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"Patent Assertion Entities and Innovation. What do we know from the economic literature?"

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Summary

Introduction

The market for technology has enlarged rapidly over the past few decades. The number of intangible assets increased from around 2,5 million of Intellectual Property filings (split among patents, trademarks, and industrial design filings) in 2011, to around 23 million in 2022 (WIPO). In the past, patents were deemed as a simple tool to protect inventions: a well-running patent system incentivized innovation by giving the possibility to inventors of excluding competitors from the use of the patented technology for a certain period. Today, patents (but also the other types of IPRs) have become tradable assets that can be bought, licensed, and sold strategically in the market for technology. If the original inventor does not have the capabilities to produce or commercialize the invention, patents serve as an instrument to license or sell his idea to someone who can make better use of it. However, in the last period, the advancement of technology brought the rise of many frictions in the market for ideas that, combined with the increased opportunities for monetization of patent rights, led to the development of specialized IP businesses. One of them is represented by Patent Assertion Entities. PAEs purchase or file patented technologies from a variety of sources, and obtain licensing fees and royalties by asserting them against alleged infringers (Federal Trade Commission, 2016). They are mostly known as "patent trolls", to emphasize their negative reputation developed over the years in the IP field. This negative reputation has been gained due to the billions of dollars spent annually by companies to defend themselves against the opportunistic attempts of PAEs to extract massive royalties from the initiation of pointless litigations.

A popular opinion among researchers and scholars is that the phenomenon of assertion entities is 'the most significant issue of the patent system today" (Lemley, 2006). The U.S. has become the world's largest market for these entities, but the last innovations introduced in the European legislation might lead to the rapid growth of the assertion activities also in the old continent.

The term "patent trolls" initiated the debate on the detrimental effects that these entities cause on innovation and economic growth. Their aggressive behavior hinders producing firms and chokes innovation by redirecting resources towards legal battles rather than profitable R&D. Through the creation of new jobs and the increment in productivity and global competitiveness, innovation is the key driver of economic growth. As a result of their litigious activities, patent trolls cast a pall over this crucial process. By only threatening costly patent litigation, PAEs can deter individual inventors and producing firms from developing new technologies, launching products, or entering markets. The resulting feelings of concern hamper the natural evolution of industries and freeze economic growth.

Despite the importance of the theme, many discussions about PAEs have been based on theoretical evidence. This is mostly because the activities of these entities lack transparency

and most of their cases are concluded through private settlements, making access to data complex. Just considering the theoretical approach, it is uncertain whether the surge of PAEs is good or bad for innovation. According to some researchers, PAEs act as efficient intermediaries, that incentivize innovators to invest in new technologies (McDonough, 2006). On the other hand, the detractors of these entities sustain that PAEs only extract royalties from operating companies through the exploitation of the inefficiencies in the market for technology (Cohen et al., 2015). Due to the fact that theory cannot definitively predict PAEs' influence on innovative activities, this economic literature has the objective of addressing the problem of the PAEs' impact on innovation mainly through empirical evidence. In particular, this thesis responds to the need of reorganizing the extensive as well as confusing empirical literature, identifying whether the advantages brought by assertion entities (if any) can offset their opportunistic actions. In the end, I will have a clear and definitive result regarding the impact of PAEs on innovation.This paper is organized as follows. The first Chapter will provide an introduction to the market for technology, its inefficiencies, the consequent rise of PAEs, their diffusion and their business model. In the second Chapter, there will be a discussion regarding the common features of the patents targeted by the assertion entities. This examination allows to analyze the behavior of PAEs and empirically demonstrate their negative impact on the patent system.

The innovative effort of operating firms is deemed as the key factor that defines the global innovative direction and magnitude. For this reason, the third Chapter will provide evidence of the negative consequences of PAE litigations on corporates' R&D activities. Finally, in the fourth Chapter will be presented some legislative and judicial proposals to regulate the assertion entities' behavior.

Chapter 1. Patents and Patent Assertion Entities

1.1 Intellectual Property and Patents

Intellectual Property (IP) is classified as intangible asset, which represents human "intellectual" creations legally protected through the registration of the related rights (Arora et al., 2004). Although intellectual assets have been present for thousands of years in several forms, their economic significance has increased in the last period. In terms of volume, in 2021, global patent filings enumerated 3.4 million, trademark filing activity 18.1 million and industrial design filing[1] activity 1.5 million according to the WIPO (World Intellectual Property Organization) Statistics Database of 2022. They respectively increased by 3.6%, 5.5% and 9.2%, compared to 2020 (WIPO, 2022). These data become more impressive if compared to the ones of 2005, when patents were 1,7 million, trademarks were 3 million and industrial design around 500 thousand (WIPO, 2011).

The growing awareness of the R&D activities as a crucial element for the firm's operations brought to a new view of intellectual property rights. IP strategies started to be considered as source of competitive advantage and this led to the huge growth of patent applications and to the consequent pervasivenss of the knowledge economy in our globalized context. By codifying intellectual property and establishing the ownership of this property, patents facilitate forthcoming providers of complementary inputs to assign a value to the underlying invention but also, they make possible the process of disclosure (Steensma, Chari, 2016). Intellectual Property Rights, and especially patents that will be the focus of this literature, are now identified as crucial competitive assets by almost every company.

To emphasize the effectiveness in increasing profits and generating value of Intellectual Property resources, and hence their growing priority in corporate strategy, a study carried out by the European Union Intellectual Property Office (EUIPO) in cooperation with the European Patent Office (EPO) in 2019, showed that SMEs that are active in the Intellectual Property Right's field are more likely to grow in the following years than other SMEs[2]. This study

[1] Refers to the total number of designs embedded in industrial design applications.

[2] In particular the main findings of the study "High-growth Firms and Intellectual Property Rights (IPR) Profile of high-potential SMEs in Europe" (May, 2019) are:
1. The likelihood of becoming an High Growth Firms (HGF) is even higher for SMEs that have registered a European IPR, where HGF means companies that experience a growth rate of 20% or more for a three-year period.
2. SMEs adopting a mix of patents, designs and trademarks are more likely to achieve high growth, than those adopting only one IPR's category.
3. The better performance of prior patent filings in high-tech and low-tech sectors.
4. The better performance of prior trademark filings in consumer-oriented sectors.

highlights the positive correlation between the economic and financial performance of corporates and their ability to focus on R&D activities.

Again, it is helpful to bring up the World Intellectual Property Organization and its accurate definition of the patent as "an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem" (WIPO). Inventors, that bring to life an invention that meets the requirements of uniqueness, usefulness and non-obviousness, might present, to the pertinent offices, a patent application that recognizes its work, to allow policymakers to perform their duties of remuneration for the R&D's activity and protection against third parties (Gilbert, Shapiro, 1990). Indeed, a patent grants a monopolistic power to the inventor by exploiting her veto power over actors who unlawfully benefit from the innovation (Weatherall and Webster, 2014). In the past, patents, and other types of IPRs, were thought as mere tools to protect inventions. Today, they are widely and strategically exploited by the firms, through their possibility to be traded in the market for technology and thus, to provide always more opportunities for capitalization. According to some scholars, many technology-based companies would not engage in any innovation process without the possibility, but also the encouragement, of monetization of their innovation through the commercialization of IPRs on the market (Arora et al., 2004). Haus and Juranek (2017) sustained that the perspective for innovators to sell their patents is an incentive for innovation.

1.2 Market for technology

In this section, it is presented a brief overview of the market for technology, necessary to understand the context where these IP protections were introduced and operate nowadays.

In 1986, David Teece has noticed that the possibility for a firm to succeed from its inventions relies on the existence of a "market for ideas", which is a place where the enterprise can commercialize its ideas or innovative products. Arora and Gambardella (2010) define market for technology as "a place that allows transactions involving full technology packages, like patents and other intellectual property, as well as know-how and patent licensing". This market facilitates the diffusion and the commercialization of innovative ideas (Arora et al., 2003). Teece recognized two main issues that influence the market for ideas and its commercialization opportunities. First of all, to sell the technology, an inventor needs specialized assets, like producing or marketing know-how. If the innovator does not own these kinds of expertise than the bargaining power shifts from the inventor to the manufacturer, which extracts all the possible profits. Secondly, if a technology and the underlying Intellectual Property rights are not well protected, the inventors cannot presume to receive important returns for that idea.

On the same concept, Arrow (1962) highlighted the uncertainty in the market for technology introduced by asymmetry of information. According to the appropriability problem, those who want to purchase a technology need to know in advance the value of it and need to have all the information available to take a reasonable decision. On the other side, sellers of the innovative technology do not want to disclose crucial information with the fear of the possible expropriation of the idea. Also the European Technology Assessment Network (1999)[3] understood that markets for technology, information and knowledge, might observe some issues in operating, issues that can be solved by an accurate and rigorous arrangement of intellectual property's protection, patents.

Patents favor the development of the market for technology by solving these problems through the prohibition of imitations of the patented technologies, which gives to the inventors the right to exclude other individuals or firms from the appropriation and the possibility of selling the idea. By solving free-riding problems, they create also revenues for the inventors.

Moreover, the patent system helps in resolving other market inefficiencies. It enables more efficient transactions by eliminating the costs of codification and transmission of technological information, especially when the tacit knowledge embedded in the invention is complicated to communicate to potential buyers. Hence, they provide standardization of Intellectual Property, decreasing the costs of contracts drafting, between inventors and manufacturing companies.

Markets for technology modified the way of acting of firms both as technology users, buying innovations, and as technology suppliers, selling creations (Arora, Fosfuri, 2003).

With the rise of patents, market for technology enables companies to profit from innovation and get access to new technology. Indeed, companies are interested in trading patents in the markets for technology, since they can completely realize the financial value of their inventions before selling them. The higher effectiveness of trade in technology helps to generate private and social gain because it provides a platform where firms with low production capabilities have the possibility to licence or sell their innovations to companies with high manufacturing and marketing capabilities.

Thanks to the efficiency brought by patents, by operating in the market for technology innovative startups might concentrate more on R&D processes rather than on the consequent production or application since their efforts will be adequately remunerated by relying on other companies. Furthermore, every competitor or new entrant in an industry has the same access of the already established incumbents to every technology in the market.

Likewise, the entry barriers at the industry level are flawed and competition boosted.

[3] Strategic Dimensions of Intellectual Property Rights in the Context of S&T Policy. (1999)

The introduction of the market for technology, and its extensive modification in corporate conduct, brought the urgency to define what would be exploited and constructed in-house and what would be tradable on the market, for instance taking into consideration the importance of the transaction costs associated with selling or licensing the technology in comparison with the costs of acquiring production's resources (Penin, 2012).

Holding that an efficient and effective market for technology is necessary to incentive R&D activities of both individual inventors and innovative firms, the frictions seem to be significant, particularly in the ICT sector. Firstly, according to Gans and Stern (2010), technological systems are now composed by a multitude of components and each of them is developed by a diverse innovator. This fragmentation and the intense patenting activity originate a tight web of overlapping IP rights, aknowledged as patent thicket (EPO). In these crowded technology areas, acquiring a single patent makes sense only if the potential acquirer already possess complementary patents, hence the number of buyers is reduced. Moreover, the information and searching costs to find the appropriate technology and thus, to make the right "match" between inventors and manufacturing companies, or more in general between sellers and buyers, are high. The elevate and dispersed number of operators in the patent system and the lack of transparency in the negotiations have been perceived by analysts as one of the biggest obstacle in the proper functioning and efficiency of the market for technology (Comino et al., 2019). In addition, the complexity of patents make them more difficult to be evaluated. ICTs have some common characteristics, like the fragmentation of IP rights, the cumulative process of innovation, the growing number of patents and their complexity, that favor the presence of all these inefficiencies. The scarce effectiveness of patents as appropriation systems drives software firms to sustain that patents are "the least important mechanism to monetize their R&D activities" (Comino et al., 2019), preferring methods such as secrecy or the sale of complementary services or goods. In ICT, and in all the industries with complex technologies, patents are usually employed as a tool to be exchanged during cross-licensing negotiations.
Furthermore, from the rise of the market for technology in the mid-1990s (Arora et al., 2003), it has been observed a consequent positive trend of patent monetization driven both by the rise in the number of patent transactions and the growth of the monetary returns linked to them (Rivette, Kline, 2000). As a result of the growing intensity of patent monetization activity in the market for technology, but also of the increasing complexity brought by the inefficiencies explained above, there has been the emergence of highly specialized entities, like Standard Setting Organizations (SSOs), patent pools and patent intermediaries, that facilitate the transfer of exclusive rights on innovation (Orsatti, Sterzi, 2018) and that seek to extract value from this

market either behave like “offensive” or “defensive” patent aggregators (Papst, 2012). Among patent intermediaries, are positioned Patent Assertion Entities, that ease the meeting between demand and supply in the markets for technology and to ensure profits to the original inventor (Coriat, Orsi, 2002). They also purchase patents with the aim of suing practicing firms and asking for damages without the risk of being countersued. As can be understood from the two characteristics just provided, the effect of PAEs on the innovative context appears to be complicated.

The presented overview, on how patents enable the functioning of the market for technology but also introduce further frictions, is functional to introduce the figure of assertion entities and to explain the context where they developed and operate.

In the next sections, the discussion will move on describing how these entities operate and investigating the fragmented and contradictory literature on their impact on innovation.

1.3 Patent Assertion Entities

From now on in this chapter, the discussion will be focused on the wrong overlapping between the terms PAEs and NPEs, on their global diffusion, on their business model, on the legal framework that regulate their actions and on the two roles that PAEs might play in the market.

1.3.1 PAEs and NPEs

Regardless the broad use of the word and the general awareness of these entities, in the last period, it has been tried to give a common definition of what PAEs are and how they can be recognized (Joint Research Centre, 2016). By the late 1990s and early 2000s, those types of organizations have been considered non-practicing entities (NPEs), patent assertion entities (PAEs), patent monetization entities (PMEs), patent elves (Pohlmann, Opitz 2013) and, in many situations, they have been described as “patent trolls” reflecting the negative attitude around their action (Chien, 2013). “Patent troll” was first used, as a description of these organizations, by Peter Detkin in 2001, during a complaint about the NPE Tech-Search and its patenting strategy. He sustained that “a patent troll is somebody who tries to raise money exploiting a patent that they are not practicing and in most cases, they will never practice”[4] (McDonough, 2006). This claim was responsible for the confusion arisen, since both universities and technological firms would have been represented as patent trolls given that none of them produce from their patents but only collect licensing fees (Lemley, 2007). This intuition suggests that probably there are two different meanings for PAE, patent assertion entity, and

[4] Sandburg, B. 2001. Inventor’s Lawyer Makes a Pile from Patents, The Recorder.

NPE, non-practising entity, even if in many cases the two terms frequently indicate similar or coinciding institutions.

According to Penin (2012), in the market for technology, we can count at least three types of NPEs: technological firms, intellectual property brokers and patent trolls.
All Non-Practising Entities operate with intellectual property rights and they are eager to gain loyalties from them. At the same time, they cannot cross-license their patents because they do not operate in the products market. But these three institutions have some distinctions among them.
Technological firms, like universities or semiconductor manufacturers, create knowledge and develop new technologies that will be sold to manufacturing companies. Hence, they are clearly NPEs since they do not "practice" the innovation embedded in their patents.
In the market for technology, patent brokers are positioned in the middle between technological firms and manufacturing companies by lowering transaction costs and mainly transferring intellectual assets. They do not invest in R&D (Benassi, Di Minin, 2009).
Finally, there are patent trolls. Their core business regards litigation. They only purchase cheap patents in sectors like electronics, where the underlying technology results complex and the possibility of infringement is substantial (Fischer, Henkel, 2011). They usually buy patents from financially distressed companies, hence at a very low price and they are specialized in the capitalization of the hold-up problem. The hold-up describes the ability of the patent's owner, the patent troll in this case, to extract a higher licensing fee by waiting to enforce patents, until the accused infringers make important expenditures to implement or develop the patented technology. Then, the patent's owner initiates litigations against those manufacturers to obtain the infringement reward or to settle the agreements before arriving in court. The hold-up situation occurs when the potential infringers realize that the sunk costs are too high to be sustained and the investments in the patented technology cannot be redeployed. By that time, a settlement is the only available option.

Referring to the concept of "patent trolls" explained by Penin (2012) and to the definition provided by the Federal Trade Commission (2011) "PAEs purchase patents, and then sell or license them as assets whose values are based on the amount of licensing fees that can be extracted from operating companies already using and marketing the technology, or they facilitate others who make the assertions", there is one more feature that still misses in defining these entities. According to the Joint Research Centre in the report "Patent Assertion Entities in Europe" (2016), the process of attaining patents may result both from acquisition or in-house R&D.

A PAE can be a non-practicing firm or a patent aggregator that only acquires patents from other companies or that both acquires but also develops them in-house. Moreover, a shell company established by a practicing firm to assert its patent rights can also be qualified as PAE.

Another reason for the confusion regarding the definition of the PAEs' role was the presence, into the patent market, of patent aggregators. Patent aggregators embody companies that predominantly do not produce goods, as the NPEs, but create huge patent portfolios composed by a great number of patents whose rights they assert. It is quite visible the similarity with the PAE's activities. Yanagisawa and Guellec (2009), defined the difference between Intellectual Property portfolio companies, also known as patent aggregators, with two different purposes: selling patents to earn revenues from the activity of licensing or, on the other side, pursuing the defensive intent, behaving like a protector of the companies' freedom to operate. The authors sustained that PAEs belong to the first category (Abrams et al., 2019).
Also, Papst (2012) explained the same concept, identifying two different IP aggregation strategies: offensive patent aggregation ("OPA") and defensive patent aggregation ("DPA"). The first strategy implies seeking patents with the intent of licensing them and, in case of necessity, enforcing rights via litigation, what PAEs do. The second strategy consists of removing patents from the market by acquiring and licensing them to their partner, to avoid that other offensive patent aggregators would enforce innovation rights by starting litigation against their clients. Thus, buying patents that are already contended or that may be acquired by PAEs. (Yanagisawa, Guellec, 2009). By doing so, defensive patent aggregators do not litigate but offer to their partners the patent portfolio as a shield to defend against assertion.
Operating the same distinction, the Federal Trade Commission (2016) defined "Litigation PAEs" and "Portfolio PAEs".
After looking at the whole picture of the IP licensing background, this literature will focus on the more controversial entities, Litigation PAEs. As we will see afterwards, they are also more numerous.

To sum up, Patent Assertion Entities have emerged as a competitive force in markets for technology to exploit the legal and technological arbitrage opportunities (Delcamp, Leiponen, 2015). These entities are a sub-category of non-practicing entities, indeed they do not sell products. The existence of patents, and their characteristics of protection of the IP rights and of tradeability in the market, allow PAEs to operate in the market for technology. They identify and purchase patented technologies in order to make profits by legally asserting them against infringing operating companies. The increasing patent applications of the last decades and the

frictions in the market for technology, particularly in the ICT sector, drove to the extensive presence of these entities.

1.3.2 Global diffusion

Over the last three decades, an ascending number of PAEs litigations has affected the patent system, especially in the US, and their estimated cost exceed 300 billion dollars (Bessen et al., 2018).

Proceeding by using as source the FTC study, which is the most comprehensive research available in the field of PAEs within the U.S. background, they built the study dealing with 2452 patent lawsuits, between 2009 and the half of September 2014, that according to their estimates, account for between the 14% and 46% of the total number of patent infringement lawsuits in that period. In consideration of licensing commitments that PAEs divulged for the study, 87% were anticipated by infringement lawsuits. The tendency of PAEs to litigate a patent is six times higher than the possibility that all the other granted patents are litigated (Feng & Jaravel,2020).

In the "Patent Assertion and U.S. Innovation" report (2013), the Executive Office of the President claimed that PAE activity, intending the litigation activity, has a great increment.

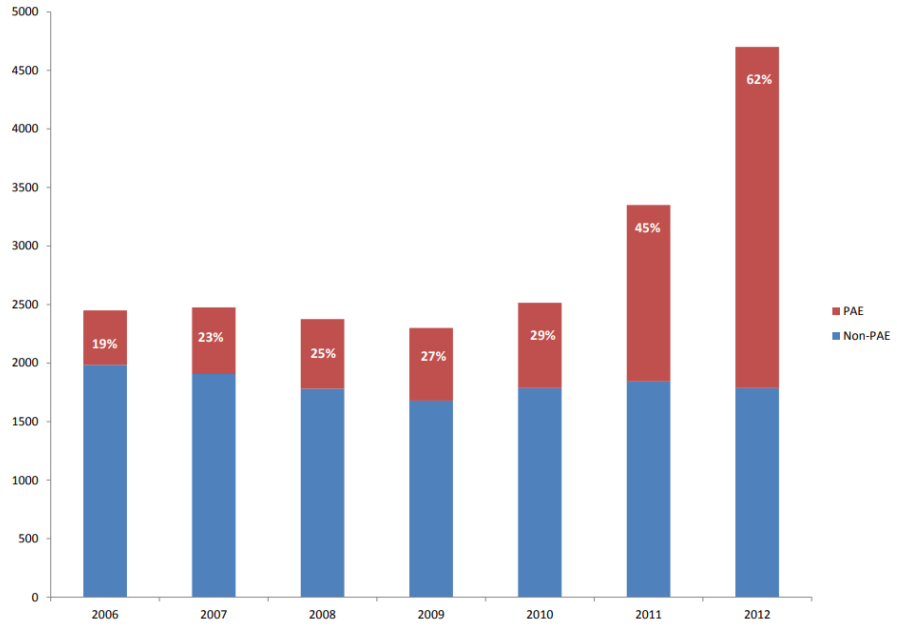

Figure 1. Number of patent cases from 2006 to 2012[5]

[5] https://obamawhitehouse.archives.gov/sites/default/files/docs/patent_report.pdf

Figure 1 shows that, in 2012, PAEs began 2,500 lawsuits, which rapresents 62% of all patent suits. Instead in 2011, they were 1,500 and in 2010, 731, accounting for 29%.
PAE suits are condensed in the ICT field, indeed, according to Chien (2013), 82% of PAE defendants were sued on the basis of a software patent, very differently from the 30% of those sued by entities that are not PAEs.

