *Portfolio NPEs* acquire patents highly cited in the first 5 years since filing and around the transaction year.

Conversely, technological quality does not correlate with the likelihood that the patent buyer is a *Litigation NPE*. In this case, we estimate an RRR for a one-unit increase in the number of citations (5-year Citations (ln)) lower than one, although not significant, and non-significant coefficients also for the number of citations received two and three years before acquisition. However, rather than targeting high-quality patents, *Litigation NPEs* target patents with broader patent scope (RRR between 1.50 and 1.59).

Overall, our results point to a strong heterogeneity with respect to the relationship between NPE business models and patent acquisition strategies.

5.3 NPE business model and follow-on innovation

In the last step of the empirical analysis we investigate whether different NPE business models are associated with different uses of acquired patents after transfer (RQ-2a).

We look at the number of forward citations received by transacted patents *after* the acquisition to investigate whether the three groups of NPEs differ in terms of follow-on innovation with respect to practicing entities. Precisely, we include the number of citations received in the two (or three) years after the transfer among the explanatory variables. The rationale is that a negative correlation between the number of forward citations received by acquired patents after the transaction and the likelihood that one of the three types of NPEs is the patent buyer is a signal of the reduced use of the patent after transfer (Abrams et al., 2019; Orsatti and Sterzi, 2023). Conversely, a positive correlation would indicate a more effective use of patents targeted by NPEs after transfer compared to (similar) patents acquired by practicing entities, suggesting patent acquisitions by NPEs enhance technological exploitation around targeted technologies.

Even if the common feature of all NPEs is that they do not provide goods or services directly from the exploitation of their patents, the way they use these patents may differ substantially. When the business of patent enforcement dominates technology transfer activities, a drop in the use of acquired patents should be observed. Therefore, one can expect a higher likelihood of observing a patent acquisition by a *Litigation NPE* when the drop in after-transfer citations is higher. Conversely, one can expect positive (or non-significant) correlations between the number of citations received by a patent after transfer and the likelihood that the patent acquisition is made by either *Portfolio NPEs* or *Technology NPEs*. Indeed, these entities act, respectively, as intermediaries and technology providers in the market.

Table 9 reports the results. As expected, we estimate a negative and significant correlation between the number of citations received by the patent after the transaction (both two and three years after the patent acquisition) and the likelihood that the buyer is a *Litigation NPE*. If patents acquired by *Litigation NPEs* show a similar number of citations to those acquired by practicing entities before the transaction, the number of forward citations is lower after the transaction. This result suggests that patent acquisitions by these entities are associated with a significant reduction in the use of the patent compared to patents acquired by practicing companies. Although our econometric model does not claim causality, it provides evidence of the fact that technologies acquired by *Litigation NPEs* are less used than similar technologies acquired by practicing companies.

Interestingly, we also estimate a negative correlation between the number of citations received in a 3-year window after the transfer and the likelihood that the patent buyer is a *Portfolio NPE*. These findings suggest that, on average, *Portfolio NPEs* do not act as intermediaries. However, a possible alternative explanation is that *Portfolio NPEs* amass large stocks of patents that, at least in part, necessitate time to be allocated through licensing agreements.

By contrast, we do not estimate significant correlations between after transfer citations and the likelihood that the patent buyer is a *Technology NPE*.