Up to now, most of the accessible, and presented here, literature on PAE statistics is US-centred, since in Europe PAEs seem to be a less pervasive phenomenon. Compared to the US, patent monetization has been unusual in Europe due to less comprehensive laws about intellectual property and probably a small and less dynamic market for technology (Mayergoyz, 2009). However recently, many PAE litigations have been lodged in European Courts, mainly in Germany (Love et al., 2015). To demonstrate that, Darts-ip[6] described an average annual growth of almost 20% in PAE litigation cases between 2007 and 2017, especially in the ICT sector.

Surely, the fact that PAEs are not practicing entities, hence they cannot be countersued by the defendant firms, suggests that they are in a clearly better position than non-PAEs and this can be an additional reason for the increasing numbers of PAEs' litigations.

1.3.3 How PAE operate in Europe and in the U.S.

According to the U.S. analysis of Patent Assertion Entities, the Federal Trade Commission (2016) provides an extensive study on the activity of PAEs in the United States and presents a well-defined differentiation between two main classes of PAE business models: portfolio PAEs and litigation PAEs.
Portfolio PAEs enter into big licensing agreements, covering large portfolios with thousands of patents frequently worth many millions of dollars, and then they manage the patents by grouping all of them into even bigger portfolios.

[6] https://www.darts-ip.com/.

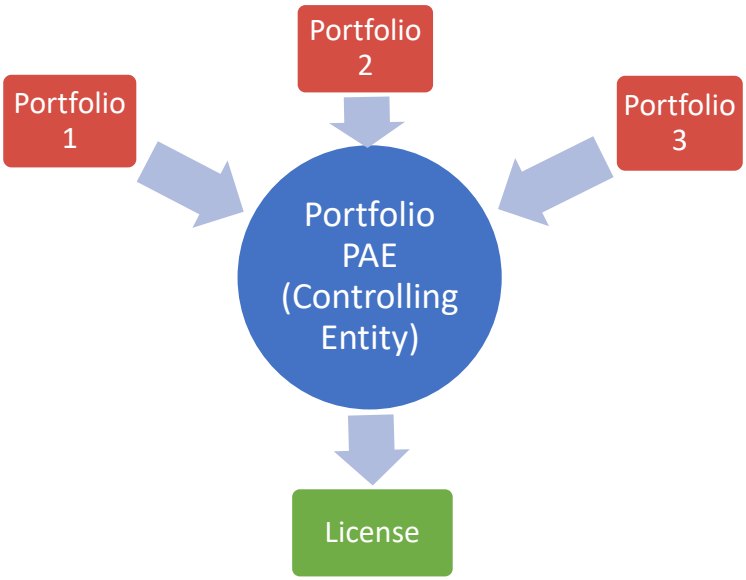

Figure 2. Business Model of Portfolio PAE[7]

As shown in Figure 2, the controlling entity licenses many portfolios incorporating many patents in one main portfolio. And then, it attains licenses in most cases without suing the future licensee but only by sending demands to enter into the agreements. Indeed, PAEs might decide to contend their patents by sending, to potential infringers, demand letters that vary from those that request licensing fees by mentioning accused patents and specific products, to those that simply ask for NDAs before the negotiations. Some demands include detailed claims, others might be vaguer.

In case of litigation, these entities involve experienced management and licensing executives. In the Study carried out by the FTC, the Portfolio PAEs represent only 9% of the investigated licenses, but they produce 80% of the revenues. These entities are usually financed by both manufacturing firms and investment funds (FTC, 2016).

The leading difference with Litigation PAEs is that, typically, these last organizations start (or threaten) infringement lawsuits with defendants before beginning license negotiations.

[7] Federal Trade Commission (2016). Patent Assertion Entity Activity. An FTC Study.

Figure 3. Business Model of litigation PAE[8]

Their business model engaged in the creation of one or more affiliate entities, shown in the scheme of Figure 3, that assemble and assert a portfolio with a very small number of patents. Usually, affiliates exist only on paper and represent the plaintiffs during the litigations. These PAEs did not combine patents acquired from different transactions into one single affiliate but they attribute each patent, or small bundle of patents, to one affiliate. Inventors entrust their patents to a Litigation PAE to be repaid with a percentage of the licensing revenues attained by the PAE thanks to those patents (Chari et al., 2022).

There are also Multi-affiliate Litigation PAEs that, instead, are one legal person organized as one main controlling entity which generate and manage many new Affiliates for each acquired portfolio (FTC, 2016).

Along with both the typologies of PAE, the potential defendant firms are exposed to the danger of an assertion action, since the aim of both is a private settlement. With Portfolio PAEs, the conviction process of the target firms passes through the costs of appraising the patent portfolio, instead in case of Litigation PAEs, this is accomplished through the costs of an eventual lawsuit. Hence, the two distinct business models consist of a financial threat to their counterparts (Thumm, 2018) with the objective of obtaining the biggest royalty or other payment, possible. Moreover, PAEs can assure many licenses for the same bundle of patents since they suggest nonexclusive license agreements (Chari et al., 2022).

However, it should not be ignored that, according to the sample of the FTC, Portfolio PAEs sign 71% of their licensing agreements without initiating litigations, preferring the "Demanding behavior" as conduct. Overall, Portfolio PAEs make 80% of the revenues, even if they account for only the 9% of the asserted patents. The remaining percentage of patents (91%) is asserted

[8] Federal Trade Commission (2016). Patent Assertion Entity Activity. An FTC Study.

by Litigations PAEs, but they generate only 20% of the profits. This information is indicative to understand the greater diffusion of the speculative activity conducted by PAEs and to justify the extensive debate over their impact on innovation. Litigations PAE can be created only to litigate a small group of patents and then, independently from the result, dissolved. Nevertheless, it is important to remark that the demanding behavior represents an abusive action itself, especially when PAEs start a mass campaign of trivial demand letters regarding not valuable patents.

Anyhow, the distinction between Portfolio and Litigation PAEs has not been used by the Joint Research Centre in their report for the European Union, consequently the data cannot be compared based on this difference. Despite this, JRC highlights many other aspects.
First of all, PAEs differ in their sources of funding, which can be universities, banks, the State, hedge funds, venture capital or companies. The funding source, the kind of assertion achieved, and the strategy pursued by PAEs seem to be correlated. In fact, since venture capital and hedge funds aim at profits in the short-term, those PAEs that use them as a source of funding are likely to behave with a more aggressive assertion strategy, using techniques that bring quick returns for their clients (Fusco, 2013). Also "privateering"[9] activities might be associated with aggressive conduct against competitors.

Moreover, PAEs usually have patent portfolios with very different characteristics. Patents within can vary according to their origin (they can be enacted by small firms, firms that want to liquidate their patent portfolios, distressed or bankrupt firms, both large and small, or they come from the entity itself, through R&D), according to the age of the patents (usually some older patents are most likely to be chosen by PAEs, even if it is not always the case), according to the presence of Standard Essential Patents (SEPs)[10] and to the quality of the patent (this aspect will be explained in the next chapter) (JRC, 2016).

1.3.4. Legal structure

Conventionally, patent assertion activity has always been more flourishing in the US, compared to Europe, according to several legal and institutional distinctions between the two. These distinctions have been investigated by the Joint Research Centre (2016) in their report.

[9] Privateering occurs when PAEs act as shell companies, which are financed by practicing firms.

[10] SEPs are those patents that cover important technical interoperability standards in industries like wireless communications, computer networking and semiconductor design. To enlarge the adoption of their standards, like 4G or WI-FI, technology Standards Development Organizations (SDOs) require their participants, the technological firms which develop innovations, to license SEPs either royalty-free or prone to "fair, reasonable, nondiscriminatory" royalties (FRAND) since the majority of the new technologies have the high probability to infringe those patents. Clearly, they are very attractive to PAEs. *Contreras, Jorge L., et al.(2017) "Litigation of standards-essential patents in Europe: A comparative analysis."*

First, the European patent licensing process is considered stricter and with higher quality methods than in the US, meaning that those innovations, that were eligible to be patented in the US, were not judged in the same way in Europe (Bisthoven, 2013). The legal certainty that characterizes the patent system in EU probably has dissuaded those PAEs that usually rely on litigations about patents with low legal quality. Also, the possibility for anyone who notice any violation to invalidate the patent during the PAEs' assertion process makes more difficult the operability of certain kinds of entities. Indeed, now, the U.S. jurisdiction has implemented the post-grant reviews.

Moreover, Fusco (2013) has exhibited also concern about the legal fragmentation of patent laws for litigations in Europe, which means that a single patent assertion refers to a domestic market of a country. It is self-evident that the dimension of a single country cannot be compared to the size of the U.S. market, and it requires PAEs to attain a deep knowledge of many European jurisdictions, something quite unfeasible. Graham and Van Zeebroeck (2014) claimed that the probability for the patents to reach the court, as well as receive a final judgement, change extensively across European countries. PAEs' activities are discouraged by the market size and the differences among all the jurisdictions (Fusco, 2013).

Besides, the litigation costs for the patents are higher in the United States than in EU, allowing experienced PAEs to raise the necessary funds from investors and put financial pressure on defendant firms, which cannot sustain those costs and agree to settle before going to court. The low litigation costs in Europe do not permit PAEs to have the same advantage over operating firms, losing their possibilities to extract high royalties. Another aspect that supports PAEs activities is highlighted by Barry et al. (2014). In the U.S. the loser of a patent lawsuit does not have the obligation to cover the entire costs of the trial. According to that, PAEs can start any meaningless litigation without the risk of refund to the winner.

Finally, obtaining injunctions in Europe appears to be very difficult because of the discretionary practices and the accurate examinations of the judges in court. In this context, the credibility of the PAEs' threatening behavior is lost. Instead, filing an infringement and the consequent injunction continue to be very easy in the United States. The demonstration that this is a factor that inhibits the activity of PAEs is that the European country where the injunctions seem to be more relevant and the infringement proceedings are less intricate is Germany, which is also the jurisdiction where PAEs present more cases of patent litigation (Love et al., 2016).

Despite all these evidences, in the last years, there has been the enactment of the Unitary Patent (UP) and of the Unified Patent Court (UPC) that changed the legal framework and encouraged PAEs' action. Effectively, these acts allow the possibility of injunction with the effect over all the European countries. They bring to an enlargement of the market, but also to the opportunity

of undertaking forum shopping by choosing the court with higher technical expertise or with the highest chance of success. Furthermore, these acts might introduce a bifurcated legal system that ensures to the injunctions a faster way to be granted, already in force in Germany, and the possibility for the rise of a centralized appeal court.

As found by the JRC (2016), the growing number of assertions in Europe mainly comes from US-based PAEs. This migration of American PAEs to Europe can be brought back to the above mentioned European new enactments but also to the numerous court decisions in the U.S. that limit the acquisitions of software-related patents, reduce the easy access to injunctions and regulate forum shopping (Fusco, 2013). One example might be the Alice Corp. v. CLS Bank (U.S. Federal Circuit 2014) resolution, which disputed the validity of software-related patents and restricts, for these types of patents, the possibility of injunctions (Thumm, 2018). Furthermore, the E-Bay Inc. v. MercExchange case (U.S. Federal Circuit 2006) decided to stop the automatic process of injunction that occurred right after the infringement and required a specific test, where the PAE's interests were weighted with the harm of the injunction (Mezzanotti, 2021). Moreover, in 2011, the America Invents Act made it more difficult for PAEs to monetize their patents (FTC, 2016). As a result of these reformations, the number of lawsuits concerning patents in the United States started falling from 2009, and in 2014 it showed a negative trend of 13% compared to previous years (JRC, 2016).

The legal framework has been useful to understand how the patenting laws in every jurisdiction can encourage/discourage the activities of PAEs and how the background has changed in the last years. Patent laws play a fundamental role for PAEs, in the decision of whether and how to operate in a country.

1.3.5 Two views on PAEs

Now, to start pursuing the objective of this paper, it will be presented an overview of the quarrelsome dispute about how PAEs affect innovation, providing two different views that summarize the objections and the supporting arguments to PAEs activity.

In the first conception, all the beneficial effects of the assertion entities will be enumerated, holding the idea that they behave as "market-makers", hence promoting innovation (Orsatti, Sterzi, 2018).

In this case, the intermediation role of PAEs helps to link the suppliers of inventions, which have a more valuable insight of the characteristics and the quality of their technology, with those firms, that can create products from the inventions, that can boost their commercial value and propose a way to sell and make money for inventors (Yeh, 2012). PAEs can be seen as entreprises that flatten information asymmetries and, consequently, searching costs on both

sides, offering the opportunity to cut down on costs for gaining competences in the recognition and commercialization of worthwhile technologies. Notwithstanding, a small inventor wanted to license a patent by herself, she would not have any possibility to achieve an agreement as advantageous as with the assistance of any other PAE, due to its unique bargaining capability to threaten credibly the potential manufacturer with a major infringement lawsuit (McDonough, 2006). A Patent Assertion Entity has the necessary means to enforce the acquired patents, find the potential infringers, keep an eye on their conduct, litigate before the trial to attain a settlement and, at the same time, compensate the small inventor (Allison et al., 2003). Thanks to PAEs and their experience on assessing the most relevant patents, an inventor can sell her inventions and keep focussing on the pursuit of other new technologies, instead wasting resources and time on the trade and commercialization. As a consequence, her activity can be fairly remunerated and PAEs increase the liquidity of patents, creating an efficient market for technology and hence, stimulating innovation (Shrestha, 2010). James McDonough (2006) stated that these entities can convert the market for innovation, from a complete system with several buyers and sellers, "search market", into a "centralized market with intermediaries".
In addition, due to their experience in the field of patent monetization, these entities may exploit their learning curve and achieve a Minimum Efficient Scale (MES) in patent assertion, something that is usually unattainable and, sometimes, not even considered by producers (Steensma et al., 2016).

The opposite view regarding Patent Assertion Entities concerns the idea that their main business is to collect money from innovative and creative companies, behaving like "market-breakers". This conduct seems to be allowed by the inefficiency of the patent system, especially in the United States as seen above, where it is quite easy to obtain an injuction that makes the threat of a lawsuit credible and forces the targeted firm to take the potential good off the market, even without the certification of the actual infringement (Lemley, Feldman, 2016). In particular, the U.S. system is composed by a great number of irrelevant patents and fragmented ownership rights, that create the so called problem of "patent thickets"[11] (Shapiro, 2000), to remark the inefficiencies explined before. This aspect is exacerbated in the Information and Communication Technology sector, where the technologies, and clearly the patents, are complex, patent boundaries and ownership are blurry, one patent can be used for several products and moreover, producers, most of the times, have already spent a lot in irreversible

[11] Carl Shapiro described a thicket of patents as a "thick web of overlapping Intellectual Property rights that a firm should cut in order to succeed in the commercialization of new technology.

technology-specific capital, engaging in holdup problems (Orsatti, Sterzi, 2018).
Besides, these entities are “non-practicing”, which means that they are not involved in the final product market and those solutions, like cross-licensing agreements, cannot be used to stem the problem by other firms (Haus, Juranek, 2018).
Furthermore, to attain substantial revenues, PAEs make use of low quality patents to begin trivial controversies and litigations, that are not proportionate to the underlying technology’s value, establishing a tax on innovation (Feng, Jaravel, 2020). This behavior, besides overloading the legal system, bring up costs for manufacturers, that waste time and money to protect tehmselves, and, consequently, for costumers. To avoid these situations, companies might decide to move their focus and stop R&D activities.
Likewise, despite the advantages that assertion entities can provide to small inventors, the latters can also be manipulated if the PAE offer a small amount of money for the patented technology. Or again, a PAE might decide to acquire patents from small firms with financial issues at a low price and then sell those patents to earn big extra profits.

All the topics covered in this chapter were necessary to understand the rising importance of intermediaries, in particular assertion entities, in the market for technology and innovation. This pervasive presence inevitably, brought to the start of the debate, resumed in the last paragraph, about whether PAE’s way of acting follows the main purpose of the patent system or not. The debate develops mostly regarding the activities of Litigation PAEs, or patent trolls, which is what will be discussed in this analysis. Patents should promote the progress of technology since they are the foundation of the market for inventions. Do PAEs behave according to this criterion, fostering innovation, or do they exploit their position to initiate frivolous litigation for not valuable patents, thus reducing incentives for R&D? This issue will be addressed in the following chapters.
From now on, this literature will take into consideration a set of studies that have tried to investigate what is the impact of PAEs on innovation and will sort the obtained results out, given that the opinions on the subject are, occasionally conflicting and confusing.

Chapter 2. How PAEs impact the patent system

A properly running market for technology improves welfare by supporting inventors in trading and licensing their technologies to innovators who want to sell them more efficiently (Fischer, Henkel, 2012). The patent assertion has become an ordinary procedure to bring equilibrium between the creation of innovation and the diffusion of innovation in the market for technology. The significance of patent assertion in the market for innovation is further accentuated by the development of Patent Assertion Entities (PAEs) that own patents just to enforce them and not to produce new products.

The consequences of assertion activities, and their impact on innovation, could be better comprised by studying the quality of the patents purchased by these entities in the market for technology.

According to the Joint Research Centre (2016), the European Patent System has a persistent tradition of high-quality patents compared to the USPTO, since the former is deep-rooted in stricter and protracted procedures for patent granting, which reduce legal uncertainty regarding the validity of patents, as already mentioned in the previous chapter.

Patent quality might be interpreted in several ways. According to some scholars, quality is reached when the legal requirements are met correctly, such as the requirements of utility, nonobviousness, novelty, enablement and the opportune subject matter (Scotchmer, 2004). Some others sustain that quality is measured by the degree to which a patent meets the statutory standards of patentability, such as the clearness of the written document, its proper disclosure, its novelty and its nonobviousness (Wagner, 2009). In addition, a high quality patent must be able to stand a trial without the risk of being invalidated, and should enhance economic, social or environmental welfare through its commercialization (Merges, 1988). Finally, a patent is not a raw innovative concept but a carefully written legal document, granting to its owner the right to sue for infringement (Feng, Jaravel, 2020).

Summarizing the above literature, this study splits the concept of quality into two different aspects: technological quality and legal quality.

Technological quality is characterized by the extent of nonobviousness, that is the technical originality of the invention, and by its utility to other innovative activities. The technical value is fundamental to determine the market value of the patent but also to stimulate further innovation on a valuable technology.

Legal quality regards the positive outcome of the examination process, which means whether the document has been well written, or technical instructions have been adequately disclosed

or the claims accurately specified in order to be granted by the patent office. Higher legal quality patents are often more challenging to be questioned in invalidation procedures or in court.
In this chapter, these two aspects will be analyzed separately. According to Trajtenberg (1990), the main method to assess the quality of a patent is to go through the evidence provided by the patents themselves, indeed I will analyze the characteristics of patents possessed by PAEs to determine whether they are valuable or not. The quality of patents acquired and litigated by assertion entities will be useful to discuss their impact on innovation.
In the first section, I will present the literature that indagates the technical features and the age of the patents acquired and asserted by PAEs. In particular, taking into consideration research about patent acquisitions and litigations operated by PAEs, I will understand what are the common features of the patents targeted by the assertion entities and whether they are technically valuable or not.
In the second section, two empirical studies will use the concept of technological quality to demonstrate the negative impact of PAEs on R&D activities.
In the final section, I will provide an overview of the studies regarding the litigations initiated by PAEs, and their outcomes. This will be functional to determine the legal quality of the asserted patents.
The question that will be addressed in this chapter is whether PAEs acquire and enforce valuable patents and how this notion can help to understand PAE's influence over innovation. Asserting technically and legally valuable patents drives to positive connotations for technological innovation both by promoting enforcement of top-quality technologies against opportunistic practices of infringement and by offering opportune compensation to high-end inventors. On the opposite side, asserting low-quality patents would mean allocating R&D resources to frivolous infringement lawsuits, then wasting a considerable amount of time and money on patents that should not be validated ex-ante. Thus, shutting down innovative activities.
For these reasons, determining the overall value of patents will be crucial to comprehend what is the impact of Patent Assertion Entities on innovation.

2.1 Technical characteristics of acquired and asserted patents.

Most of the actual studies and research on patent quality, like most of the studies regarding PAEs, focus on patent litigation data instead of referring to the acquisition activities. Examining only this kind of information makes extremely hard to analyze PAEs' business without the very likely risk of underestimating/overestimating their significance. Litigations on patenting activity are undoubtedly useful and valuable, but "visible actions are only the edge of the

iceberg" (Morton, Shapiro, 2013) because they provide an unrepresentative and incomplete picture of the weight of PAE actions in the market for technology. For this reason, also the information about acquisition will have a fundamental role in this analysis. Indeed, in this section, I will demonstrate that assertion entities acquire and assert patents with common characteristics. Identifying these features will be functional to describe how they operate.
Shrestha (2010) sustained that "demonstrating that PAEs possess high [technological] value patents will also strengthen the argument that these entities foster innovation" (Shrestha, 2010). This affirmation will be easily refuted.

Shrestha (2010) is also the first author that will be presented to start this discussion on the impact of PAEs on the market for technologies. In the first part of the paper, the author has conducted an empirical analysis to determine what is the technological quality of the patents held by PAEs and their consequent relevance in the market. The author's interest is to verify whether, as claimed by many, PAEs essentially own patents of low value and/or of little relevance, which they use to extract value from companies through threats of litigation.
To verify the value of the patent, the author built four measures:

- The number of received citations or "Forward Cites". A patent is said to be more valuable than other less-referred patents if the following patents mention very frequently the underlying technology of the previous patent.
- The generality of the patent: If the forward cites come from many different technology classes, then the patent has had an impact over a wide range of fields, meaning that its value and innovativeness have been recognized by several technological areas.
- The originality of the patent: The number of technology classes mentioned in the "prior art"[12] of a given patent also indicates the value of that patent.
- The number of claims: Claims indicate the technology that the patent refers to and describe the exact scope of it. The higher the number of claims, the higher should be the value of the patent.

These measures, with some exceptions, will be used in some of the following papers in the attempt to quantify the technological quality of patents. Particularly, the number of forward citations is usually recognized as a powerful indicator of patent value, because analyzing this measure provides an idea of the citation network originated by the patent and thus, its technological contribution (Trajtenberg, 1990). However, a simple aggregation of citations can be inaccurate. First, usually, patents that receive a high number of citations are the oldest ones.

[12] Prior art is a section in the patent. It communicates the patented technology or classes of technology, that the inventor refers to in her invention (Trajtenberg, 1990).

Second, independent inventors might use new patented technology as an excuse to quote and thus, give visibility, to their past patents. In this study and in most of the others that will be discussed, two solutions have been found. Regarding the first problem, it has been computed the yearly average number of cites, in order to avoid the bias of time. For the second problem, "self-citations" have been excluded from the total.

The research has been made focusing only on patents that are disclosed due to infringement litigation, since no PAE reveals in public its portfolios and so did the 51 entities of the sample. More specifically, the analysis consists in a comparison between the value of the 287 patents possessed by 51 PAEs to the value of patents chosen from 500 randomly selected lawsuits filed in the period from 2000 to 2008. The value of each patent has been computed by summing the four measures of technical quality mentioned before.

	PAE Patents (287 obs.)		**Litigated Patents (731 obs.)**		**Litigated Peer Patents (300 obs.)**	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Number of Citations Received	**36,0**	**50,9**	15,8	26,5	21,6	32,5
Number of Non-Self Citations	35,0	48,7	14,0	25,1	19,5	31,0
Number of Citations by Year	3,6	4,2	1,9	2,9	2,6	3,7
Number of Non-Self Citations by Year	**3,5**	**4,0**	1,7	2,7	2,3	3,5
Originality	**6,9**	**7,6**	4,5	4,4	4,8	4,6
Generality	**6,6**	**5,7**	3,1	3,4	3,9	3,8
Number of Claims	**41,0**	**59,9**	23,5	23,7	25,7	23,2

Figure 4. Average Measures of Value[13]

Looking at the mean and standard deviation of each measure in Figure 4, it can be noted that PAE patents have higher scores in every measure, compared to the random sample of litigated

[13] Shrestha, S. K. (2010). Trolls or market-makers? An empirical analysis of nonpracticing entities. *Columbia Law Review*, 114-160.

patents. PAEs patents gain more citations every year, have higher generality and originality and possess more claims, which means that they have an important power over following patents and a broader scope. Therefore, this comparison is in strong contrast with the common wisdom according to which PAEs own trivial patents.

Lemley and Shapiro (1991), claim that PAEs ask for excessive royalties to the producing firms as a mere opportunistic behavior, since the underlying value of the patented technology do not reflect the required licensing fees. Instead, this study suggests that PAEs assert technical valuable patents and require higher royalties because the value of their patents is on average larger than other patents. A valuable patent represents a credible threat to intimidate potential operating firms that, to avoid any litigation risk regarding an important patent for their business, would pay any price to the assertion entities.

Shrestsha's analysis is certainly interesting and leads to a clear and unambiguous result. Nonetheless, it is strongly affected by some limitations. Firstly, the sample was constructed selecting lawsuits cited by newspapers. Considering that usually media favor more catching and higher-profile cases, this choice might introduce a selection bias that makes the sample not representative. Secondly, the data rely only on a small number of litigated cases, clearly underestimating the presence of PAEs on the market for technology and their assertion activities. The study conducted by the Federal Trade Commission (2016) and the analysis of Fischer and Henkel (2012) are attempts to fill this gap. Focusing their research on patent acquisitions, instead of information available through litigations, allows them to include also all those patents that can be a possible threat for infringement but that have not been litigated yet.

In 2016, the FTC in the U.S. found evidence about the technical quality of the patents asserted by assertion entities looking at the number of the forward citations. The dataset was composed by surveying the USPTO, which keeps all the citations that every patent, registered there, has received from other issued patents. A peculiarity of this study is the distinction between Litigation PAE and Portfolio PAE, abovementioned. The mean of the received citations by Litigation PAEs is 40,7 compared to the mean of 19,7 of Portfolio PAEs. The mean of the entire sample of patents granted by USPTO, in the period 1990-2013, is 9,8.

Consequently, the same dataset has been controlled for the age of the patent and the technology field. Litigation PAE patents were cited, on average, 2,5 times more than the average patent granted in the same year and within the same technology field. The median patent owned by a Litigation PAE boasts 40% more citations compared to the average patent in the control group. Instead, patents of Portfolio PAE receive, on average, 1,5 times the number of citations of patents in the control group. These findings corroborate the always more convincing view that

patents asserted by Litigation PAEs protect a technology that is extremely more cited than other technologies, thus more useful for further innovation. Similar evidence might be found in the data regarding Portfolio PAEs, but the behavior is far less pronounced.

In the end, the FTC compared patents litigated by PAEs with any other patent registered in the USPTO since 1990, also other patents possessed by the same assertion entities. The findings demonstrate a higher number of received citations for litigated patents, emphasizing that the same PAEs choose the highest quality patents in their portfolios to initiate any litigation.

Another evidence in support of the technological quality of PAEs patents is provided by the paper of Fischer and Henkel (2012). In this case, the authors highlight other patents aspects that describe the preferences of PAEs in the acquisition of patented technologies. The same characteristics were found on a smaller scale, also by Shrestsha's paper but the larger sample and the robustness of the results that will be presented in the following study make the discussion more credible.

Fischer and Henkel used information coming both from the European Patent Office (EPO) and from the United States Patent and Trademark Office (USPTO). It is important to emphasize this aspect because the American context of assertion entities is much more developed that the European one, mainly due to the great differences between the two legislatures, explained in the first chapter. However, PAEs started to operate also in Europe in the last decades and not taking into consideration this new diffusion would mean misinterpreting the phenomenon.

The sample is composed of 392 patents purchased by 27 PAEs in the period between 1997 and 2006. They compared this sample to three control groups of patents purchased by practicing firms within the same years. The first group has the aim to control for some acquisitions' characteristics, like the technology area they belong to and the age of the patents. The second control group is used to control for cohort effects and avoid those biases brought by correlations of alternative variables, like forward citations. The final control group eliminates other technological biases. Both for patents in the control groups and those in the PAEs' group, each acquisition was checked manually, to find out whether there was a real transfer of the ownership. The dependent variable is a dummy that catches whether the patent was purchased by a practicing firm or by a PAE. The independent variables are:

- Scope ("Number of related IPC[14] classes)", that describes the potential areas of application for the patented technology.

[14] International Patent Classification

- Density of technology field ("Number of triples[15] in technology field"), indicating the, above-mentioned, patents thickets and, in general, the degree to which patents overlap.
- Technological quality represents the number of forward citations collected by each patent, hence the overall contribution in its technological area.
- Proximity to basic research embodies all the references coming from non-patent literature[16] (NPL).
- Age of the patented technology is computed between the time when the patent was filed and the time of the acquisition.
- Crowdedness of the technology area is defined by the number of patents in that technology field.
- Number of backward references.
- Number of claims. The higher this number, the higher is the probability that the patent will pass an invalidation process.

In the comparison between PAEs patents and the control groups, substantial[17] differences emerge for 5 characteristics. PAEs purchase patents that have more forward citations, more claims, with broader scope and in dense technology areas, hence technologically valuable. They also target patents that are near to expiration date.

Furthermore, to determine which are the features of a patent that lead a PAE to acquire it, with respect to a practicing firm, the authors built logit and probit models, with the dummy "acquired by a PAE" as dependent variable.

[15] Von Graevenitz et al. (2011) defined a triple as "a measure that recognizes constellations composed by three firms that own patents. Each firm owns a patent which blocks the patent utilization for the other two firms. When three firms block each other, they form a triple." The triple indicator captures the density of a technological area.

[16] The references can be split in two groups: references to older patents, that is patent literature, and citations to other kinds of documents, such as scientific articles, books, technical reports and many others, the so-called non-patent literature (Velayos-Ortega, López-Carreño, 2021).

[17] Subastantial means p-value< 0,001 or p-value<0,01

Estimator	Model 1a		Model 1b	
	Logit		Probit	
Variable	**Coefficients**	**Marginal Effects**	**Coefficients**	**Marginal Effects**
Number of Assigned IPC sections	**0,381** *(0,095)*	0,063 *(0,016)*	**0,216** *(0,052)*	0,066 *(0,016)*
Number of Triples in Technology Field	**0,0268** *(0,00005)*	0,004 *(0,001)*	**0,016** *(0,002)*	0,005 *(0,001)*
Logarithmic Number of Forward Citations	**0,528** *(0,092)*	0,087 *(0,013)*	**0,304** *(0,044)*	0,092 *(0,013)*
Number of Claims	0,0113 *(0,005)*	0,002 *(0,001)*	0,007 *(0,003)*	0,002 *(0,001)*

Figure 5. Model estimations[18]

In Figure 5, the positive and highly significant coefficients of the "number of assigned IPC classes" (0,381 and 0,216), which indicate the scope of the patents, suggest that there is a high possibility for a patent with a broad scope to be acquired by a PAE, compared to a Practising Entity[19] (PE). Likewise, the significant and positive "number of triples in a technology field" (0,0268 and 0,016), which refer to the patent density, indicates that PAEs prefer to purchase patents in dense technology areas. In addition, the positive numbers regarding forward citations (0,528 and 0,304) suggest the likelihood of PAEs to acquire high-quality patents. All the results are significant and robust.

Those findings reveal that PAEs prefer patents with a broader scope and in crowded technology fields, besides valuable patents. Patents with high technological quality are the perfect mean to credibly threaten operating firms and convince them to pay a huge amount of royalties, in order to avoid any litigation regarding valuable technologies. But also, the scope and the density of the technology field confirm this opportunistic behavior. Patents that protect innovations i) used in different technological areas and ii) in particularly "dense" technological areas, where it is difficult to find innovative spaces that are not yet covered, are those that are most likely to be violated by the counterparties and, therefore, can generate more royalties. This reasoning is

[18] Fischer, T., & Henkel, J. (2012). Patent trolls on markets for technology–An empirical analysis of NPEs' patent acquisitions. *Research Policy*, *41*(9), 1519-1533.

[19] Practicing entities, or operating firms, generate profits through the production and/or the commercialization of a good or a service. Differently from non-practising entities that extract money from the licensing of a patent.

consistent with the empirical evidence that PAEs disproportionately purchase and assert ICT and software patents (FTC, 2016). PAEs were created with the aim of exploiting the inefficiencies in the market for technology, inefficiencies that highly affect the ICT sector. Due to the complexity of its technologies, the persavive patenting activity, the cumulativeness of the innovation processes and the fragmentation of the Intellectual Property rights, the ICT industry is fertile ground for PAEs' activities, as explained in the first chapter.

2.1.1 The age of the asserted patents

The age of a patent is frequently identified as a measure of its usefulness but not of its technological quality. A patent might be technically valuable or not regardless its age. However, an old patent has already provided its scientific contribution and is no longer useful to stimulate further innovation. Usually patents are claimed by their inventor in the first years after being granted, hence when the probability to be implemented and thus infringed by potential firms is higher. Nonetheless, some scholars have found that PAEs assert old patents. Cohen, Gurun and Kominers (2019), using litigations data instead of acquisition data, wanted to detect some differences between PEs and PAEs litigated patents, in order to emphasize the offensiveness of the assertion entities. Through a large sample[20] of PAEs' litigations, they found that these entities assert patents that have a higher number of claims, thus broader in scope, corroborating the previous findings. But they observed also that PAEs litigate patents that are closer to expiration date, than those litigated by PEs. More specifically, PAEs' litigated patents are 25% older than producing firms' patents.

Keeping the patents' age as the main focus, the study of Love (2012) deepen the issue by examining a broad random sample of recently expired patents. He tracked the lifetime of every patent, from issuance to expiration, paying attention to the transfers and the identities of the acquirers.

The final findings are remarkable: producing companies mostly enforce patents immediately after the publication, more than 12 years before expiration, and finish long before their patents expire, with still more than 9 years of life. On the contrary, PAEs start their assertion activity many years after the issuance of the patent, on average less than 9 years from the termination of valid activity, and finish, on average 4,4 years before the expiration.

Assertion entities on average lodge twice as many lawsuits as PEs and their litigiousness is impressive in the final years before expiration. PAEs assert 83% of all patents within 5 years from expiration and concluded again more than 83% of all the assertions in the 3 years before the life term. Even if PAEs represent only 20% of all the patent owners in the sample, they

[20] The sample was compised by detailed information on 21300 lawsuits over the period 2010-2012.

asserted 55% of patents that have never been litigated before, in the last 5 years of the patent's lifetime.

Moreover, patents acquired or issued by PAEs change ownership 3 times more than PEs' patents, hence, on average patents asserted by PAEs have changed hands 50% more often than those asserted by operating firms. Patents are acquired by the last firm, that is usually a PAE, about 9,5 years after the publication and the lawsuits over those patents start on average 2,4 years after the acquisition.

According to these findings, it is reasonable to think that this conduct should not be applied in case of high-tech patents. Products and technologies in these industries are characterized by short lifecycles and continuous innovative processes, hence asserting an old patent in such sectors would be pointless. The following table will be an additional empirical proof of the PAEs aggressive behavior.

	Producing Company			**PAE**		
	Patent	**Suit**	**Assertion**	**Patent**	**Suit**	**Assertion**
Overall						
% software	25,5	21,7	22,2	**39,8***	**65,6***	**60,6***
% other high-tech	16,2	15,5	16,2	**25,0**	**16,3**	**20,0***
% medical device	8,4	7,0	10,6	12,5	4,5	5,5*
% bio-pharma	5,4	6,8	6,0	0*	0*	0*
Litigation ongoing less than 3 yrs from expiration						
% software	34,2	26,7	25,8	45,8	**69,2**	65,3*
% other high-tech	23,7	33,3*	45,4*	27,1	**16,8**	22,5*
% medical device	10,5	6,7	3,8*	14,6	3,5	5,8
% bio-pharma	13,2*	18,3*	15,2*	0	0	0
**p<0,05*						

Figure 6. Technology Areas of litigations by Producing Companies and PAEs.[21]

[21] Love, B. J. (2012). An empirical study of patent litigation timing: Could a patent term reduction decimate trolls without harming innovators. *U. Pa. L. Rev.*, *161*, 1309.

As we can see from Figure 6, results show that the number of high-tech patents is excessively high in the PAEs[22] litigations, especially near the expiration date. Around 65% of patents asserted by PAEs are software or high-tech related (39,8% and 25%) and the shares of high-tech litigation operated by these entities are about 80% (60,6% and 20%) of assertions and 82% (65,6% and 16,3%) of suits. About 86% of the PAEs' assertions in software or other high-tech industries are still going on, even if the patent has less than 3 years left.

Thanks to this analysis, we can conclude that PAEs are liable for a huge part of infringement suits and assertions, starting near the expiration date in the high-tech industry. These entities acquire patents only when most of their life is already passed and the patented technology is stagnant. They hold them for some years before deciding to file lawsuits, probably waiting for the manufacturers to make sunk-cost investments on that technology. In this case, if the investments cannot be redeployed in other fields, the operating firms is forced to pay huge licensing fees. In addition, lifecycles of products in the high-tech industry are short, hence it is credible to think that when patents in this area are asserted by PAEs, much time after issuance, they might be obsolete and mostly useless for innovative purposes. The only purpose that can be recognized in this litigious attitude is to extract the maximum profits from the operating companies.

2.2 The assertion of technologically valuable patents

After defining the characteristics of acquired and litigated patents and demonstrating their technological quality, the focus shifts over the impact of PAEs on those patents to bring an evidence of the PAEs' direct influence on innovative technologies. Orsatti and Sterzi have conducted two interesting analyses by observing the U.S. and European patent transfers. They empirically verified whether their litigation activity, and the consequent behavior of extracting value from manufacturers through excessive royalties, has a real negative impact over the innovations purchased from the market. In both studies, the authors considered the effect of assertion entities on follow-on innovation by looking at the number of citations collected by PAE patents and comparing it with the number of citations collected by patents that were not transferred and with those that were acquired by PEs. Focusing on the upstream activity of PAEs (the acquisition of patents), it is possible to explore the indirect impact of these entities on downstream innovation.

One more interesting aspect of these studies is the inclusion of both the main contexts of assertion activities: United States and Europe. In Orsatti and Sterzi (2023), one of the sources of information has been the U.S. Patent Assignment Database, which records information on

[22] Referred in the table as NPEs

each step of the granting process and also any eventual transfer of U.S. patents; instead in the study of 2018 (Orsatti, Sterzi, 2018), the authors utilized data provided by the European Patent Register. Differently from the mainly US-based literature, Orsatti and Sterzi decided to include also the European environment, in view of the implementation of the Unitary Patent (UP) and the Unified Patent Court (UPC) system that, with the more effective enforcement of rights and the cut of patenting costs, are thought to be crucial factors for PAEs' spread in Europe. Furthermore, the European telecommunications sector draws attention of the most PAE activity worldwide, as production leaves Asia. In the near future, the growing complexity and the blurry boundaries of patents, brought by the interoperability with the internet of things, is likely to expand PAE operations into many other sectors besides telecommunications. That is why a European perspective is important.

In the analysis based on U.S. data (Orsatti, Sterzi, 2023), the authors constructed a database, covering granted patents presented at the USPTO during the years from 1976 to 2016.

As first step, they matched patents purchased by PAEs with never-transferred patents according to: the type of technology, the number of citations before the acquisition period, and the year of filing. The pairs that resulted from the matching were used to elaborate an event study, where the "citation trajectory" of patents acquired from PAEs and of those never transferred (control group) were tracked and compared. The study observed patent citations throughout 3 to 11 years.

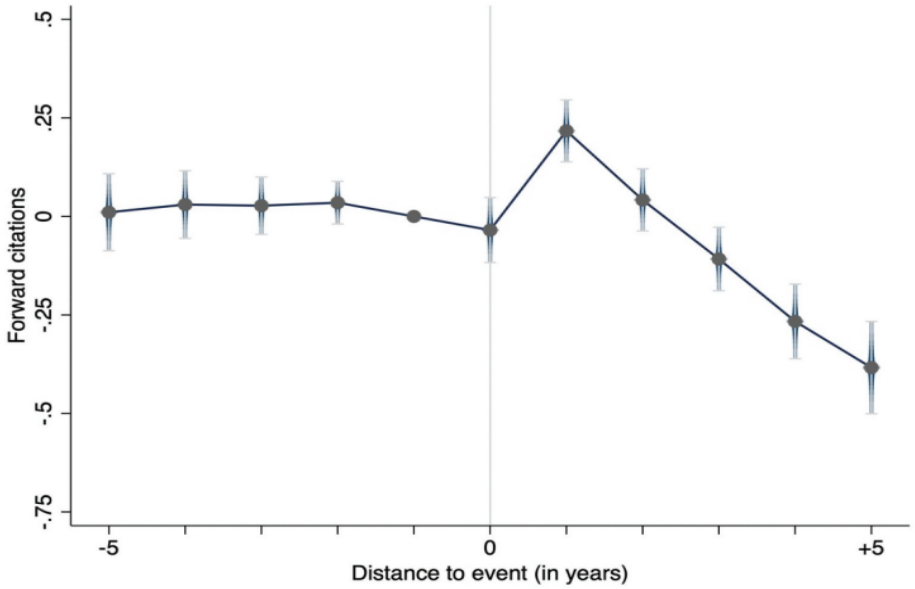

Figure 7. PAE-acquired vs never transferred patents.[23]

[23] Orsatti, G., & Sterzi, V. (2023). Patent assertion entities and follow-on innovation. Evidence from patent acquisitions at the USPTO. *Industry and Innovation*, 1-35.