Table 8: Business model heterogeneity: patent acquisition strategy

	(1)			(2)			(3)		
		(Age>2)			(Age>2)			(Age>2)	
	Litigation NPE	Portfolio NPE	Technology NPE	Litigation NPE	Portfolio NPE	Technology NPE	Litigation NPE	Portfolio NPE	Technology NPE
5-year Citations (ln)	0.9659	1.1137***	1.1220***						
	(0.0522)	(0.0257)	(0.0480)						
2-yr Cit. before acquisition (ln)				1.0041	1.0971**	1.5327***			
				(0.0907)	(0.0437)	(0.0870)			
3-yr Cit. before acquisition (ln)							0.9984	1.0962***	1.4272***
							(0.0767)	(0.0362)	(0.0727)
Patent scope (ln)	1.5877**	1.0040	1.2428*	1.5878**	1.0179	1.2043	1.5879**	1.0156	1.2096
	(0.3051)	(0.0764)	(0.1591)	(0.3075)	(0.0772)	(0.1549)	(0.3083)	(0.0770)	(0.1549)
Family size (ln)	2.6999***	1.3467***	3.6579***	2.7082***	1.3640***	3.6319***	2.7072***	1.3608***	3.6141***
	(0.3356)	(0.0683)	(0.3472)	(0.3360)	(0.0687)	(0.3447)	(0.3361)	(0.0686)	(0.3439)
Claims (ln)	1.3014***	1.1810***	1.1542**	1.2843***	1.2038***	1.1328**	1.2862***	1.1998***	1.1330**
	(0.1199)	(0.0429)	(0.0714)	(0.1157)	(0.0438)	(0.0696)	(0.1160)	(0.0437)	(0.0697)
Backward Citations (ln)	0.8875	0.8483***	1.6050***	0.8795	0.8570***	1.5803***	0.8806	0.8552***	1.5753***
	(0.1013)	(0.0371)	(0.1249)	(0.0995)	(0.0375)	(0.1215)	(0.1002)	(0.0374)	(0.1210)
NPL	1.6213***	1.1875***	1.2891***	1.6109***	1.1994***	1.2803***	1.6120***	1.1984***	1.2815***
	(0.1486)	(0.0459)	(0.0781)	(0.1477)	(0.0462)	(0.0782)	(0.1478)	(0.0462)	(0.0782)
Constant	0.0002***	0.1147***	0.0043***	0.0002***	0.1192***	0.0046***	0.0002***	0.1192***	0.0045***
	(0.0002)	(0.0333)	(0.0019)	(0.0002)	(0.0347)	(0.0020)	(0.0002)	(0.0347)	(0.0019)
Filing year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Technology FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations		10,497			10,497			10,497	
Pseudo R^2		0.0818			0.0834			0.0832	

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The table reports the estimated coefficients (and associated standard errors in parenthesis) calculated as relative risk ratios. The reference category is the acquisition by a PE. We exclude patents traded after 2016 (citation data are from PATSTAT, version October 2019). The variable "X-year Cit. before acquisition" is the number of citations received by the patent X years before the patent acquisition; the variable "X-year Cit. after acquisition" is the number of citations received by the patent X years before the patent acquisition. We restrict the analysis to patents transacted at least seven years from the filing date to avoid overlapping between the count of citations received in the first five years from the filing date and citations received two years before the acquisition.

Table 9: Business model heterogeneity: acquisition strategy and follow-on innovation

	(1)			(2)		
		(Age>2)			(Age>2)	
	Litigation NPE	Portfolio NPE	Technology NPE	Litigation NPE	Portfolio NPE	Technology NPE
2-yr Cit. before acquisition (ln)	1.0342	1.1855***	1.5233***			
	(0.1070)	(0.0562)	(0.1098)			
3-yr Cit. before acquisition (ln)				1.0375	1.2033***	1.4626***
				(0.0907)	(0.0481)	(0.0919)
2-yr Cit. after acquisition (ln)	0.7010**	0.9222	0.9051			
	(0.1037)	(0.0593)	(0.0913)			
3-yr Cit. after acquisition (ln)				0.7405**	0.8995*	0.8808
				(0.1003)	(0.0527)	(0.0794)
Patent scope (ln)	1.5140**	1.0326	1.1261	1.5103**	1.0286	1.1307
	(0.2978)	(0.0848)	(0.1491)	(0.2980)	(0.0845)	(0.1491)
Family size (ln)	2.6607***	1.4702***	3.4869***	2.6559***	1.4639***	3.4618***
	(0.3395)	(0.0801)	(0.3440)	(0.3390)	(0.0799)	(0.3421)
Claims (ln)	1.3437***	1.2379***	1.1245*	1.3435***	1.2308***	1.1258*
	(0.1224)	(0.0491)	(0.0700)	(0.1224)	(0.0489)	(0.0702)
Backward Citations (ln)	0.9371	0.8880**	1.6310***	0.9361	0.8857**	1.6277***
	(0.1098)	(0.0430)	(0.1302)	(0.1103)	(0.0429)	(0.1297)
NPL	1.5922***	1.1297***	1.2892***	1.5896***	1.1277***	1.2893***
	(0.1496)	(0.0486)	(0.0818)	(0.1493)	(0.0485)	(0.0819)
Constant	0.0002***	0.0976***	0.0043***	0.0002***	0.0973***	0.0042***
	(0.0003)	(0.0305)	(0.0020)	(0.0003)	(0.0304)	(0.0019)
Filing year FE	Yes	Yes	Yes	Yes	Yes	Yes
Technology FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations		9,047			9,047	
Pseudo R^2		0.0885			0.0889	