Figure 7 shows the effect on forward citations of patents acquired by PAEs matched with the control group of never-transferred patents. The vertical axis represents the citation number of patent "p" in year "t". The vertical lines on the points are the 95% confidence interval and the year 0 is the year of the acquisition. In the figure, it can be seen an increment in citations in the first year after the acquisition and then, a serious decline, after year three. The drop becomes substantial after five years.

Then the same analysis has been repeated also for low-cited and high-cited patents and the results confirmed the noteworthy decrease in the number of citations, but this time only for highly cited patents. The line that reflects the trajectory of citations' number remains flat for low-cited patents, reflecting no differences between the two groups.

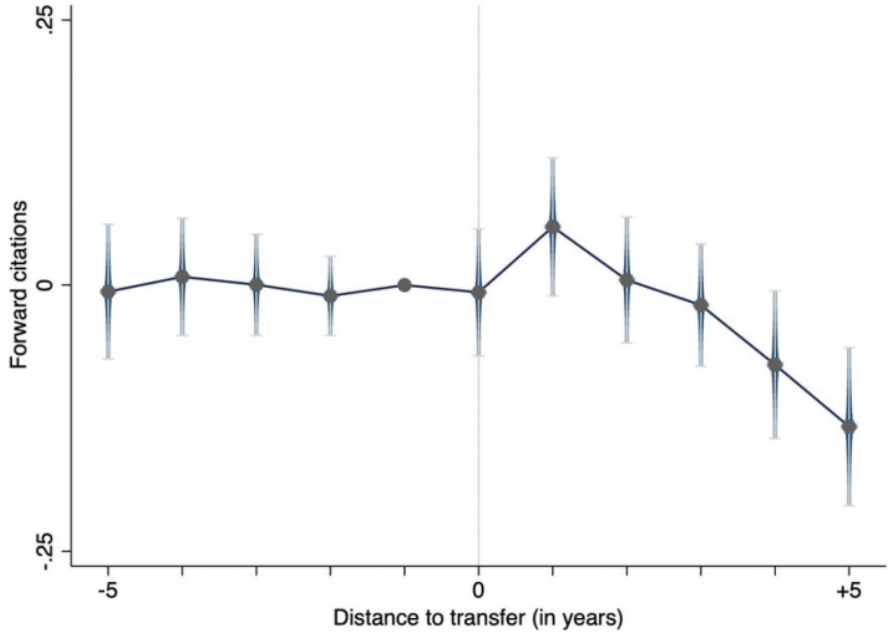

Figure 8. PAE-acquired vs PE-acquired patents.

The same test was conducted doing the comparison between the group of PAE patents and the control group of those acquired by PE and a similar important drop in citations was noted after four years from the acquisition. But, looking at the scale in Figure 8, it can be easily noted that points are characterized by a smaller magnitude concerning Figure 7 and in particular, both the increase in the first year and the consequent drop are less significant.

The test with these 2 groups has been replicated with high-cited and low-cited patents and the results are pretty much the same as in Figure 7. For patents with a low number of citations, the difference between PAE-acquired and PE-acquired is not relevant.

Additionally, the authors repeated the analysis to address the question of whether PAEs assert patents that do not have long fruitful life in front of them, but prefer those close to expiration

date, thus with an almost insignificant useful value left at the time of the monetization (Bessen, Love, 2013). In both tests, with never-transferred patents control group and with acquisitions by PEs control group, the results are in line with the previous ones. The influence of PAEs on follow on innovation is significant for old and young patents and, in years 4 and 5, the drop in citations is more evident for older patents.

The findings of this analysis are self-evident. According to the fact that most of the authors commonly agree on the affirmation that the technological quality of a patent is measured also by the number of its forward citations, it can be noticed that before the transfer, patents were able to gather a good number of citations, touching a peak in the first year when these are acquired and thus, published to the community. This evidence corroborates the conviction that PAEs acquire mostly technological valuable patents. Then, from the third year after the transfer, in the case of PAE-acquired patents vs not transferred ones (Figure 7), and for the following periods, an important fall takes place with the consequent obvious implication that PAEs decrease the value of a patent.

It must be said that, in the comparison between PAE-acquired patents and PE-acquired patents, the magnitude of the results is smaller, compared to previous tests. This means that, probably it is the acquisition itself that reduces the citations, without regard to the type of acquirer. Hence, the deduction is that traded patents in general collect fewer citations than never-transferred patents.

However, the fact still relevant is that there is a reduction also in the citations in Figure 8, where PAE-acquired patents were matched with PE-acquired patents, meaning that PAEs have a negative effect on the number of forward citations compared to PEs.

Furthermore, the evidence found by Orsatti e Sterzi confirms that PAEs are damaging follow-on innovation, since they target high-quality patents. Obviously, the quality of the patented technology remains the same, but operating firms that were investing on that innovation, or technological area, prefer to change their focus, avoiding any risk of litigation and causing a fall in the number of citations. This adjustment of the manufacturers' R&D strategies can be observed both in Figures 7 and 8. Indeed, the decrease in citations of PAE patents appears to be remarkable four years after the acquisition, stressing that operating firms need time to react to PAE acquisitions and reorganize their strategies. Therefore, the negative effect on innovation is not immediate. These conclusions can be drawn also looking at the similar analysis conducted with European data.

In this case, according to the already mentioned notion that PAEs operate substantially with complex technologies, Orsatti and Sterzi restricted their analysis to high-tech patents. In Europe, the four more relevant technology areas where PAEs operate are Audio and Visual

Technology, which constitutes 9% of the total patents, Computer Technology, 12%, Telecommunication, 18%, and Digital Communication, 45%.

The sample is composed of 151133 high-tech patents presented at EPO between 1997 and 2010 and the citation pattern is tracked up to 2013. They conducted a difference-in-difference-in-difference (DDD) analysis with a treated group that includes transferred patents and a control group with never-transferred patents. Then, the treated group was divided into acquisitions from PAEs and acquisitions from PEs, like the previous study. They built an equation to estimate the impact of the entities on the number of forward citations, which considers both the types of acquisitions in the treated group and distinguishes whether they were transferred or not. The main results are presented in Figure 9 and are coherent with the previous analysis.

	(1) Cit (LN)	(2) Cit (LN)	(3) Cit (LN)	(4) Cit (LN)	(5) Cit (LN)
PE	0,027 (0,0031)	0,027 (0,0031)	0,0075 (0,0030)	**0,0072** (0,0030)	
PAE	0,068 (0,024)	0,094 (0,029)	0,058 (0,028)	**0,050** (0,028)	
Traded	-0,012 (0,0031)	-0,011 (0,0031)	0,014 (0,0030)	**0,015** (0,0029)	0,015 (0,0021)
Traded x PAE		-0,064 (0,028)	-0,061 (0,028)	**-0,058** (0,028)	-0,080 (0,023)

Figure 9. Baseline model[24]

In column 4 of Figure 9, we can observe the results of the equation with the inclusion of all the considered variables. Before the transfer, patents acquired by PAEs attained 5% more citations (dummy PAE), than those never transferred in the market. Even if the percentage appears quite small, it highlights once again that PAEs "cherry pick" high-quality patents also in Europe. Instead, PE patents before the acquisition received only 0,07% more citations than patents never transferred, meaning that they acquire high-quality patents too, but not as PAEs.

Looking at the interaction term TRADED*PAE, it can be noticed that the results are always negative. Specifically, patents purchased by PAEs received on average 5,8% fewer citations than those bought by PEs, with a reduction from +5% to -5,8% of forward citations in the years following the transfer. Comparing these results with the increase in the number of citations of PE (from +0,07% to 0,15%), the negative impact of PAEs is evident.

Successively, they matched the transferred patents, both to PAE and to PE, to the group of not

[24] Orsatti, G., Sterzi, V., (2018). Patent Assertion Entities and Innovation: an Empirical Analysis Using EPO Patent Transfer Data. DRUID18 Copenhagen Business School, Copenhagen, Denmark.

transferred ones, controlling for many components that affect the probability of the transfer to occur, and the findings are consistent to those of the previous study (Orsatti, Sterzi, 2023). Not transferred patents receive more citations than transferred ones, proving that, a partial cause of the decrease in the number of forward citations, is the transfer itself. All the results are robust and significant.

This paper has enriched the previous U.S.-based literature, confirming the negative impact of PAEs on citations but also that, part of this negative effect might be caused by the transfer itself. However, the reduction in the number of forward citations in the case of PEs can be explained by strategic acquisitions of patents, especially in the high-tech industry. As we know, the strong overlapping situations and complementarities in the ICT sector drive an increase in IP ownership fragmentation and the constant risk of mutual hold-up (Schankermann, 2013). Therefore, to avoid hold-up issues, but also to gain external capital, firms make wide use of cross-licensing agreements and strategic acquisitions became fundamental. This, added to the tendency of PEs to acquire patents in order to further innovate and to exploit in-house that innovative technology, are the explanations to justify the fewer citations, but only in practicing entities' transfers. PAEs are non-practicing entities and these excuses cannot be used in their case.

Accordingly, we can summarize by saying that the decline in forward citations must be driven by the decision of operating companies to reduce their R&D effort due to the aggressive behavior of PAEs. Moreover, this effect can be attributed only to assertion entities, for the non-practicing nature of their operations. Hence, we can conclude that PAEs have a negative effect on innovative activities.

This section starts with the objective of analyzing whether patents acquired and asserted, or more generally owned, by PAEs are technologically valuable patents or not. To examine this aspect, it was necessary to go through the characteristics of the patent themselves. All the studies contrast the statement, generally believed in past years, that PAEs achieve and litigate patents with arguable quality (Lerner, 2006). In this analysis, no studies support this latter declaration. It can be thought that demonstrating the value of PAE patents would automatically support the reasoning that these assertion entities operate as "market-makers" and thus, enhance innovation (Shrestha, 2010). However, as can be noticed by the results of the previous studies, it is nothing like that.

PAEs acquire patents with a high number of forward citations and several claims, indeed they can be defined technologically valuable. These patents represent the perfect "weapon" to

threaten potential infringers and extract the largest amount of royalties possible. They also acquire and assert patents that protect complex technologies or that operate in crowded technology fields, in order to exploit the inefficiencies of the market for technology. Moreover, the opportunistic action of PAEs is emphasized by their preference over patents close to expiration date and by their habit to file lawsuits only after some years from the acquisition, waiting to exploit a holdup situation. The literature concerning these characteristics is resumed in the following table.

Patents characteristics	**High number of forward citations** *[technological quality]*: Shrestha (2010), Federal Trade Commission (2016), Fischer and Henkel (2012), Orsatti and Sterzi (2023), Orsatti and Sterzi (2018).
	Broad scope *[technological quality]*: Shrestha (2010), Fischer and Henkel (2012), Cohen et al., (2019).
	Belonging to a dense technology field: Fischer and Henkel (2012), Federal Trade Commission (2016), Love (2012).
	Close to expiration date: Fischer and Henkel (2012), Federal Trade Commission (2016), Cohen et al., (2019), Love (2012), Orsatti and Sterzi (2023).

Figure 10. Summary of the characteristics.

Finally, the direct evidence of PAEs impact on innovative technologies is straightforward. The drastic decline in the number of forward citations is an obvious limitation to the innovative activity, especially if, as in this case, are taken into consideration technologically valuable patents, that would be abandoned for the fear of possible lawsuits. And, according to the found evidence that PAEs own broad patents, there might be the abandonment of a whole technological area.

The implication deducted in Orsatti and Sterzi (2023), that PAEs behave worse than PEs might be refuted by the argument that the decrease in the number of follow on citations is brought by the transfer of the patent, from the owner to the purchaser, and the difference between the two entities (PAE and PE) is not that large. In reality, the reduction in the number of forward citations with PEs can be justified with strategic acquisitions of patents or with the intention to acquire patents to exploit their underlying innovative technology in-house, justifications that

cannot be used for PAEs. Therefore, the negative effect on the quality of the patents after the transfer must be mostly due to the negative effect on innovation and not due to the transfer itself. These final findings, included with the observed characteristics of PAE's behavior, bring to the feared outcome that the opportunistic conduct of assertion entities damage innovation, reducing R&D activities. Their massive diffusion represents bad news especially for rapid developing sectors, where PAEs are able to better exploit inefficiencies.

2.3 The legal quality of asserted patents

In this section, the focus will be the legal quality of the asserted patents. In 2022, 3460 cases out of 6959 (49,7%) were lodged by PAEs in the U.S. district courts. Almost half of the patent lawsuits. Analyzing whether the patents are legally valuable or not is functional to determine the overall impact on innovation, since a litigation over a patent that should not be granted is a waste of both time and money for a manufacturer. PAEs acquire and assert technologically valuable patents to make sure that the defendant settles before arriving in court. But what happens when the defendant is strong enough to sustain a trial? The opportunity of "forum shopping" is largely exploited by assertion entities to increase their probability of win the cases. However, lawsuits outcomes will be included to show further evidence of the kinds of litigations engaged by PAEs and to assume the legal value of their patents. Moreover, an investigation of the examiners' behavior will be useful to address the issue of this section, according to the fact that a permissive granting process is associated to patents with scarce legal value.

To start our discussion, the concept of "forum shopping" must be introduced. Cohen, Gurun and Kominers (2015) explained this phenomenon and how it is widely exploited by PAEs. In the United States, patent lawsuits can be lodged in any of the ninety-four federal district courts and the "forum shopping" phenomenon allows any plaintiff to choose the most favorable court. Companies, and consequently number of patents, are supposed to be uniformly distributed among all the American courts, or at least, they should be concentrated in the district of Delaware, where most of the enterprises are incorporated. For this reason, it appears to be quite strange the disproportionate rate of patent trials started in the Eastern District of Texas, in the period 2005-2013, more specifical in the town of Marshall, which does not have a specialization on Intellectual Property rights or more developed industries[25].

[25] Those data come from RPX Corporation, which reports information of "Public Access to Court Electronic Records" (PACER). This database tracks all patent lawsuits by NPEs against publicly traded firms from 2005–2013 (Risch, 2012).

	Operating company	PAE	Total
TX Eastern Dist.	56 8,20%	**71** **26,9%**	127 13,4%
Delaware Eastern Dist.	101 14,8%	21 8%	122 12,9%
CA Northern Dist.	64 9,4%	17 6,4%	81 8,6%

Figure 11. Comparison between Operating firms' forum shopping and NPEs' forums shopping.[26]

We can see looking at Figure 11, that forum shopping is a more frequent way of acting for PAEs (NPE), with respect to operating firms, regarding patent litigations. The percentages in the bottom raw report the rate of litigations lodged in that district with respect to all the litigations presented in the entire United States, over the period 2008-2009. PAEs choose Texas more than operating firms. Allison et al. (2015) discovered more evidence about this phenomenon. They found that PAEs file in the Eastern District of Texas more than a quarter of the lawsuits, against only 8.2% of operating companies. Instead, the percentage of PAE cases decided in the popular district of Delaware is similar to the percentage of operating companies (13,5% for PAEs and 14,8% for operating firms). Each result is significant[27]. Among patent lawsuits that arrive to be judged, 26% of those brought by PAEs are presented in East Texas, compared to 8% brought by PEs. According to Leychkis (2006), the motivations can be sought in some special patent laws that help to quicken practices, in the experience gained by judges or in very friendly judgment. Love (2017) enriched this affirmation by bringing empirical proofs that the Eastern district of Texas is such attractive to patent plaintiffs due to many plaintiffs-friendly policies. Its tendency to disclose deadlines to defendants very late but, at the same time, requiring a quick defendants' response to claims, facilitates the high volume of litigations lodged by opportunistic plaintiffs. Indeed, in the Eastern district of Texas, an accused infringer is forced to incur in a huge amount of discovery costs to study in advance the case, since this opportunity is not provided by the court. For this reason, plaintiffs can file a great number of lawsuits and offer to the defendants the opportunity to settle for amounts of money that result to be lower than the discovery costs. Moreover, judges in this district are used to exercise their discretion more than in other districts, harming the effect of prior reforms that point to reduce abusive patent suits.

[26] Cohen, L., Gurun, U. G., & Kominers, S. D. (2015). Empirical evidence on the behavior and impact of patent trolls: A survey. *Available at SSRN 2708224*.

[27] Eastern District of Texas p-value = 0.001; Delaware p-value = 0.039.

According to this, the Texas district is attractive to institutions that i) enforce ICT patents that are broader and that can be asserted against many potential infringers and ii) prefer quick settlements. Patent Assertion Entities seem to be the perfect match.

After defining that PAEs prefer courts that favor, or at least do not deter, opportunistic patents litigations, Allison, Lemley and Schwarts (2017) compared the outcomes of litigations between PAEs and PEs, to examine what do they say about the patents asserted by assertion entities.

They built their dataset using "Lex Machina", which allowed them to precisely identify all patent lawsuits presented in American federal district courts over the period 2008-2009.

They found that PAEs, in their dataset, are presented in 114 out of 945 cases (about 12%), a little more than a quarter of the total amount. In 2022, 3460 cases out of 6959 (49,7%) were lodged by PAEs in the U.S. district courts, thus the percentage examined in this study appears curious. The explanations provided by the authors are, firstly, that the dataset is not recent. Information refers to many years ago and nowadays the number of PAEs' cases is much higher. Secondly, the unit of measurement is patent cases, not the number of defendants associated. In 2011, 2 years after the end of the period taken into consideration by the sample, it was enacted the America Invents Act. The AIA, among other reformations, requires lawsuits against different defendants to be presented separately, unless the action is referred to the same transaction or the defendants are connected. Before 2011, PAEs were used to attack many counterparts within the same lawsuit, differently from operating firms. Thirdly, usually, PAEs settle cases before any patent ruling or court decision[28]. Therefore, these interpretations drive us to think that the dataset underestimates the real presence of PAEs in the market, but the results are significative for the discussion.

First of all, as already said before, authors individuated big differences between operating companies and PAEs in different federal districts where cases were decided.

Moreover, they found further evidence that corroborate the PAEs' preference to litigate ICT patents, compared to PEs. 76.9% of PAE lawsuits are in the field of software, but also in biotechnology, which, with 6,7% of cases, imitates the percentage of cases filed by operating firms in this area. PAEs are not massively committed in electrical (6,7%) or mechanical (4,8%) patent disputes. Operating the distinction not by the technology field but by industry area, PAE lawsuits are even more present in electronics and computers (35,6% of that industry lawsuits are composed of PAE cases) and biotechnology, which accounts for 23,3%.

[28] "Most of patent lawsuits settle or are left before trial" (Lemley, 2000)

According to the litigation outcomes from the data set, operating companies won typically more than PAEs.

Top Row = Frequency; Bottom Row = Percentage	Operating Co.	Univ.	Indiv.	Failed Startup	PAE	Total
Patent Owner Interim Winner	222	2	35	8	24	291
	41.8%	22.%	35.4%	26.7%	26.4%**	
Patent Owner Definitive Winner	136	3	11	6	7	163
	30.6%	30.0%	14.7%**	21.4%	9.5%**	
Patent Owner Definitive Winner + Interim Winner	358	5	46	14	31	454
	52.6	38.5	41.4**	38.9	29.8**	
SJ Invalid.—All Grounds	87	0	23	7	14	131
	26.9%	0.0%	41.8%*	50.0%	50.0%*	
SJ Non–infring.	172	3	38	9	33	255
	51.8%	42.9%	63.3%	47.4%	62.3%	
Total Direct Infring.—Any Stage	160	3	16	6	12	197
	42.4%	30.0%	29.6%	25.0%	15.6%**	
Patent Owner Trial Winner	142	3	12	10	8	175
	60.9%	100.0%	37.0%	85.7%	72.6%	

Figure 12. Success rates of PAEs vs Operating Companies.[29]

In Figure 12, are contained both definitive and interim wins for the patentee. Interim judgment are those cases whose judgment is only provisional and that do not reach the complete judgment. After the interim win or lose, the parties can decide whether settle and finish the trial or continue to the final judgment. Operating companies win 52.6% of the cases, 358, instead PAEs only 29,8%, 31 times. Considering definitive wins, PAEs are the worst compared to other types of NPEs but especially compared to operating companies, succeeding in only 9.5% of the patent cases. Also, on summary judgment of invalidity PAEs' patents perform way worse than those of operating companies, being judged invalid 50% of the times, compared to 26,9% of PEs. Moreover, assertion entities win only 15,6% of infringement lawsuits that reach the final

[29] Allison, J. R., Lemley, M. A., & Schwartz, D. L. (2017). How often do non-practicing entities win patent suits?. *Berkeley Technology Law Journal*, *32*(1), 237-310.

judgment, differently from the 42,4% of PEs. On inadequate disclosure, not displayed in the above Figure, PAEs perform perfectly, with a 0% failure to comply with all the requirements to file a patent, considerably different from the poor performance of individuals, who are unsuccessful in 70% of the cases.