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The table reports the estimated coefficients (and associated standard errors in parenthesis) expressed in terms of relative risk ratios. The reference category is the acquisition by practicing companies. Yearly citations are computed by using PATSTAT (Version October 2019); Patents transacted after 2016 are excluded from the analysis in order to compute citations after the patent acquisition. The variable “X-year Cit. before acquisition” is the number of citations received by the patent X years before the patent acquisition; the variable “X-year Cit. after acquisition” is the number of citations received by the patent X years before the patent acquisition. We restrict the analysis to patents transacted at least seven years from the filing date to avoid overlapping between the count of citations received in the first five years from the filing date and citations received two years before the acquisition.

6 Concluding remarks

The proliferation of NPEs has become a topic of intense academic debate and an important public policy issue in the US, upon which academic researchers have focused most of their attention. In contrast, NPEs in Europe have been relatively overlooked, with only a few studies investigating their activities within the European landscape. Our analysis demonstrates that this lack of attention is unjustified. Indeed, we show that NPEs have filed and acquired a large number of patents in the last decade in Europe, in particular in the Electrical Engineering domain, where they account for approximately 9% of EPO patents transacted during the period spanning from 2010 to 2019.

Our contribution to the literature is threefold. First, we analyze the expansion of NPEs beyond the US patent market, presenting novel evidence based on their patenting activities in Europe, a region where the patent assertion landscape is growing rapidly and where the introduction of the Unified Patent Court (UPC) and the Unitary Patent (UP) are likely to be groundbreaking events that could possibly increase the amount of patent litigation activities initiated by NPEs. Second, we bring fresh data on patent acquisitions to a heretofore literature that focuses mainly on litigation data to assess the impact of NPEs on innovation. For this purpose, we build a brand-new database of patent applications filed at the EPO where NPEs are identified as the last owners. To build this database, we have leveraged a comprehensive list of over 600 groups and 3,508 affiliated subsidiaries recognized as NPEs by industry experts specialized in patent litigation and licensing. Our empirical analysis reveals substantial differences between NPEs and practicing companies regarding the attributes of the patents they acquire. Specifically, through OLS and Logit models, we show that NPEs target patents that are relatively old and with a high level of technological quality. These findings support the idea that NPEs strategically invest in IP assets to capitalize on their efficiency advantage when it comes to implementing and enforcing patents, thereby assisting inventors in monetizing their inventions. Third, we present evidence that highlights the significant heterogeneity among NPE business models, including their diverse patent acquisition strategies and their varying impacts on innovation. Precisely, we analyze the composition of NPEs' patent portfolios, and observe that there is a strong heterogeneity between NPE types in terms of litigation intensity and R&D investments (that we proxy with the number of patents filed—rather than acquired—in their portfolio). Moreover, we investigate also the heterogeneity of NPE types with respect to the attributes and the subsequent utilization (that we proxy with forward citations) of targeted patents. Our empirical analyses show that the type of licensing business model adopted by the NPEs correlates with the dynamics of innovation. NPEs that commercialize their own inventions via licensing and patent assertion acquire high-quality inventions whose after-transfer use does not diverge substantially from the after-transfer use of similar patents purchased by practicing entities. Conversely, NPEs that primarily focus on asserting patents as their core business acquire patents similar to the patents targeted by practicing entities in terms of technological quality; however, their acquisitions are associated with a reduction in the use of the acquired patents. Finally, nuanced results are found for NPEs that commercialize patents that they acquire in the secondary market without litigating them aggressively. On one hand, these NPEs acquire high-quality patents; on the other hand, their patent acquisitions correlate with a reduction in the use of the protected technology.