The final takeways from this research are several. The Eastern District of Texas decides PAE lawsuits more than any other district and adjudicates PAE cases, especially for software patents and in tech industries, those with more overlapping and blurred patents, but also in the biotechnology industry.

Practicing entities win more often than PAEs on interim and definitive judgments but also on summary judgment in both invalidity and noninfringement cases. There may be several explanations. First, some judges might have negative opinions regarding Patent Assertion Entities, biased by the poor reputation of patent trolls and due to this, the final judgment results flawed. But, referring to the phenomenon of the forum shopping, probably those "non-friendly" judges represent a smaller part. Second, it can be assumed that their attorneys are less skillful than those of operating firms, even if it seems very improbable since these entities are based on their capability of assertion. Third, PAEs might assert legally weak patents, with vague claims and fuzzy boundaries (high tech patents), that allow them to start assertions and making the defendant believe that an infringement is ongoing. If the threat is not credible enough, the defendant will arrive in court and will waste time and money to defend himself in a frivolous litigation. However, as found by both Allison et al. (2013) and by the authors of this study, more than 90% of lawsuits were settled before the court, confirming that PAEs "bet" on the technological quality of their patents, and probably also on their reputation of expert litigators (Allison et al., 2013), to avoid trials.

Evidence in support of these findings are brought by Love (2012). Looking at litigations' outcomes the author demonstrated that more than 55% of PAEs patent lawsuits were declared not infringed, compared with less than 30% of PE patents.

Judgments of both noninfringement and invalidation express the weak legal value of the patent asserted by PAEs. Losing a case for noninfringement means that a PAE has tried to exploit the fuzzy boundaries of its patent with the hope that the defendant could not properly realize whether the asserted patent overlap its products or not. Losing a case for invalidation means that the patent asserted should not have passed the prior granting process. Referring to the definition provided at the very beginning of this chapter, a patent must be cautiously designed, since it is a legal document that provide the rights to sue for infringement. Accordingly, the fact that PAEs lose many cases suggests that their patents do not have the proper formal qualities to defend the underlying technology.

Regarding the concept of legally weak patents, the analysis of Feng and Jaravel (2020) studies the impact of patents drafting on the probability for a patent to be acquired and asserted by PAEs. After the empirical demonstration that patent assertion entities engage in frivolous litigations, Feng and Jaravel (2020) focus on the legal quality of patents, providing the proof that PAEs acquire patents from lenient examiners and that those patents are one of the main sources of litigation.

Examiners play a crucial role in patent system, as they must legally guarantee that granted patents are precise, without ambiguous claims and with the opportune scope. Examiners are heavily committed in the prosecution process, which is the entire process of drafting, filing, and negotiating the rights protection with the USPTO. After a patent application is submitted, an examiner starts to review every formal matter and address different issues concerning the invention's patentability. At the end of the process, the examiner decides whether to grant or reject the patent. According to patent law, patent applications must be accepted if they comply with the requirements of utility, nonobviousness, novelty, clarity and a patentable subject matter (USPTO), not if they are examined by a permissive examiner. Instead, employing much information about the prosecution process, the authors obtained empirical evidence regarding the conjecture that the legal value of patents is strongly linked with the particular traits of each examiner. The dataset is compsed by patents granted over the period 2001-2015 and analyzes the behaviors of examiners. The impact of examiners on the probability that patents are acquired by PAEs accounts for about 63%, meaning that PAEs purchase patents issued by examiners with specific characteristics. This data is even bigger if compared to the rate of acquisition by non-practicing entities influenced by examiner effects, which is only 14,61%.
Moreover, authors wanted to examine whether these examiners, which affect the probability of a patent to be acquired by an assertion entity, are lenient or not. The term "leniency" refers to the number of demands made by the examiner to the applicant during the process of prosecution and hence, wants to determine the degree of carefulness and meticulousness of the examiner. According to this study, the three features that evaluate the leniency of an examiner are i) the average number of changes per claim, to indicate how many times the examiner requires the applicant to clarify the claim, ii) the grant rate of each examiner, since usually picky and precise examiners have lower grant rates and iii) the amount of references made to different sections of patent law, since with many references the examiner demonstrates that the grant is consistent with the law. If the examiner is permissive the issued patent is not legally valuable, since it runs the risk to be invalidated in court. In Figure 14, the study demonstrates the correlation between the probability of a patent granted by lenient examiners to be acquired by PAEs.

Patent purchased by PAE									
Examiner effects/ Panel A. Patent acquisition by PAEs	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
% change in number of words per claim from app to grant	**-0,139** (0,030)								-0,115 (0,0490)
% change in number of claims from app to grant		**0,073** (0,034)							0,0519 (0,0345)
Grant rate			0,114 (0,028)						-0,0298 (0,0637)
Use of Section 101 [Ineligible, lack utility]				**-0,061** (0,036)				-0,0468 (0,035)	-0,0225 (0,0366)
Use of Section 102 (a) [Prior art exists]					**0,007** (0,021)			0,0171 (0,021)	0,00835 (0,0216)
Use of Section 103 (a) [Obvious invention]						**-0,0602** (0,024)		-0,050 (0,026)	-0,0223 (0,0285)
Use of Section 112 (b) [Vague claims]							**-0,037** (0,027)	-0,004 (0,026)	-0,00392 (0,0291)
Fixed effects	**Year by art unit**								
Observations	274464	274537	311615	311470	311470	311470	311470	311470	274464

Figure 13. Patent Acquisition and Examiner Behavior

In Figure 13, the results rely on acquisition data. Particularly, in column 1 of Panel A, we can see that 1% of increase in the number of words per claim drives a 13,9% decrease in the likelihood of an acquisition by PAEs, meaning that if an examiner does not make too many demands before granting, then the patent has a higher probability to end in the hands of a PAE. In column 2, 1% of increase for the claims' number brought to a 7,3% increase in the probability of PAE acquisition. We can notice a positive relation between PAE's purchase and grant rate, in column 3 and negative relations if examiners refer to sections of patent law number 101, 103 (a) and 112 (b)[30].

In column 8 are presented the results of whether all the mentions of patent law are included and

[30] Section 101 is applied by those examiners who give more attention to the usefulness and eligibility of a patent.
Section 102 is used by those examiners more careful about preceeding inventions.
Section 103 regards non-obviousness.
Section 112(b) focuses on the clarity of the claims.
Even if, every examiner should use the same standards, that come from the patent law, authors discovered great causal variatin across all the examiners, looking at their tendency to invoke the sections.

it can be noticed that section 103 is the one whose use reduces the most PAE acquisitions.
The same regression computed for patents bought by practicing entities indicates results which are opposed to the trends observed for PAEs. The examiner effects on the likelihood of an acquisition by PEs are much smaller and almost insignificant. Therefore, the relationship between the leniency of the examiners and practicing entities appears to be quite weak.
In Figure 13, the results rely on acquisition data, but the authors arrived at similar findings using patent litigations as outcome, unless for the fact that the magnitude is greater. Just the effect of the change in the number of words per claim accounts for most of the relationship (46%) between examiner effects and PAE litigation. In fact, in the regression that includes all examiner effects, the overall results emphasize the role of examiner leniency as a fundamental event to boost PAE litigations. Indeed, they found that permissive examiners increase of 65% the likelihood of a litigation initiated by PAEs. Another evidence that highlights the preference of PAEs to assert patents with not well-designed claims.
Up to now, clearly PAEs prefer to buy patents granted by lenient examiners and thus, legally weak. However, as litmus test, the authors tried to understand if lenient examiners release patents that have a higher probability of being invalid. The results shown a strong link between the leniency of the examiners and a variable to detect the invalidity of the patent, the re-issuance of already granted patents.

Authors found that examiner characteristics have a significant impact on patents' value and outcomes. Moreover, lenient examiners, and the process of examination of patents, highly affect legal patents value. Problems in the prosecution process, hence lenient examiners that do not guarantee unambiguous and clear patents, drive to patents with a substantial risk of litigation and invalidity. These legally weak patents are more likely to be acquired and asserted by PAEs than operating companies. The fact that the excessive tolerance of examiners is an important driver of litigation, particularly for PAEs, indicates that assertion entities are the symptom of another inefficiency in the patent system: the way patent rights are originated by lenient examiners. This friction in the patent system leads to the grant of questionable patents that mostly PAEs are willing to buy and exploit though frivolous litigations. The reduced care in the prosecution process of some examiners might be one of the causes for the widespread patenting activity and for the increasing number of litigations. Invalid or ambiguous patents cannot properly defend the ownership rights of an innovation and their only use ends up being assertion tools. Indeed, they are mostly acquired by PAEs. Surely, this is not the aim of patents.

In this section, it has been evaluated the legal value of patents acquired and asserted by PAEs. The widespread habit of "forum shopping" provide first evidence that assertion entities engage in trivial litigations, and they look for the most favorable district, Eastern District of Texas, in order to increase their chances of victory, or at least the probability that a defendant decides to settle before the final judgment. The most adjudicated cases for PAEs regard software patents in tech industries, hence those with more overlapping and blurred boundaries, but also innovations in the biotechnology industry.

The futility of PAEs assertion actions is demonstrated by the fact that PAEs are more likely, than operating firms, to lose both on summary judgments and on definitive processes due to invalidity and noninfringement. The inaccurate design of the patent claims, namely the blurry boundaries of its scope, and the poor definition of the formal aspects lead to the inevitable conclusion of losing lawsuits for noninfringement and invalidation. Therefore, these characteristics indicate the low legal value of the asserted patent. To provide further evidence about this issue, Feng and Jaravel (2020) introduce the fundamental role of the examiners in the so-called "prosecution process" and studied how specific traits of examiners affect the granted patents and, most importantly the probability that those patents are then acquired by PAEs.

All patents should be granted following the principles of the patent law enforced in that country. In case of the US, USPTO declares that patent applications must be accepted if they comply with the requirements of nonobviousness, utility, novelty, clarity and a patentable subject matter. As shown in this study, this is not what happens. The presence of lenient examiners highlights an additional inefficiency of the market for technology, which drives to many trivial litigations. These trivial litigations are usually engaged by PAEs, that prefer patents granted by those types of examiners, hence legally questionable.

But why PAEs would take the risk to enforce patents that might be adjudicated invalid? Because more than 90% of lawsuits were settled before the court, confirming their necessity to credibly threaten operating companies with a technological valuable patent.

The facts that they overload the legal system of trivial lawsuits, that they assert patents with low legal value and that they exploit another market friction, impact negatively on overall innovation, by causing innovators to incur in heavy costs of litigations.

2.4 Concluding remarks

The findings of these two sections cannot be defined in line with the aim of the patent system. Patents were created in order to foster innovation, by allowing the transfer of innovative ideas and, through the market for technology, commercializing them. The proliferation of the assertion entities is a response to the frictions of the market for technology; the growing patenting activity, the increasing complexity of technologies, the fragmentation of the IP rights, and the consequently substantial costs for searching and identifying potential buyers/sellers of a technology, create the "space" for PAEs to operate. Patent Assertion Entities (PAEs) and the pervasiveness of patenting litigations have become a theme of fierce debate.

This chapter aims to bring order to the economic literature about them, particularly looking at their impact on the patent system.

According to Shrestha (2010), "demonstrating that PAEs possess high-value patents will support the argument that these entities foster innovation". Through many empirical studies, I demonstrate that the technological value of asserted patents is used as an effective "weapon" against operating companies to extract the highest possible amount of royalties. Indeed, these high-quality patents lose their value after the transfer in favor of an assertion entity, which, instead of simply identifying the real infringers, litigates technically valuable patents to collect licensing fees.

I also provide evidence about the futility of the litigations initiated by PAEs, recognizing that they assert old, invalid and vague patents. With these frivolous litigations, PAEs impose a tax on innovation, meaning that the targeted firms have to shift their resources from R&D activities to the defense against alleged infringements. Up to now, this is just a conjecture. In the next chapter, I will investigate the implications of PAEs' activities on targeted firms.

The initial question regarding the impact of PAEs on innovation has been addressed by examining their opportunistic behaviors. When an entity has the objective of collecting the highest possible amount of licensing fees, and for this reason it reduces the utility of technologically valuable patents and/or it starts pointless litigations against operating firms, its impact on innovation can only be disastrous. Firms would reduce their innovative activity, or they would start to diverge their focus to simpler and less disruptive technologies, to avoid any expensive risk of litigation.

PAEs' opportunistic behaviors identified in this chapter cannot be complementary to the support of innovation.

Chapter 3. How PAEs impact operating companies

Large firms are likely to be very conscious of threats posed by PAEs, and they operate to minimize their exposure (Bessen, Meurer, 2013). As we know, PAEs focus on acquiring technically valuable patents to impose a credible threat to profitable companies, thus extracting a large amount of royalties. For this reason, also large and rich companies are a great target.

On the other side, small firms have more limited resources to fight against PAEs. Their knowledge of the patent system and its intricate mechanisms cannot be even compared to the expertise possessed by large firms. Furthermore, they do not have enough financial resources to sustain long and challenging trials. Thus, an infringement letter sent by a PAE is much more effective with small companies, that opt for settlements with a quick license payment, rather than for an expensive lawsuit. Moreover, startups are defined as the most important driving force of global technological advancement (Chien, 2013) and the largest part of their operations are guided by R&D activities, usually in narrow technological areas. They lack funds to employ a patent counsel and might abstain from hiring experienced legal teams. Accordingly, they are not able to carefully move in a world of countless fuzzy patents, thus their probability of being sued by assertion entities increases exponentially.

After having analyzed the characteristics of the disputed patents in Chapter 2, I will discuss how both large and small operating firms react to the assertion of technologically valuable but legally weak patents. Innovators who decide to invest in new technologies have to consider the risk of inadvertent infringement as a cost of doing business. In reality, it is not only inadvertent infringement that worries innovators all over the world. As we know up to this point, PAEs start litigations even if no infringement has occurred, simply because they leverage on blurry boundaries. This litigation risk decreases the revenues that operating companies expect to gain from their investments and hence reduces their willingness to further innovate. Moreover, patent litigations may have a significant influence on firms' behavior since PAEs might induce them to interrupt their innovative path and change their innovative focus towards less dangerous, but also less groundbreaking, technologies.

In this chapter, I will discuss the impact that Patent Assertion Entities have on corporates. In the first section, I will look at what kind of firms are the most targeted and how their R&D expenditures change subsequently to a PAE's litigation. I will provide some evidence regarding the drop in sales of asserted patented technologies, but also the effects on the peer companies of defendants in PAE's lawsuits. Finally, I will examine how firms' patenting strategies change after the experience with a PAE.

In the second section, I will focus on PAE's influence over startups and small firms, and in the

third section, I will analyze the behavior of individual inventors towards assertion entities.
In the end, I will cover the quantitative evaluation of the costs imposed by PAEs to corporates.
The issue addressed in this chapter is the overall impact of Patent Assertion Entities on corporates and individual inventors, balancing negative and positive aspects.
Corporations are naturally pushed towards innovation. Rigby et al. (hbr.org) sustain that successful technologies lead to a stronger company's purpose and originate common value for its customers, suppliers, employees, inventors, and communities. Accordingly, and considering that corporate's R&D activities are the key factors that define the global innovative direction, it seems unavoidable, to pursue the final objective, an analysis of how the assertion entities phenomenon affects operating corporates.

3.1 General impact on corporates

To start the discussion about corporates, Cohen et al. (2019) provide evidence through a large sample, on which types of corporations are targeted by PAEs and how these kinds of litigations impact those firms' innovative activities. They gathered data regarding PAEs' lawsuits over the period 2005-2015 from RPX Corporation and hand-coded data collected by Cotropia et al. (2014). They reiterated that PAEs behave opportunistically. More specifically, the authors found that PAEs target firms with large amounts of cash and firms that have had recent cash injections. Indeed, a one standard-deviation increase in the cash levels of a target firm boosts the probability of being sued by a PAE by 7.40%. A possible explanation for this behavior might be that firms, who are infringing a patent, know that they will be sued by an assertion entity and then start to raise money as a precautionary measure, to preempt the future lawsuit. However, additional findings demonstrate that PAEs target firms with small legal representations and it seems quite unlikely that a company is collecting money for future lawsuits but, at the same time, reducing its legal teams. Therefore, the cash-targeting observed seems to be more consistent with an opportunistic behavior. Furthermore, PAEs choose to target also firms that realize all, or the biggest part, of their revenues from technologies completely unrelated to the allegedly infringing technology, thus even if the litigated patent is far from the core business of the firm. This practice of bringing to court technologies that are not central to the innovative activities of a firm highlights once more the anti-innovative behavior.
Moreover, the authors found that the cash-targeting behavior is a common habit of large patent aggregators, PAEs, and not of small inventors or practicing entities.
After, remarking on the frivolous litigations engaged by PAEs, the authors examined the real impacts of those litigations on the R&D activities of targeted companies. They examined all firms targeted by PAEs, splitting them into two groups according to whether i) they lost in court

or decided to settle (Treated), or ii) the cases against them were dismissed, or PAEs lost (Untreated). Using a difference-in-difference approach, they tested whether the future R&D expenditures change in some way conditional on the outcomes of the cases against PAEs. The Figure 14 reports the results.

Sued by	Treated	Untreated	N(Treated)	N(Untreated)	Change in R&D around Litigation
NPE	Settled+Won by NPE	Dismissed+Lost by NPE	1929	533	-163,97 (7,18)
PAE	Settled+Won by PAE	Dismissed+Lost by PAE	1868	502	**-155,02** (6,60)
PE	Settled+Won by PE	Dismissed+Lost by PE	175	38	**167,657** (1,28)

Figure 14. Real Effect on corporates[31].

The analysis compared the average annual R&D expenditures two years before the litigation, to the average annual R&D expenditures two years after the litigation. In Figure 14, it can be seen that losing or settling with a PAE has a big and negative influence on future R&D activities. The results indicate that firms, that lose the lawsuit or settle with a PAE (Settled + Won by PAE), invest 155 million dollars less in the years following the lost lawsuit, compared to firms that were also targeted by PAEs but won (Dismissed + Lost by PAE).

Finally, with an additional regression built on the same two groups of firms (Treated and Untreated), the authors discovered that losing/settling with a large aggregator (PAE) brings to an approximately 20% reduction in R&D expenditures. Again, there are no significant reductions in R&D investments after the loss of a lawsuit against practicing entities. These results are very important because, in the prior chapter, some evidence sustained that 90% of the litigations end with a settlement. Therefore, 90% of the time the targeted companies are forced to reduce their innovative activities by 20%.

In the end, it has been measured the changes in innovation outcomes in the exact technology areas where PAEs' litigations are most frequent. The findings suggest that there has been neither an observable increase in innovation by small innovators, nor significant PAE remuneration to original inventors.

To sum up, the evidence supports the conviction that PAEs behave opportunistically by targeting cash-rich firms, firms that earn revenues from sectors that are not those attacked, firms with small legal teams that have minor possibilities to properly defend themselves. All these

[31] Cohen, L., Gurun, U. G., & Kominers, S. D. (2019). Patent trolls: Evidence from targeted firms. *Management Science*, *65*(12), 5461-5486.

behaviors are consistent with large patent aggregators and not with any other institution, like small inventors or practicing entities. The main findings regard the important evidence that PAEs have a negative impact on company's innovative activities, heavily reducing their expenses in R&D after a settlement or a lost lawsuit. But also that original inventors do not receive significant remuneration for their activities from PAEs.

More evidence about the impact of PAEs on corporates has been found by Tucker (2014), who focuses on sales of companies sued by PAEs. He examined a case study of how the actions of a patent assertion entity affect technology diffusion by looking at sales in the empirical setting of healthcare information technology. She utilized this setting for three reasons. First, there are complete data about the sales of Digital Medical Picture Archival and Communications Systems (PACS) to American hospitals. Second, the large PAE called Acacia, in 2005, started a considerable litigation campaign against multiple firms producing PACS, after the acquisition of two patents with broad scope and a large number of citations. A great example to study. Finally, the litigation targets are big healthcare IT companies, that produce products that can be both outside or inside the scope of the asserted patents, hence targeted or not by the PAE. Those similar products outside the scope of the patents indicate the perfect control group. The data come from the HIMSS Analytics Database (2011 version), a database for professionals that sell healthcare IT to healthcare structures, and cover 4829 hospitals. She identified all the PACS technologies purchased by hospitals over the period 2005-2008. Two datasets were built, one with sales made by sellers involved in the Acacia lawsuit and one with sales made by sellers not in the Acacia lawsuit.

	Affected Vendor (1) No Controls	**(2) Fixed Effects**	**(3) Full Controls**	**(4) Double-Cluster**	**(5) Time Trend**	**Not Affected Vendor (6) Full Controls**
PostLitigation x ImagingSoftware	**-0,019*** ** (0,003)	**-0,011*** ** (0,003)	**-0,020*** ** (0,003)	**-0,020*** ** (0,004)	**-0,026*** ** (0,003)	**-0,004** (0,003)
ImagingSoftware	0,028*** (0,002)					
Postlitigation	0,001*** (0,002)					

Figure 15. Sales of sued vendors after litigation starts[32].

Figure 15 presents the analysis for sales of imaging software (those protected by the sued patent) compared to sales of software designed for textual data (those not protected by Acacia's patent). In every column, the author added diverse fixed effects and controls, but the direction and the importance of the key results persist all along. The fall of sales of imaging software products relative to textual software[33] is emphasized by the negative coefficients of the interaction between "Postlitigation" and "ImagingSoftware". The absolute values (not reported in the figure) indicate a fall of approximately one-third of sales after the lawsuit began. This drop in sales might be simply due to external causes, like hospitals that prefer to save money in a period of financial restrictions and not purchase imaging software. However, the author found that there were growing requests for both imaging and textual software in that period, indicating that no reduction in demand was observed, hence the decline was caused by the supply side (producers). Firms that produce imaging software decline their production subsequently the litigation.

As we can see in Column 6, also the not sued vendors of imaging software observed a tiny decrease. This is because, the not sued vendors' control group probably was affected by the ongoing lawsuit, since they could not be unaware of one of the largest patent litigation in the industry and hence, they could have been afraid of becoming a potential target of Acacia. However, the decrease in the selling numbers of not sued vendors demonstrates only a small and negligible decline for them. Why do vendors decide to reduce their effort in selling products during the litigation?

The fall in sales was connected to a decrease in incremental innovation. Compared to non-sued firms and products not covered by the scope of the patent, sued producers do not release any new model of imaging software or any modification of existing software during the lawsuit. A reason for this absence of innovation is that the producers wanted to avoid the risk of "wilful infringement" in the lawsuit and being forced to pay additional damages. Therefore, we can say that the litigation initiated by the PAE, not only decrease the revenues for sued firms but also slow-down the release of new products. This means that even if PAEs lose in the trial, like in the case of Acacia, their behaviors have important negative consequences on innovation, during litigations.

These findings are consistent with those reported by Smeets (2014). With a sample of 534

[32] Tucker, C. E. (2014). Patent trolls and technology diffusion: The case of medical imaging. *Available at SSRN 1976593*.

[33] Textual software that are produced by the same firms involved in the suit but are not covered by the contended patent. The only technology covered by the litigated patents regards the imaging software.

public U.S. firms that were sued for patent infringement in the U.S. during the period 2000-2012, he developed a model that explains the relationship between patent litigation initiated by PAEs and corporate innovation. In this model, corporate innovation was positively linked to both corporate revenues and the probability of being sued for patent infringement. He assumed that, in equilibrium, the degree of innovation is negatively affected by past litigations because an infringement lawsuit not only reduces revenues and innovation during the litigation, as seen with Tucker (2014) but also the prospect of future innovation, especially for small firms for whom litigation costs are very high and persistent over time. These predictions were matched by the empirical results. Corporate R&D activities are diminished between 2,6% and 4,7% points, but only for small firms (less than 500 employees) that are dealing with costly PAEs' litigations, and typically in the first three years after the lawsuit. This influence over the R&D intensity of the defendant is accentuated when litigated patents largely overlap the overall patent portfolio of the defendant itself.

Once more in this study, PAEs' patent litigation is a significant factor that reduces the innovation of the defendant, particularly if this defendant is a small firm.

These studies measured the effects on corporates that play the role of defendants in litigation against PAEs. Instead, Chen et al. (2023) provided evidence also on the impact of assertion entities on the defendant's peer companies and their results confirmed the small evidence discovered by Tucker (2014) in Column 6 of Figure 15.

Using RPX data, Chen et al. (2023) analyzed patent litigations from 2000 to 2017. They found evidence of a sequential behavior of PAEs. Specifically, after the first lawsuit regarding a patent, PAEs file around seven following lawsuits about the same patent. Furthermore, they found that in the year following a lawsuit, the probability of a peer of the sued company being sued itself by a PAE increases by 14%. An at-risk technology peer is one of those firms that use technologies similar to the litigated patent. Instead, in the case of practicing entities, the probability for at-risk technology peers to be sued after an initial lawsuit is only 4%. These results introduce another singular PAE strategy: sequential rounds of litigations.

In addition, they examined the influence of PAEs' litigations on the market value of at-risk technology peers in the first days after the announcement of the litigation. In terms of dollars, an at-risk technology peer incurs in a decrease of the market value of about 29,8 million dollars, in the first three days after the start of the litigation. These losses of market value are substantially connected with the high likelihood of being sued and the understandable fear of investors, who react by blocking investments. Again, these negative reactions of the market are

much more pronounced in the case of PAEs' lawsuits rather than PEs' lawsuits, whose impact accounts only for 9,2 million dollars of market value.

Accordingly, the authors investigated why these market losses happen. They discovered that those peers that have never been involved in litigations in the prior five years (at-risk technology non-litigated peers) increase their R&D activities, as soon as they experience losses of market value. This increase in R&D activities in the five years following the initial lawsuit is represented by the attempt of not yet targeted technology peers to lower the probability of being sued. This attempt is performed through the investment in "workaround technologies", replacing the infringing innovation with a safe alternative.

Workaround technologies may be either strategic technologies with lower value and with the only objective of avoiding litigations, or technologies that provide long-term value to companies (Mezzanotti, 2021). The values of the patents created by non-litigated technology peers regarding workaround technologies (in the five years after the initial lawsuit) have been examined. The findings show a decline in the number of forward citations, providing evidence that the increase in R&D activities focuses only on strategic technologies. The lower value of R&D brought to potential losses in profitability and operational risks. Indeed, results demonstrate that non-litigated peers reveal a substantial decrease in operational cash flows and returns on assets (ROA) in the five years after the start of PAE's litigation. These reductions are less pronounced in the case of PE's lawsuit. In their annual reports, technology peers describe PAEs' litigations as a potential operational risk.

To summarize, the results demonstrate that sequential litigation strategies of PAEs bring to substantially high market value losses for at-risk technology peer firms. This documents that an eventual decrease in shareholder wealth might be caused not only by the direct litigation risk of defendants, as suggested by Cohen (2019), but it expands by their technology peers. Hence, the number of corporates affected by PAEs is greater than thought. Moreover, these findings highlight the two types of reactions of defendant companies and their technology peers, regarding R&D activities. Cohen (2019) verified that defendant companies reduce their investments in R&D during and after litigations with PAEs due to heavy settlement and legal costs. This study showed the increase in R&D expenditures of technology peers after the announcement of a PAE's litigation. However, these investments are strategic to reduce the risk of potential lawsuits and do not generate valuable patents. On the contrary, they bring operational damages and reductions of cash flows, once again highlighting the detrimental effect of assertion entities towards innovation.

Up to now, all the studies highlighted the negative impact of PAEs on R&D investments mostly from a financial perspective. The authors have examined the R&D expenditures, the products' sales, the firms that PAEs favor to target and the economic impacts on peers. With the following study, Lee et al. (2019) wanted to bring attention to how firms change their patenting strategies after having experienced a lawsuit against PAEs.

Firms that already experienced a PAE's litigation seek strategies for alleviating the risks of further PAE's assertions. As we know, PAEs are non-practicing entities, thus they are invulnerable to both the end of an eventual business relationship and the counter-attack of sued operating companies. When the defendant and the plaintiff are both manufacturers, the defendant has the possibility to cross-license patents or retaliate through other patents' infringements (Lemley, Shapiro, 2006). Manufacturers use patents as leverage in negotiations, exploiting the risk of mutual holdup (Lerner, 2006). However, if one party is a PAE, this is not feasible because assertion entities are not market competitors. Thus, defendants during PAEs attacks have only two choices: bearing the high costs of litigations or settling for a lower amount than the litigation. Moreover, as demonstrated in the previous chapter, the characteristics of disputed patents differ between PAEs and PEs.

In view of the above, when there are disputes between parties with interlocking business relationships (PE vs PE), the conduct would be different compared to disputes against PAEs. These differences in the characteristics of litigations indicate the need for firms to adapt their strategies to assertion activities operated by assertion entities. In addition, considering the growing number of PAEs' litigations, a firm's endurance is subordinate also to its effective responses to assertion attacks. Accordingly, Lee et al. (2019), decided to analyze the change in firms' patent strategies after a PAE's lawsuits. In other words, they examined the effect of patent disputes brought by PAEs on innovation strategies at the corporate level.

Pitkethly (2001) defined patent strategies as "intellectual property that can be combined with other resources or used alone, to reach company's strategic objectives". He divided firms' patent strategies into i) external dealings created to acquire external resources and ii) the internal management of the creation and protection of patents. This study focuses on both types of patent strategies, examining corporates' way of developing/acquiring patents and the innovative path undertaken, after a PAE's attack.

Lee et al. (2019) analyzed patents issued in the U.S. medical device sector from 2000 to 2016. They found evidence regarding the assumption that a patent PAE's lawsuit affects corporate's patenting activities. The study concentrated on how patents are obtained and applied after being defendants in litigation initiated by PAEs. The findings suggest that corporates, who experienced a litigation started by a PAE, were more likely to enlarge their search scope and to

apply their patents in broader technology areas. Indeed, firms with previous experiences of lawsuits against PAEs tend to avoid technologies similar to those already litigated, trying to prevent an additional lawsuit (Lemley, Shapiro, 2006). Therefore, after the legal difficulties with a PAE, corporates prefer to broaden their innovation search in less crowded areas, hence with lower danger of infringement.

In addition, the authors found that, after PAE's attack, patents were attained through acquisitions and co-patenting in the market for technology. The reasons for both these types of choices are understandable. Acquisition is preferred because when companies see their innovative paths obstructed by assertion entities, they have to look for alternatives. However, an alternative technology is difficult to be realized in the short term. Then, according to the possibility of trade offered by the market for technology, firms will seek there the appropriate developed technology.

Instead, co-patenting allows to distribute R&D expenditures among several firms, thereby considerably decreasing the risks connected to brand-new innovative projects. When a firm is sued by a PAE, usually it tries to invent around the disputed patent to keep constant the level of investments in the same market. Nevertheless, keeping the same levels of investment during patenting lawsuits seems to be very complicated, due to the enormous litigation costs that might force the firm to downsize R&D activities. Moreover, usually the alleged infringer must pause the use of the disputed technology during litigation, to wait for the judgment (Lemley, Shapiro, 2007). These two factors increase uncertainty in companies' patenting activities. Hence, this study found that firms who have already experienced PAEs' litigations and want to increase their R&D expenditures, will find a strong incentive in spreading costs and uncertainty with other firms. For these firms, collaboration in the patenting activity is crucial to the recognition and prevention of trolls (Penin, 2012). The more a market is dynamic, fast-growing and large, the more uncertainty will be a problem, and the more monitoring processes are necessary to prevent PAEs' actions. Therefore, firms are more likely to collaborate.

With this study, it has been introduced a new point of view. Corporates, that have experienced litigation brought by PAEs, decide to change their innovative strategies by looking for patents in different technological fields, compared to the previously litigated technology, and preferably in not crowded areas, to reduce the risk of another attack. But, they also prefer to acquire patents in the market or develop them in collaboration with other corporates.

Instead of looking at the reduction in the investments regarding the litigated technology, according to the authors, it should be appreciated the opportunity to change the innovative path and focus on a new technology area. They sustain that, in some cases, acquisitions and co-patenting might represent a better way to realize the needs of the corporate. However, it must

be considered that the growing complexity of many technology fields and the consequent diffusion of PAEs will make patent litigations almost inevitable. What we know for sure is that the principal target of assertion entities are startups, and a firm in its early stages rarely has the financial and operational expertise to change its innovative trajectory. Therefore, this modification of the innovative path might be lethal for most firms.

3.2 Impact on small firms and startups

As previously anticipated by Smeets (2014), PAEs' lawsuits reduce innovation, particularly if the defendant is a small firm. In this section, we will provide evidence of the PAEs' preference for startups and small firms, and why this occurs.

One of the fundamental elements of the patent system are startups. They can be conceived both as constituents of innovation and as targets of patent lawsuits (Chien, 2013). The Engine and the Kauffman Foundation sustains that "high-tech startups are an essential factor for job creation in the US." (Kauffman.org). Startups are a great source of innovation, employment and new wealth (Chen et al., 2023). For these reasons, among others, PAEs are conflicting for startups, more than for any other innovator, since they have the potential to help as well as harm innovative companies. Firms with less than 10 million dollars in revenue compose 55% of the defendants in PAE lawsuits. This type of behavior seems to discriminate PAEs from operating firms, which sue small companies only 16% of the time (Chien, 2012). With their thin margins, high rates of innovation and focused operations, startups cannot engage in expensive and burdensome litigations to defend themselves against assertion entities or to sue potential infringers. Accordingly, they are an easy target for patent lawsuits. However, startups might also benefit from assertion entities; they have the possibility to monetize their patents through PAEs, thus not wasting crucial resources by engaging in cumbersome lawsuits. Indeed, startups do not have the deep knowledge of the patent system that large companies have, and an intermediary that asserts innovations on their behalf might be helpful. But understanding in what way startups are influenced by PAEs matters. Therefore, Chien (2013) described the experiences of startups with PAEs, surveying about 300 venture capitalists and startups in 2013. She also included surveys regarding patent litigators and startups conducted in 2012, for a total amount of 1100 respondents. She found that about 75% of venture capitalists and 20% of startups have been impacted by a PAE's demand, particularly almost 90% of tech VCs have been targeted. As explained in Chapter 1, PAEs send thousands of "demand letters" where they mention the infringements of patents and propose licensing agreements to avoid lawsuits. Small

innovative firms, such as startups, are vulnerable targets of these demands, due to their lack of bargaining power and their tendency to pay royalties regardless of the merits. One venture capitalist sustained that "If you start being successful, you will be sued by a PAE since, at the beginning of your business history, it is less expensive a settlement than a fight". Moreover, small companies are targets of patent lawsuits because they are great users of other technologies to create their own innovations. Indeed, 40% of the demands concerned the use of another's technology (for instance the implementation of digital scanners or the use of wifi), rather than the innovations developed by the startup. In addition, the number of assertions seems to occur in strategic moments. A manager of private equity claimed in an interview that "PAEs sue at fundamental moments for the startups when they know that the company is afraid to receive a demand that would compromise its value and thus, is more likely to settle". In another study conducted by Chien in 2012, the impact of PAEs on startups is described more deeply.

Primary Response to PAE Demand	**Primary Response**		**Average Cost of Response**		**% of Annual Revenue Spent Resolving Demand**	
	N	**%**	**N**	**Average $**	**N**	**Average $**
Product/Business Change	7	9%	5	32.000	5	13%
Doing nothing	17	**22%**	15	2.400	15	0%
Settlement ($ or equity)	14	18%	12	340.000	12	13%
Fighting in court	9	11%	7	**857.000**	6	24%
Fighting out of court	19	**24%**	18	168.000	18	5%
Other/unresolved/legal fees	13	17%	9	7.000/21.000	8	0/6%
Total	79	-	66	-	64	-

Figure 16. Primary Responses to PAE Demands and Their Costs[34].

[34] Chien, C. (2012). Startups and patent trolls. *Stan. Tech. L. Rev.*, *17*, 461.

From Figure 16, we can see that the first answer to the PAEs' demand is "fighting out of court" (24%) which is much more expensive than the second preferred response, "do nothing" (22%). Indeed, the costs of the answers vary broadly, with "fighting in court" representing the most expensive (857000 dollars, on average). According to further results, these answers are distracting from the core business for 89% of the respondents, also because they require the time of the founder; 63% of them incur a reduction of the annual revenues. Particularly, "fighting in court" means employing 24% of the yearly revenues to resist against the assertion claims.

Furthermore, Chien (2013) found that venture capitalists and startups experienced mostly non-financial effects after an assertion demand, such as delays in the achievement of business milestones, in hiring new professionals, and the consequent loss of revenues and customers. 49% of venture capitalists experienced one or more significant operational impact and 12% of them were induced to exit a business, due to the expensive lawsuits brought by PAEs.

Finally, most venture capitalists from pharma, medical equipment and biotechnologies sectors, believe that patents are the key driver to innovation and about 5% of startups encounter some benefits from the sale of their patents to PAEs. However, almost all of the venture capitalists, including those who sold their patents to PAEs, believe that assertion entities are detrimental to innovation. Although their experienced benefits of relying on PAEs, these venture capitalists think that "an entity that uses the IP of a firm to sue another firm can only be an enemy of innovation". 83% of them strongly disagreed that the monetization of patents through PAEs helps innovation.

According to the reported responses, patent assertions damage startups when these firms are more vulnerable and least able to fight; assertion entities have crucial and, in some cases, devastating impacts on the novel firm, that prefers to settle and avoid tragic consequences. Therefore, most part of the interviewees, also those that benefit from PAEs, strongly agreed with the affirmation that assertion entities are damaging innovation in their industry. As showed by comments of the directly involved parties, PAEs reduce the value of innovative firms and increase frictions in technology transactions, going against the patent system purpose. Companies that operate with patents already bear some risks associated with them, but with the introduction of PAEs, those risks appear to be "unbounded".

With this study, we add other characteristics to the "perfect target" for PAEs. They must be startups or small innovative firms (Chien, 2013), with a small legal team (Cohen et al., 2019), with patents in crowded technology areas (Lee et al., 2019) and with a recent cash injection (Cohen et al., 2019). And, we also observed how startups respond to the actions of assertion entities. However, there is an additional aspect that must be considered when talking about

startups. A startup to operate needs the initial support of investors. But, operating in industries where the presence of PAEs is pervasive, such as ICT sectors, might discourage this starting support.

In their paper, Kiebzak, Rafert and Tucker (2016) empirically explore how venture capital investments change according to different degrees of patent litigation in various American industries. The highest level of patent litigation occurs when PAEs operate in the sector.

Venture capital investment can be considered as an exhaustive measure of the effectiveness of entrepreneurial activity since the higher the level of investments the higher will be the probability that the startup financed by these investments will be successful, or at least, has the possibility to be successful. One of the methods used by investors to decide whether a startup is worthy of trust or not is trying to understand if the firm could be a possible target for patent litigations (Kiebzak et al., 2016). If the answer is positive then they would avoid investing in that startup, whose probability to start operating sharply decreases.

The authors tracked each patent litigation filed in every U.S. Federal District Court over the period 1995-2012 and designed a model including three factors.

The first factor is the number of granted patents, which is connected positively with the number of patents that can be potentially litigated. Granted patents reflect also the degree of innovation in that industry and hence the attractiveness for VC funding. Hence, this factor depicts a positive link between VC funds and patent litigation. The higher is the number of granted patents, the higher the probability of a venture capital investment but also of patent litigations.

The second factor is the effectiveness of the patent system's protecting role. Investors might see higher levels of patent litigation in that industry as evidence of a well-running patent system that is able to shield their funding. However, this positive relationship exists only in the early stages, when patent litigation can still be the "proof" of the court's effectiveness in defending the IP rights of the patent's owner. When patent litigation becomes extensive, thus probably linked to opportunistic behaviors, any incremental degree of litigation will bring a decrease in VC investments. This factor's effect on the relationship between VC investments and the degree of patent litigation is ambiguous.

The third factor represents the fuzzy boundaries of asserted patents. The vagueness of patents' scope brings not only to a greater amount of opportunistic litigations but also to the uncertainty of the legal outcomes. Patents without a well-defined scope make the judgment over the case more difficult and time-consuming. Both the number of opportunistic litigations and the uncertainty of the outcomes dissuade venture capitalists from investing, due to the possible pending royalties to be paid by the startup. In this case, the relationship between the degree of litigation and VC investments is clearly negative.

Through the mix of these three factors, the authors found an inverted U-shaped relation between the probability of patent litigation and the degree of entrepreneurial activity (or venture capital investments). They identified a positive relationship between patent litigation and VC funding for low degree of litigations, meaning that an increase in the probability of a firm to incur in patent litigation consists of more venture capital investments. But subsequently, when patent litigation increases, the relationship becomes negative, meaning that a further increase in the probability of patent litigation for a startup consists of lower venture capital investments.

In addition, the authors found that this negative relationship is even more evident if the startup has to face large asymmetric litigation costs, like against PAEs. In this case, there is less potential for a positive correlation between patent litigation and VC funding, because litigations initiated by a PAE (frequent litigator) have only detrimental effects on VC investments. Indeed, litigations brought by PAEs are surely opportunistic litigations, as demonstrated in the second chapter, and they cannot, in any case, increase the attractiveness of an industry. The frivolous lawsuits, the exploitation of holdup situations, the uncertainty of legal outcomes, and the massive litigation costs are some of the burdens that startups must carry during PAEs' attacks. And they are so heavy that venture capitalists could never think of investing in them.

This explanation is confirmed by the numerical results. The results show the direct negative effect on VC funding from litigations coming from a PAE (frequent litigator). In particular, keeping everything else constant, each patent litigated by PAEs will lower VC funding in the district by 2,7 million dollars. Furthermore, results demonstrate that PAEs have stopped 21,772 billion dollars of VC investments on startups that, compared to the 130 billions of the total investments in startups and innovation over the analyzed period, represent a significant rate. This is an obvious contraction of innovation.