Our study is not without limitations. First, it would be worth adding data on licensing deals that may complement the data on patent transfers, allowing for a better understanding of the presence and impact of NPEs in Europe. Licensing deals would allow for a better identification of the different NPE licensing models and their impact on innovation dynamics. Unfortunately, these deals are often secret. Second, our analysis does not allow assessing the net impact of NPEs in the market for technologies in Europe: while our econometric results suggest that NPEs do not act as intermediaries in the market, we cannot rule out that NPEs may nonetheless foster innovation by providing innovators with effective patent monetization options. On one hand, anecdotal evidence from the US market holds that NPEs collect high royalties and settlement amounts received, and pass on little to end-inventors; on the other hand, Chari et al. (2022) show that individuals and small inventors are responsive to increasing PAE intermediation, although only by producing greater numbers of incremental inventions. However, the available evidence on this mechanism is not sufficient to draw general conclusions.

Last remarks concern the policy implications of our work and future research. Our results point out the significant heterogeneity in NPE licensing business models; policy attention should thus go beyond the PE versus NPE distinction, focusing instead on market frictions that favor profitable opportunistic behavior. Moreover, since the UPC system could make the European patent market more attractive to litigate, policymakers should closely monitor specific types of entities, in particular those pursuing aggressive patent litigation and opportunistic monetization and assertion. Finally, we also note that a significant share of patents acquired by NPEs in Europe originate from large practicing companies operating in the ICT industry. This was largely due to a number of European handset manufacturers that failed in the market in the mid-2000s. Among the various reasons behind NPEs' patents being primarily sourced from large practicing companies, one is the possibility that NPEs may act as patent privateers, asserting patents against competitors of the practicing companies from which their patents were transferred. In this case, by using patent privateers against its rivals, a practicing company minimizes reputational harms of direct assertion, avoids contractual commitment (as in the case of FRAND licensing) and reduces its antitrust exposure, either to public enforcement actions or in private litigation. This calls for serious consideration of the possible consequences that such behavior may have on technology transfer and innovation in Europe.

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7 Appendix

7.1 NPE groups

This section aims to provide a detailed description of the process through which we restricted our initial sample of NPE groups to then proceed to the empirical analysis of NPEs' presence at the European Patent Office (Section 4). Table A1 describes this process:

The starting number of NPEs, which consists of 652 NPE groups (and 3,508 related subsidiaries), is the result of an append of two different lists that have been compiled at different times by Clarivate Darts IP and Allied Security Trust (AST). The first list of NPEs we adopted was provided to us by Darts IP, that we then expanded with the more recent list provided by AST in July 2021.

Some NPEs could not be found in the ORBIS IP Database; these NPEs are presumably missing because of changes in the company name (the first step removes 94 NPE groups). Some of the NPEs found in ORBIS IP do not hold EPO nor European patents (defined as patents filed at the national patent offices of Germany, Spain, Italy, France, the UK, and the Netherlands) in their patent portfolio at the time of the search (the second step removes 370 NPE groups); most of the time these are entities operating only in the US. Finally, some of the NPEs in our list do not hold EPO patents in their portfolio but only patents granted by European national patent offices (the third step removes 12 NPE groups). Thus, we restrict the final number of NPE groups that we consider in the empirical analysis from 652 to 176 NPE groups.