These findings are supported by the survey of Feldman (2013), where 200 venture capitalists argued that an extant patent demand (referring to the above-mentioned "Demanding behavior") on a startup is a big deterrent for investments since the impacts on operational costs are huge in terms of costs to hire professionals that manage demands issues but also in terms of distractions of the management. One firm declared that the expenditures of dealing with patent demands are their second biggest cost after salaries.

In the end, we can say that PAEs' opportunistic behaviors lead to a negative relationship between patent litigation by frequent litigators and venture capital investments, which does not occur with low levels of general patent litigation. Accordingly, assertion entities discourage capital injections to startups, hence deterring the development of the key drivers for innovation.

3.3 Impact on individual inventors

The idea that PAEs operate as intermediaries to lighten asymmetries between individual inventors and producing firms is well-established in the literature (Hagui, Yoffie, 2013). For instance, Golden (2007) argues that limited resources and the excessive costs of litigation drive individual innovators to settle for a much lower value of their intellectual property, compared to the full value. Similarly, McDonough (2006) sustains that PAEs improve the liquidity and efficiency of the market for technology because patent holders do not have the necessary financial resources to face large manufacturers in court. Recently, Risch (2012) suggests that inventors decide to sell to PAEs because they are not able to formulate a credible threat to manufacturers. In support of these last affirmations, Haber and Werfel (2015) conducted a survey experiment that verifies that the asymmetries in financial resources, between individual inventors and large producing firms, impede individuals from credibly threatening potential infringers. This occurs because, in the first place, individuals may not sustain the initial costs of litigation. Second, unsuccessful litigations can result in the bankruptcy of the inventor. Therefore, PAEs promise to individual innovators future profits coming from patented technologies, without dealing with costly litigations.

Finally, Steensma et al. (2016) identified an additional aspect regarding individual inventors. According to them, the main reason which leads individual investors to rely on PAEs is the considerable obstruction posed by transaction costs.

Transaction costs, incurred by inventors when licensing their patented technologies directly to commercializing companies, include i) those related to the search for potential acquirers, ii) those to negotiate licensing contracts, and iii) those to eventually assert patents against potential infringers. Inventors cannot be efficient in performing all these operations (Steensma et al.,2016). Sometimes, they are not able to perform any of them. These cases occur with focused inventors. The study of Chari et al. (2022) divides two types of inventors. The first type, the mentioned focused inventors, includes those with a limited ability to sell their inventions, such as small firms, universities, independent inventors and research laboratories. These usually rely on bilateral licensing agreements to monetize their inventions, since gaining the manufacturing and marketing experience to commercialize them on their own implies prohibitive costs (Gans et al., 2000). Furthermore, without the commercialization of their products and thus, their presence in the market for products, they cannot exploit cross-licensing agreements with other operating firms (Chari et al., 2022).

The second type of inventors, commercializing inventors, includes large companies that have both R&D capabilities and the necessary resources to produce and sell their inventions. This kind of inventors do not depend on others to monetize their technologies.

PAEs might be the perfect intermediaries. They are specialized in the acquisition and assertion of patents, but also in the negotiation of licensing agreements. They can more efficiently recognize potential infringers and profitable licensees. Accordingly, they can reach the economies of scale in these operations better than any other institution. Moreover, a threat of litigation seems to be more credible if coming from an expert of assertions, than from an inventor without adequate resources. In addition, PAEs are in a better position than commercializing firms or manufacturers, as they do not risk any counter-litigation, given that they do not produce. The efficiency and effectiveness of these entities can be useful for focused inventors to identify potential infringers of their patents and monetize their inventions. The intermediation of PAEs reduces the transaction costs associated with the issues of finding the right licensees and enforcing patents on their own. This can represent a crucial incentive for inventors to stimulate their innovative activities in a given technology class. And in that technology class, also attracting new focused inventors.

In the analysis of Chari et al. (2022), the focus will be individual inventors and in particular, how through the intermediation of PAEs, a focused inventor may be influenced to start and/or increase his invention activities in a certain technology class. The authors consider an alternative perspective regarding assertion entities. They view PAEs as market-makers that instill liquidity into the market for technologies and help focused inventors to gain revenues from their inventions, that would be lost due to potential infringers (McDonough, 2006).

As assertion entities inflict heavy damages on commercializing inventors and disincentivize their R&D activities, at the same time they act as “tax collectors” in the name of inventors from whom they acquire patents (Orsatti, Sterzi, 2018).

Chari et al. (2022) built their dataset using information coming from RPX and restricted their evaluation to infringement lawsuits filed by PAEs in 97 USPTO technologies classes, from 2002 through 2017. They found that a larger amount of focused inventors become active in technology fields where PAE intermediation increases. Further, as PAE intermediation grows in a given technology class, focused inventors increase their rates of patents, even more than commercializing inventors.

In addition, the intermediation role played by PAEs may also influence the type of technologies produced. The results show that as PAE intermediation increases in a given technology area, focused inventors are stimulated to patent incremental inventions. Incremental inventions are those that make fewer advancements to actual technologies (Hargadon & Sutton,1997); they usually refer to the prior art of a narrow technological field and are redundant with the already existing technologies in that field. Usually, the claims of patented incremental inventions overlap with the claims of other complementary inventions. Hence, commercializing firms must

acquire the full bundle of complementary patents to avoid the risk of infringement of complementary technologies. This kind of patent bundling is widely used in industries like semiconductors. Coordinating all the patent owners to license out all the complementary incremental patents and create the bundle is particularly costly, especially in such industries characterized by the fragmentation of IP rights. However, PAEs can exploit experience and scales in the acquisition and negotiation of patents, in order to economize on these coordination costs and efficiently bundle complementary incremental inventions, but also assert these bundles against potential infringers. Therefore, PAE intermediation is more efficient when inventors focus on incremental innovations because the formation of complementary patent bundles and the assertion activity against infringers are mostly required by this type of invention. This is why PAEs incentivize more incremental innovations. Again, this kind of incentive regards exclusively focused inventors since commercializing inventors can rely on other methods, like cross-licensing agreements.

To conclude, PAE intermediation reduces the expected cost for focused inventors to monetize their patented inventions, in technology classes where assertion entities operate. This works only for focused inventors because they rely more on bilateral agreements and thus, suffer more due to high transaction costs. The efficiency of PAEs in bundling and monetizing incremental activities stimulates inventors to increase their rates of incremental patented inventions, that otherwise would be unprofitable.

However, we cannot forget that Cohen et al. (2019) found something different. Examining the technological fields where PAEs were most active, they observed no significant increase in innovative efforts by individual inventors.

This study provides an additional view of how PAEs influence innovation. Through the alleviation of transaction costs between inventors and commercializing firms, assertion entities allow both of them to specialize in their respective activities. As a result, economies of scale can be reached by both entities. For commercializing entities might be difficult to find the incentive to further innovate due to organizational inertia, the risk-aversion towards unknown technologies and the possible cannibalization of existing products (Ahujia, Lampert, 2001).

However, PAE intermediation stimulates focused inventors to develop only incremental inventions. As we know, PAEs operate mostly in high-tech, semiconductors and telecommunication sectors, where patent claims tend to be fuzzy and overlap. These entities have the necessary experience to bundle overlapping patents and assert them against infringers, helping focused inventors. Although these kinds of actions foster innovation, the findings of this study indicate a potentially vicious cycle; by lightening market imperfections regarding

transaction costs, PAEs incentivize the production of incremental inventions that overlap already existing technologies, incentivizing also the assertion activities to protect them, thus increasing the number of litigations. Litigations represent a crucial issue for producing companies, as demonstrated in previous studies. PAEs' actions increase the costs for producing companies and reduce their incentives to sustain R&D activities. Indeed, while PAE intermediation encourages innovation among focused inventors, it does so through the damage of the innovative efforts of the targeted operating companies. Finally, PAE intermediation stimulates only incremental innovations and not the more significant disruptive technologies.

However, it cannot be omitted that the number of inventors who operate individually, thus not in the R&D department of a company, are a small minority. (Bhaskarabhatla et al., 2021) Moreover, if we exclude also those that, to commercialize their inventions, decide to open their own firms, the number is even smaller (Weick, 2005). Therefore, the real help of PAEs towards individual inventors is not able to offset the costs of assertion entities' litigations and the associated reduction of R&D activities at targeted firms.

Up to now, we have observed the reduction of the expenditures and of the effort in R&D of the targeted companies, but the only evaluation of the costs imposed by assertion entities has been made by Chien (2012), precisely regarding startups. In the next section, some authors tried to quantify the costs that PAEs impose on society and also what is the remuneration that investors receive from the sale of their patents to assertion entities.

3.4 Direct and social costs of PAEs

To conclude this discussion on the impact of assertion entities on companies and inventors, Bessen and Meurer (2013) composed an essay where they present some data about a set of firms targeted by PAEs and estimate the direct costs incurred by these defendants over the period 2005-2011, due to PAEs' litigations.

Direct costs consist of legal services, licensing fees, and other costs that emerged in response to the litigation risk brought by PAEs. The authors combined information derived from a survey of about 250 companies sued by PAEs, conducted by RPX in 2012, with data coming from PAEs' financial disclosures. Bessen and Meurer's (2013) study stands out in corporate literature because of three characteristics. First, it discloses some information on the costs of PAE's litigations that are settled before the cases are filed in court. Second, it contains data about small defendant firms, that are privately held. By including all those firms not publicly listed, the survey provides further evidence to determine whether PAEs help small and medium firms to gain revenues from their innovations or whether they incur in excessively high costs that cannot be counterbalanced by revenues. Third, it includes secret information on PAEs' licensing fees,

even those about assertions not filed in court, that are not available in most of other studies.
In another paper of 2011, Bessen, Meurer and Ford found that the yearly losses from PAE's litigations were around 80 billion dollars, for publicly traded American corporates. However, this analysis was slightly different from the subsequent (Bessen, Meurer, 2013). Indeed, they did not ask defendants to report direct costs (as in Bessen, Meurer, 2013), but observed the reactions of the stock market to the news of a litigation initiated by a PAE against a listed company. Hence, in 2011, they computed litigation costs by looking at the price movements in the stock market, after the lawsuits' filing. Clearly, the costs considered were not only the direct costs of litigations but the total costs (indirect+direct) associated with the reaction in the market to the PAEs lawsuit's announcement. The included indirect costs contained also the costs of the effort exerted by the managerial, legal and engineering staff of the firm, and other costs associated to business disruption like the decline of innovative activities, a lower market share and a loss of goodwill. According to these reasons, the following results of Bessen and Meurer, estimated in 2013, are quite different.

	Direct Legal Costs		**Licensing Costs**		**Total Cost**	
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**
All	**1,38**	0,20	**6,53**	0,22	**7,91**	0,56
Company Size						
Small/Medium	**0,42**	0,07	**1,33**	0,18	**1,75**	0,32
Large	**1,52**	0,23	**7,27**	0,23	**8,79**	0,65
Industry						
Software	1,50	0,17	1,82	0,30	3,32	0,55
Hardware	1,33	0,21	8,14	0,18	9,48	0,59

Figure 17. Litigation costs for defendants, in millions of dollars[35].

In Figure 17, it can be observed the estimates of mean legal costs, licensing costs (license and settlement costs) and total costs (legal costs+licensing costs). The mean of total costs for defendants during a PAE's attack is 7,91 million dollars. As might be expected, mean total costs are greater for large firms than for small and medium firms. In the first Column, mean legal costs extend from 420 thousand dollars for SMEs to 1,52 million dollars for large companies. In Column 2, it has been reported the costs to settle the case. On average, small and medium

[35] Bessen, J., & Meurer, M. J. (2013). The direct costs from NPE disputes. *Cornell L. Rev.*, *99*, 387.

firms pay 1,33 million dollars to settle, compared to the 7,27 million of large firms. The direct legal costs represent around one-quarter as large as licensing costs or about one-fifth of total costs. Thus, as expected, a significant part of the direct costs paid by defendants in PAEs' litigations are due to settlement. The expression social loss concerns socially wasteful activities, such as the deviation of managerial resources from the R&D field to lawsuits (Bessen et al., 2011).

If compared with further results about firms' revenues, found by Bessen and Meurer, the results in Figure 18 can be useful also to say that PAEs litigations are relatively more expensive for small and medium companies. Particularly, large companies' total costs were five times higher than small and medium companies' total costs. But, the average revenue of large companies is almost seven times the average revenue of SMEs. Thus, we can conclude that damages to small firms are heavier than for large firms, relative to their size. Hardware companies incur in higher costs than software companies. Considering that usually hardware companies have bigger sunk costs than software companies (Bessen et al., 2011), we can say that the likelihood of being subject to holdup problems for hardware companies is greater than software companies, thus they incur in higher settlement costs.

Moreover, according to the fact that many patent assertions are settled without any lawsuit, the authors demanded information about the costs of non-litigated assertions. Those costs include settlement costs and the legal fees for the attorneys, hence are different from the previous data that were about decisions taken after the initial filing of the lawsuit. Even if only 46 companies replied, the results are interesting. The sum of all the non-litigation costs for large companies is around half of all the litigation costs. Instead, for SMEs non-litigation costs are higher than costs for litigation in court. The explanation might be that smaller firms lack internal legal resources, making it relatively more expensive for them to fight in a lawsuit, thus the most followed path for them is to settle. Anyhow, it is well-known that settlements out of the court represent the largest part of the direct costs paid by practicing entities in PAEs' litigations. Hence, the costs estimated in Figure 17 and in the following Figure 18 probably underestimate the real costs of all those small companies that, lacking the necessary legal power to undertake a lawsuit, settle in order to avoid courts.

In addition, the authors aggregated information about lawsuits from 2005 to 2011, computing the total costs that affected operating companies in those years.

	Number of Defenses		Aggregate Direct Accrued Costs (millions)		
Year	**Small/Medium**	**Large**	**Small/Medium**	**Large**	**Total**
2005	919	482	2.916$	3.657$	**6.574$**
2006	899	530	2.853$	4.021$	**6.874$**
2007	1238	976	3.929$	7.406$	**11.334$**
2008	1571	1004	4.985$	7.618$	**12.603$**
2009	1461	1198	4.636$	9.090$	**13.726$**
2010	2588	1857	8.213$	14.090$	**22.303$**
2011	3424	2418	10.866$	18.347$	**29.213$**
Size Shares	59%	41%	37%	63%	

Figure 18. Aggregated accrued direct costs for defendants, by year[36]

Figure 18 shows aggregate accrued costs composed by settlement costs, legal costs, and other costs for every type of case (resolved lawsuits, unresolved lawsuits and nonlitigated assertions). The costs for unresolved lawsuits were computed by multiplying the mean cost of each size category (SMEs and large enterprises) every year by the number of lawsuits in that year. The left part of Figure 18 shows the annual amount of defenses against PAEs attacks for each size category. The right part reports the aggregate cost of PAEs' assertions. The last column sums both categories for each year. Aggregate direct costs of PAEs' litigations grew from 7 billion dollars in 2005 to 29 billion dollars in 2011.

In the study of Bessen, Meurer and Ford (2011), the total costs (loss of stock market value) were about 80 billion dollars. However, as specified before, those were total costs that include also social losses like delays in the development of new products, losses of revenues, redeployment of engineering or managerial resources, changes in the innovative path. And these costs correspond to about half of the total amount. Even if the samples cannot be compared,

[36] Bessen, J., & Meurer, M. J. (2013). The direct costs from NPE disputes. *Cornell L. Rev.*, *99*, 387.

one hypothesis might be that total business costs for PAEs' assertions in this case are at least twice as high as those reported in Figure 18. And considering that the total R&D expenditures in 2011 have been 428 billion dollars (nsf.gov), a tax on innovation of about 58 billions is not negligible.

In the end, the authors estimated also the amount of money transferred from PAEs to inventors of the innovations asserted by PAEs, considering both royalties and the price paid by the assertion entity for the acquisition of the patents. Inventors who rely on PAEs, both large and small firms, obtain only 7% of the total licensing fees gained by these entities, which is 5% of firms' expenses to fight PAEs.

Based on these findings, it cannot be sustained that PAEs incentive innovation. First, if we add the hypothetical, but plausible, operational and social costs to direct costs computed by the aforementioned analysis, the total costs resulting from PAEs' assertions are massive. The return to investors is insignificant, compared to the relative costs arising from patents lawsuits. Thus, the negative effect cannot be offset.

Second, small and medium corporates are more damaged by PAEs because their ratio of "costs caused by PAEs/revenues" is higher than the same ratio for large firms. And, as found in previous studies, most of the defendants in PAEs' lawsuits are SMEs, including startups. Moreover, Chien (2012) observed that only one-half of the patents litigated by PAEs come from small firms and independent inventors, meaning that assertion entities do not even try to encourage in any way innovation (or that those firms and inventors prefer to avoid PAEs). All these evidence to conclude that PAEs hinder small firms, thus discouraging innovation.

Third, the incentives provided by PAEs' activity to small inventors might divert the research agenda of small companies from disruptive innovations, preferring vague and conventional patented technologies that can be easily asserted against a great number of potential infringers, including large firms.

A 29 billion dollar tax on innovation is a problem. Just a very small portion of this tax is transferred to innovators, instead most of the amount is dissipated among PAE's owner and/or employees and the attorneys that represent either the PAE or the defendant. These 29 billion dollars of direct costs are entirely borne by operating companies that decide to innovate and thus, to take the always more pervasive risk of PAE's litigation. It is important to keep in mind that this result does not include the costs for settlement before arriving in court (the 46 respondent companies were not included), therefore it clearly underestimates the true loss of wealth.

3.5 Concluding remarks

At this point, we can conclude this discussion about the impact of Patent Assertion Entities on the R&D activities, of targeted firms and innovators, by saying that PAEs impede technological progress. The 20% reduction in innovative R&D expenditures (Cohen et al., 2019), the decision to block the production and the sales during litigations initiated by PAEs (Tucker, 2014), but also the decrease in the market value of the defendant's peers and their consequent shift to the development of strategic technologies (Chen et al., 2023) and their general change in corporates' patenting strategies (Lee et al., 2019) bring to a self-explanatory result. These considerable limits imposed by PAEs, combined with the direct and total costs to technology firms (Bessen et al., 2011; Bessen, Meurer, 2014), represent a heavy burden to innovation. These losses and costs imply a very large disincentive to innovation for these firms, also considering that these firms usually commit heavily to R&D. Bessen and Meurer (2013) showed that the more a firm invests in innovative activities, the more likely it is to be accused of patent infringement. Exactly what was demonstrated by Chien (2013), who sustained that startups, the key drivers for technological growth, are the preferred targets of PAEs. This means that companies, especially small firms and startups, have to foresee future litigation-related losses as part of their costs of developing new technologies. This risk discourages any investment in innovation, and it is much bigger than any possible incentive coming from transfers to independent inventors. Independent inventors are effectively helped by assertion entities (Chari et al., 2022) but this is the only positive aspect found in the discussion, even if not all the authors agree (see Cohen et al., 2019). Although incentives to small inventors were more generous than incentives offered to big operating companies, that produce in some cases even 10 times more than individuals (Bessen et al., 2011), these incentives would not counterbalance the massive disincentives charged to operating companies, and the final impact on innovation remains largely negative.

Finally, assertion entities provide to patent holders only the wrong type of incentives. As observed by Chen et al. (2023), Lee et al. (2019), and Chien (2013), PAEs' activity alters the innovative paths of both small and large firms, shifting their research agenda from disruptive technologies to ordinary technologies, that can be litigated against a large number of incumbents. Even worse, PAEs encourage mainly small firms, those more fearful of litigations (Bessen, Meure, 2013), to invest in broad patents with blurry boundaries that will lead to credible, but weak, lawsuits. As explained in the previous chapter, the number of litigations brought by PAEs is increasing, but rarely the defendants of these lawsuits are deemed infringers of the patented technology. Indeed, the rate of loss in court of assertion entities is much higher than the rate for operating firms. Therefore, PAEs' litigations drive avoidable costs and losses

rather than benefits. Defendant operating companies lose, while individual inventors gain very little. It seems that the only real beneficiaries of these practices are PAEs' owners and the lawyers of all the parties.

Chapter 4. Proposals to reform the patent system

This literature review has highlighted the problematic position of Patent Assertion Entities in the market for technology. Specifically, the issue of these entities' influence on innovation has been addressed and the overall negative impact is evident.

In the US, since 2010, the Congress has implemented many bills in order to reduce patent trolling behavior. In 2011, the America Invents Act was enacted, resulting in substantial changes in the American patent law regarding patent quality, such as the strengthening of the requirements for patentability or the prohibition to sue more defendants with a single suit. However, most of the findings of this literature review are subsequent to 2011, hence it is clear that still much work must be done to further regulate the PAEs' action. The evidence documented above should alert policymakers that the patent system needs substantial reforms to increase its effectiveness and promote innovation, especially looking at the potentially massive costs for society found by Bessen and Meurer (2011; 2013). This chapter will propose some suggestions to operate this change through legislative reformations. These suggestions aim at reducing the asymmetries between operating companies and PAEs, thus curtailing frivolous litigations. In addition, will be proposed also some solutions regarding the specific topic of small firms and independent inventors, given their large difficulties in defending themselves against PAEs.