7.1.1 Identification of NPE-acquired EPO patents

We use ORBIS-IP data to identify all EP patent applications whose last owner is an NPE. In doing so, we manually search NPE names (included the subsidiaries) in ORBIS IP and we build their patent portfolio. Thanks to ORBIS-IP, we then differentiate patents filed by NPEs from those that instead have been acquired. We then deploy a data cleaning process to progressively remove false transactions. In particular, we delete all transactions that follow company name changes or that we consider intra-company transactions.

In particular, we deploy the *stringdist* R package, whose main application is to compute various string distances and to perform approximate text matching between character vectors (Van der Loo et al., 2014). We thus apply the Levenshtein string distances between the name of the current owner (NPE) and the vendor or the first applicant. We then remove all transactions where the distance is lower than a threshold value of five.

For each NPE-acquired EPO patent, we identify the last transaction date, the original patent assignee and the last vendor.

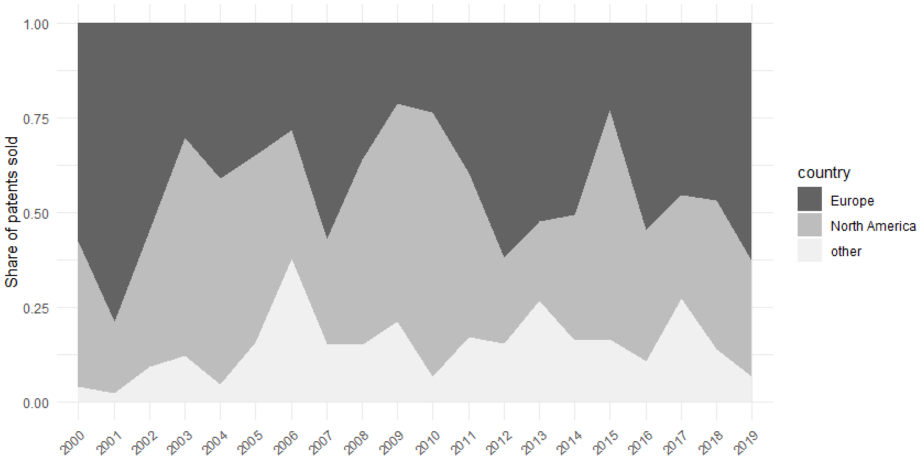
7.1.2 Identification of PE-acquired EPO patents

To compare quality characteristics between the NPE-acquired EPO patents and the PE-acquired ones, we retrieve from ORBIS IP all the EPO acquired patents from 2010 to 2020. Since we have already identified the NPE-acquired EPO patents, our objective at this stage is to identify the PE-acquired ones only, and to retrieve the same quality variables as for the NPEs' EPO patents from the OECD Patent Quality Indicators Database 2021 (Squicciarini et al., 2013).

From this list, we exclude patents that we already have in the sample of NPE-acquired patents but that ORBIS-IP consider to be acquired by practicing companies. We then identify and remove intra-company transactions applying a cleaning algorithm similar to the ones employed before.

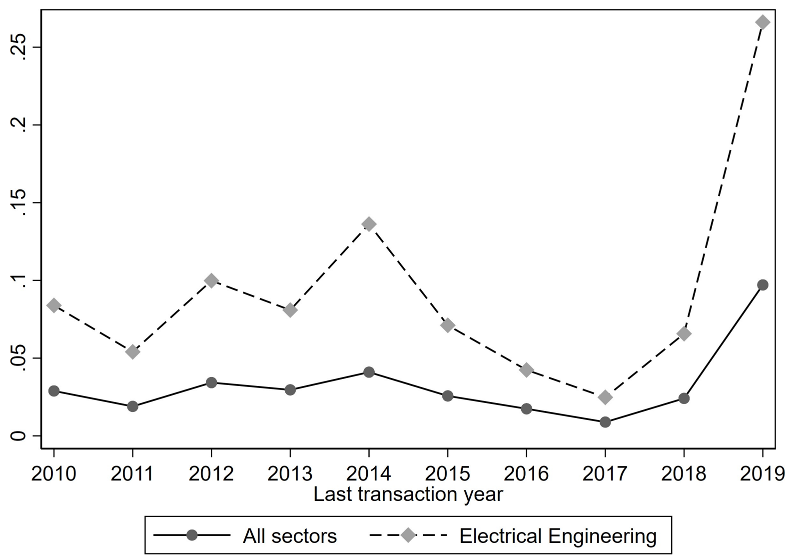
7.2 Appendix Figures and Tables

Figure A1: Share of patents acquired by NPEs by country of residence of the inventors



The figure shows the share of patents sold by country of residence of the inventors. Patents filed by inventors residing in two or more macro-regions are counted more than once. Geographical regions are constructed as follows: "Europe" gathers the most active countries in the European geographical space in terms of innovative activity (Germany, France, Italy, the UK, the Netherlands, Spain, Sweden, Finland, Austria, Belgium, Denmark, Luxembourg, Switzerland, Norway, Ireland); "North America" encompasses the US and Canada; all other countries are grouped together under the "other" label.

Figure A2: Contribution of NPEs to patent acquisitions (EPO data)



The figure plots the shares of patents acquired by NPEs over the total number of acquired patents by last transaction year. The Electrical Engineering field includes: Electrical machinery, apparatus, energy; Audio-visual technology; Telecommunications; Digital communications; Basic communication processes; Computer technology; IT methods for management; Semiconductors.

Table A1: NPE groups: Data cleaning steps

Step	N. NPE groups removed	N. NPE groups	Comment
		652	The starting sample is the merge of two lists of NPEs (Darts-IP) and AST. It consists of 653 NPE groups (and 3,508 related subsidiaries).
1	94		NPE groups that could not be found in Orbis IP Database.
2	370		NPE groups found in Orbis IP Database but that do not hold neither any EPO nor European patents at the time of the search.
3	12		NPE groups found in Orbis IP Database that do not hold any EPO-filed, but hold only European patents filed at national patent offices.
		176	The final sample consists of 176 NPE groups with EP patents in their portfolio.

Table A2: Total number of NPE-owned patent documents by patent office

	Jurisdiction of filing	N. of patents
1	EP	19213
2	DE	7810
3	ES	2016
4	GB	1375
5	FR	578
6	IT	501
7	NL	220
	Total	31713

Figures include patents whose priority years span up to 2020. The same patent can be counted twice if filed in two patent offices.

Table A3: Number and share of NPE patents by technology sector (EPO)

IPC Sector	Macro-label	N. of patents	% over tot.
H	Electricity	11726	60.68 %
G	Physics	4564	23.62 %
A	Human Necessities	1043	5.40 %
C	Chemistry; Metallurgy	1011	5.23 %
B	Performing Operations; Transporting	631	3.17 %
F	Mechanical Engineering; Lighting, Heating, Weapons, Blasting	313	1.62 %
E	Fixed Constructions	33	0.16 %
D	Textiles; Paper	13	0.07 %
NA	-	7	0.04 %
Total		19323	100.00 %

The Table shows the number of patent applications owned by NPEs by technological class (WIPO IPC scheme). A patent assigned to two NPEs is counted twice.

Table A4: Heckprobit selection equation

	(1) Selection Equation Heckprobit
Granted	0.3549***
	(0.0124)
5-year Citations (ln)	0.0599***
	(0.0094)
Patent scope (ln)	0.0158
	(0.0190)
Family size (ln)	0.2141***
	(0.0113)
Claims (ln)	-0.0659***
	(0.0090)
Backward Citations (ln)	0.0564***
	(0.0102)
NPL (dummy)	0.0617***
	(0.0125)
Constant	-0.9123***
	(0.0719)
Filing year FE	Yes
Technology FE	Yes
Observations	54,941
Pseudo R^2	0.0310

*** p<0.01, ** p<0.05, * p<0.1.