These suggestions have the objective to explain that the path is still long and complex but some legislative or judicial reforms can help to make progress in the right direction. The crucial challenge for policymakers will be to introduce reformations that limit trolling activity but, at the same time, are not harmful to innovative activities (Penin, 2012).

Some authors sustained that a pro-patentee law would increase the levels of innovative activities, and thus of innovation. Hall and Ziedonis (2001) demonstrated that stronger legal protection of patent holders is connected with an increment in the number of patents in the American semiconductor industry. The authors took into consideration two effects that influence the amount of patents in a firm's portfolio. First, with a more permissive patent law, each patent has a higher probability of being held valid in court, even with low legal value. If the risk of being judged invalid is high, a firm would defend an important technology with many patents concerning every aspect of that technology, in order to reduce the impact of a potential patent invalidity (Hou et al., 2023). But, with a permissive patent law, the advantage of possessing a large number of patents is lower because one of them is "strong" enough to protect the concerned technology. Hence, firms create fewer patents (negative effect on patenting). The

other effect works on the opposite direction: with patents more likely to be held valid in court, the costs of patent protection would be lower[37], thus increasing the demand for more protection by companies (positive effect on patenting). Hall and Ziedonis (2001) found that the balance between these two effects has a positive outcome on the number of patents (the positive effect on patenting dominates).

On the other hand, opposite results are found by Hou et al. (2023). They demonstrated how general manufacturing companies adapt their strategic patenting to a stronger legal protection (or permissive patent law). In strategic patenting, the authors included either the firms' purpose of issuing patents to increase their bargaining power over other firms producing complementary technologies or the firms' purpose of issuing patents to block or defend against competitors. Besides, as permissive laws the authors considered the action of the Federal Circuit Appeals Court (CAFC) that, in 1982, unified the courts of appeals and harmonized the interpretation of the patent law, thus shifting its decisions towards patent holders. The authors' results showed that CAFC's shift to a more permissive patent law was associated with a 23,3% decrease in strategic patenting. Therefore, manufacturing companies decided to decrease their innovative effort subsequent to the introduction of stronger protection.

These two studies suggest that a more permissive patent law towards patent holders has ambiguous effects on the number of patents released. However, what is sure is that the legal value of patents would decrease since their likelihood to be held valid in court increases, not due to the improvement of patentability requirements but due to the "kindness" of judges. Therefore, as we learned earlier, a shift in patent law that advantages PAEs, the owners of the patented technologies, is obviously bad news for innovation, regardless of the effect on the number of issued patents.

As documented by the two above-mentioned studies, even if the results are in some cases unclear, a shift in the patent law will influence the behavior of operating companies and consequently their innovative activities. Hence, well-conceived normative and judicial responses might be a valid attempt to solve or, at least, alleviate PAEs' issues.

4.1 How to reduce frivolous litigations

One of the problems faced in this analysis, concerning the low legal quality of patents and the consequent diffusion of trivial disputes, is the leniency of the examiners. The findings of Feng and Jaravel (2020) regarding the examination process suggest some reformations to regulate PAEs. Particularly, it has been demonstrated that lenient examiners are prone to issue patents

[37] The costs of patent protection are lower with more permissive laws because fewer invalidations will be produced during the prosecution process, thus filing a patent is less time-consuming and less expensive.

that have a high probability of being litigated and that PAEs select and litigate these kinds of patents. This evidence leads to the idea that policies regarding the behaviors of patent examiners (especially lenient examiners) might largely affect PAEs' litigations. Indeed, in February 2015, the Enhanced Patent Quality Initiative was launched by the USPTO. This campaign had the goals of improving work methods and measurements of patent quality, but also of educating examiners to strictly comply with patent laws (uspto.gov). The introduction of HR regulations in the patent office might be a useful complement to all the other policies aimed at limiting assertion activities.

Also, Bessen and Meurer (2013) call for a more rigorous enforcement of the patentability standards, such as the clarity of claims. In addition, they see the necessity of a constraint regarding the patentability of business methods and other concepts too abstract to define their ownership rights.

In its report, the FTC (2016) recognizes that frivolous infringement litigations can be fought by i) reducing cost and information asymmetries, ii) inducing the disclosure of more information about the plaintiff, iii) suspending the assertion action of a PAE against a customer, if the same PAE has already sued the manufacturer for the same motives and iv) granting that infringement claims are provided with adequate notice to alleged infringers.

Generally, in civil lawsuits, defendants and plaintiffs disclose necessary details about themselves and the case to the other party and to the court. Particularly, in the early stages of the trial, it occurs the exchange of financial records and/or of specific aspects of the development of the targeted product. All these elements are provided by both parties to build a comprehensive evaluation of the potential duration of the trial and the relative costs. Assertion entities do not produce their patented technologies, thus they have less information to disclose. Furthermore, they cannot be counterattacked for patent infringement and, therefore do not face the risk of counterclaims during the disclosure process. This asymmetry in the discovery burdens supplies PAEs with a consistent advantage during litigations. 77% of PAEs' settlements cost less than the estimate of the discovery costs made by the defendants (FTC, 2016). Therefore, discovery costs, and not the technological value of the patents, set the benchmark for defendants to decide on a settlement in PAEs' cases.

For these reasons, one suggestion to decrease these assertion entities' advantages in litigations might be the modification of the Federal Rule of Civil Procedure 26, which regulates the discovery process. By creating an ad hoc discovery plan for PAEs, hence imposing the early disclosure of infringement contentions and asserted claims, the information asymmetries can be balanced. Likewise, provisions that establish a timely decision of preliminary motions and

that order an early discovery of damage claims would provide the necessary information for settlement considerations (Chien, 2013). In general, every proposal that reduces the discovery burden and costs for the defendants will bring a better evaluation of the case and to a more conscious choice.

In the second suggestion, the issue concerns multi-affiliate PAEs[38]. With these kinds of assertion entities, the disclosure of details about the plaintiffs is complex. The financial relationships among the affiliate companies in a multi-affiliate PAE are difficult to define but might be crucial for the defendants' evaluation of the litigation costs and for the judiciary decision. Because of that, it must be requested a specification about the structure, and the internal relationships among affiliates, of every PAE which wants to start a litigation.

The third suggestion regards the simultaneous PAEs' litigations against both the producer and the customers/retailers, on the same theory of infringement (meaning, regarding the same patented technology). These types of redundant litigations charge either the judicial system or the private parties with unnecessary costs. For instance, if a patent results invalid in the case against the manufacturer, it is avoidable a further lawsuit on the same technology against the retailers. On the other side, this is profitable for assertion entities, since the more patent lawsuits can be initiated, the more licensing fees they can extract. Moreover, producers of a patented technology are more knowledgeable and thus better prepared to defend themselves against PAEs, compared to retailers or customers. Indeed, it seems important the enactment of a provision that orders the infringement lawsuits against manufacturers to be resolved before the filing of an additional lawsuit against end-users.

The final point regards the requirement to the plaintiffs, and more specifically to PAEs, of more details about the scope and the nature of alleged infringement. This potential reform might be included in the discovery plan suggested above.

According to Love (2012), two reforms are necessary for the patent system to regulate the activity of assertion entities: a patent term reform and a maintenance fee reform.

With regard to the first point, the Congress of the U.S. may reduce the rate of frivolous litigations by shortening the life of patents by three years or even more. In these years close to the expiration date, producing companies do not assert patented technologies anymore. Instead, as seen in Chapter 2, the practice of enforcing old patents is a common characteristic of PAEs. Specifically, a three-year reduction in patent life would cut short more than 26% of PAE

[38] Multi-affiliate PAEs have some transparency problems. They usually do not disclose the identity of the controlling entity and other related affiliates. In these cases, it might be difficult for the potential licensee to recognize the other party in the litigation. Accordingly, the possibility for the accused firm to determine whether it has already licensed the alleged technology (through a cross-license or a different method) with another party, results highly complicated (FTC, 2016)

litigations and eliminate about 35% of them, while it would impact only 13% of operating companies' lawsuits (Love, 2012).

Some operating companies, as pharmaceutical firms, are extremely skillful in a process called "evergreening"[39] and more in general, they have the possibility to file additional patents covering updated versions of its previous technologies. On the other side, when a patent expires, PAEs, usually, have the only possibility to buy a replacement. For this reason, the reduction of the lifetime of a patent would impact producing companies less than PAEs (Love, 2012). By reducing the patent term, PAEs are forced to litigate supposed infringing products before what they are used to. In some cases, manufacturers might be not already engaged in costly fixed investments and thus, the hold-up power of assertion entities is diminished.

However, this type of reform is not viable in the United States because they are part of the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), which requires to its members a minimum of twenty years of protection of the patented technologies. In case of non-respect of the agreement, the World Trade Organization will sanction the violator (wto.org).

A less radical reform would be to increase the amount and the frequency of the maintenance fees in the second half of the patent's lifetime. As seen in Chapter 2, PAEs are usually those entities that acquire patents in the last years close to the expiration date, thus a maintenance fee might be seen as a tax on them.

Many European countries, including the United Kingdom and Germany, already impose high annual maintenance payments after the early years of patents (epo.org).

Also according to another author, Penin (2012), to increase the patent quality and thus, reduce pointless litigations, a concrete measure may concern the increment of the cost of obtaining and maintaining a patent. In particular, an increase in the fees to file and maintain a patent should deter the strategic use of patents by self-selecting only those with a higher value. Unfortunately, this argument has a clear limitation. A higher amount of fees (pre-grant and post-grant) would mean also higher costs for SMEs. After the dissertation about small firms and startups in the previous chapter, it is now well-known their importance for innovative activities. Hence, a negative impact on them can drive only a substantial negative impact on innovation. However, as argued by De Rassenfosse and von Pottelsbergue (2013), there is a link between patent fees and companies' patenting behaviors, thus further discussions and empirical evidence surrounding this topic must be pursued.

[39] The evergreening process is the strategy of obtaining multiple patents that cover different parts of the same technology to extend the life of a core technology (Feldman, 2022).

4.2 How to protect SMEs and indipendent inventors

Chien (2012), talking about the America Invents Act (AIA), sustained that all the improvements introduced to reduce the cost of litigations for defendants are admirable, but the "elephant in the room" is represented by small companies, against whom the dispute is threatened but not filed.

Many scholars deem startups the key engine of economic growth and innovation (Appel et al., 2019), thus the tendency of PAEs to target these firms must be curbed. The evidence provided in the previous Chapter demonstrated that poor-resources defendants have many more disadvantages in slow and expensive patent trials, compared to large companies. These disadvantages make startups extremely vulnerable to assertion entities. Driven by these concerns, several reforms have been proposed to the Congress since 2012. However, most of them have been rejected. The common fear among the opponents of anti-trolls laws is that PAEs "play a financial intermediary role to support small inventors" and that limiting assertion entities' activity would imply a decrease in the IP rights' protection of the weakest players in the market for technology (Cohen et al., 2019).

Appel et al. (2019) analyzed the adoption of 32 anti-trolls laws in a difference-in-differences framework, to understand how startups and small firms react after the implementation of such laws.

Anti-troll laws were first enforced in the state of Vermont and have two objectives. First, they impose sanctions on the senders of mass demand letters that require excessive licensing fees, private information or payments in a short period of time. Namely, those demand letters that start bad-faith patent infringement assertions. Second, they establish the refund of damages inflicted by PAEs to targeted small firms.

According to the results, reforms that limit PAEs' possibility to lodge bad faith infringement claims drive higher employment percentages at high-tech startups. Notably, startups that operate in a state with anti-troll laws noticed a 4,4% increase in the employment rate. These results regard startups in the information technology (IT) industry, where assertion entities deal more damage. On the contrary, anti-troll legislation does not have any effect on nonhigh-tech industries.

Detractors of these types of norms sustain that the effort to curb PAEs' activities may provoke unintended consequences. For example, increasing the barriers to enforcing patents' rights might lead to the difficulty for startups of legitimately monetizing their inventions, thus disincentivizing innovative activities. On the other side, proponents of anti-troll laws state that making patent infringement claims very costly will encourage innovation. The findings of Appel et al. (2019) demonstrate this latter argument. They found that the number of IT patents

created by startups or individual inventors increases on average by 9%, after the introduction of these reforms. Another important result of this analysis regards the amount of follow on citations (technological patent quality), which in turn increases. Both these effects are substantial in the software industry.

The explanations of the benefits observed by small firms in anti-trolls states might be referred to the high costs of frivolous litigations brought by anti-trolls laws; these laws have the power to directly reduce the threats of PAEs and thus allow small firms to deploy resources in their ability to innovate, and not in pointless legal expenses. Another reason may be the effect of the anti-trolls legislature on the startups' possibility to raise capital. As we have seen in Chapter 3, a demand sent by an assertion entity affects the likelihood for a venture capitalist to invest in the targeted firm, since the presence of PAEs makes startups less attractive to external investments. Therefore, Appel et al. (2019) found that the introduction of anti-troll reforms in a state increases the number of firms that raise VC investments in that state, especially if venture capitalists were already investing there.

Taken together, these findings suggest that with a reduction in the risk faced by startups to be targeted by PAEs, their ability to raise capital increases and they can completely focus their activities on R&D.

This anti-trolls legislature is still at the center of a fierce debate. Some sustain that curbing PAE operations will do more harm than good. The main arguments remain the risk of a challenging monetization of inventions by small firms, the difficulty in legitimately asserting claims, and the lost of important intermediaries that help small inventors (McDonough, 2006). In reality, the real advantage of the reforms listed above is that they can disincentivize only one kind of PAE action: the mass campaign of trivial demand letters. Those NPEs or intermediaries that do not take part in these large-scale attacks do not incur any sanction. According to the results of this study, these anti-troll laws should be adopted by all the states where high-tech sectors are prevailing.

In another survey, Chien (2013) suggested some other legislative and judicial responses to better meet the needs of small firms or independent inventors.

HR regulations in patent offices are valid proposals also to help small companies. By improving the infrastructure and providing the adequate staff, the PTO (Patent and Trademark Office) will be sufficiently empowered to prevent the patenting activity of not-worthy technologies. Examiners must be trained and stimulated to pursue and rigorously apply patentability standards, without looking at the potential risk of jeopardizing the financial results.

Even if enhancing the quality of the patent filings is important, also already granted patents

need some reforms. The AIA (2011) has introduced some methods to challenge ambiguous patents, but they are not very accessible to small firms. For instance, the inter partes review (IPR) requires a considerable upfront investment that cannot even be considered by startups. Low-cost administrative reviews[40] should be developed with the collaboration of the PTO, in order to allow also small companies to identify potential infringers of their inventions without excessive costs or without relying on intermediaries.

Moreover, to minimize the asymmetries between PAEs and small firms, jurisdictions must deal with the high costs of defense in court. One concrete proposal is fee-shifting. Fee-shifting means that PAEs who want to file patent lawsuits have to consider that in case of loss, they would not only pay their own legal expenses, but they will be also in charge of the defense costs of the alleged infringer. This is a practice widely used in Europe and it is probably one of the main reasons for the slow diffusion of PAEs there. With the possibility of fee-shifting, small companies are more likely to go to court and fight, compared to the usual scenario where they must bear the heavy costs of wasteful litigations. Hence, a higher tendency to fight rather than settle discourages PAEs from asserting patents with low legal value. Therefore, Courts should use their discretion to shift fees in order to disincentivize frivolous trials.

Believing in this type of reform, The Stop Hacks and Improve Electronic Data Security Act (SHIELD Act) was enacted in July 2019, in the State of New York (ag.ny.gov). This Act requires PAEs to pay the defendant's fees in case a software patent was held non-infringed or invalid. Nevertheless, to receive the fees, a defendant has first to litigate in order to prove the non-infringement or the invalidation, thus operating companies continue to face the issue of wasting time. Either way, for small firms, the Act is likely to have a positive impact, by flattening the financial differences between the parties and discouraging certain PAE lawsuits from being brought at all.

Another suggestion concerns the promotion, operated by the Congress, of a larger uniformity across patent courts. As we know, when a case is submitted by a PAE to the court of the Eastern District of Texas, the likelihood that the final judgment results in favor of the assertion entity is substantial. If the defendant is a startup, then settlement is the only possible choice. Nonetheless, if the Congress makes some practices or principles compulsory to every District, assertion entities could not exploit the court's advantage anymore. For example, with the development of a common case management process that comprehends several metrics, like the time or cost of the ruling in proportion to the value of the case, courts can block unworthy cases from being judged.

[40] An administrative review is a procedure, alternative to court proceedings, to challenge the validity of a patent (Chien, 2013).

Finally, an effort to make small firms less attractive to assertion entities concerns a self-help solution. Any collective defense effort, like an industry association group, may set a code of conduct for the member firms and provide an organized coordination of the patent defenses. Disseminating awareness on best practices about patent disputes among peer companies might lead to a reduction of costs, risks, transaction costs and, at a certain point, also to reach economies of scale in the patent defense. Achieving these sorts of advantages reduces the reliance of SMEs and independent inventors on PAEs.

Proposals for the patent system	The update of the HR regulations in the patent office. Examiners training to strictly enforce patentability standards.
	The creation of a discovery plan for PAEs, imposing the early disclosure of infringement contentions and asserted claims to reduce the information asymmetries.
	The disclosure of more information about the PAE which starts the litigation.
	The enactment of a provision that orders the infringement lawsuits against manufacturers to be resolved before the filing of an additional case against end-users.
	Patent term reform (shortening the life of patents by three years or even more).
	Maintenance fee reform (increase of the cost for obtaining and maintaining a patent).
	Anti-troll laws with the aim of deterring the mass campaign of trivial demand letters operated by PAEs.
	Low-cost administrative reviews.
	Fee-shifting.
	Uniformity across patent courts.

Figure 19. Summary of the legislative suggestions.

4.3 European context

In this chapter has been considered the American context, but the activity of PAEs must be further investigated also in the European environment. As explained in Chapter 1, American and European legislatures observe some differences in the field of patent regulation. These differences explain the pervasiveness of this phenomenon in the US, compared to the diffusion in EU. Patent monetization is "chased" less often in Europe due to the blending of several conditions (Thumm, 2018): the high barriers for the patentability of softwares, the high costs of filing a patent lawsuit (compared to the US), the low costs of defending it and the smaller damages reimbursed to defendants (compared to those charged in the US). However, according to Love et al. (2017), the practise of fee-shifting is the highest impediment to PAEs from litigating in Europe. In the Love et al. (2017) analysis of litigations lodged in UK and Germany, where the fee-shifting rule is applied, alleged infringers appear more likely to fight and thus, more likely to deny rapid settlements based on the cost of litigation or of discovery. According to Allison et al. (2017), PAEs would be responsible of the entire payment of fees for about 75% of the trials over the period 2008-2009. As a result, in Europe, PAEs are not encouraged to file weak patents.

Although the business model of assertion entities seems to be not sustainable in Europe, due to the expensive litigations and the high standards in the examination process, changes are on the horizon. A major regulatory reform is taking place, but probably will operate in the opposite way of the Americans new introductions. Since June 2023, the "Unitary Patents" system makes possible the single submission of a patent request to the EPO to be protected in up to 17 European Member States (epo.org). Moreover, it has been operationalized also the "Unified Patent Court" (UPC), an international court composed by participating EU Member States, which handles with lawsuits regarding both European patents and Unitary Patents. Some authors described these two introductions as gamechanging and they predicted an increment of the PAE activity in the next years (Comino et al., 2019).

The main objectives of "Unitary Patents" and of the "Unified Patent Court" are to reduce the costs of defending and mantaining patent rights (epo.org), but the real effects on assertion activities are unknown. For instance, the possibility of unitary injunctions on a large market may have two different consequences: it may bring the litigation value of a patent up, thus becoming more attractive for PAEs or, on the other side, a patent that is judged invalid on the whole European territory, might represent a disadvantage to PAEs (JRC, 2016). Moreover, there is the highly feared risk that, with UPC, PAEs will engage in forum shopping. PAEs might decide the country where to file their lawsuits on the basis of the court's tendency to judge cases in a predictable manner, or due to judgment favoritisms that arise as a result of court competition

to attract more lawsuits. The UPC is formed by regional and local chambers, hence technical expertise probably is not uniform across all the countries. There might be the risk that those regional courts with lower technical expertise become the "victims" of assertion entities that hope for a friendly and less informed judgement. However, any decision can be appealed to the court of appeal of the UPC (JRC, 2016).

Now that the UPC and UP are in place, PAEs will probably need some years to analyze whether the unitary effect deters or favors assertion actions. In any case, the real effectiveness of the reforms will depend also on the technical expertise of the judges (Thumm, 2018).

These two introductions occur in a very important moment for PAEs in Europe. The amount of multi-functional, integrated and largely-complex products and services that are boosting European high-tech economy will grow exponentially in the next period. The develpoment of the "Industry 4.0", of the Internet of Things (IoT) and the always more present connectivity among cars, home tools and many others devices represent a thriving field for the sustainability of PAEs business model. The undefined boundaries of high-tech patents and the consequent density of patent thickets will be a clear incentive for PAEs to enlarge their activities towards many high-tech sectors and to increase their diffusion in the European Union.

Some of the reforms proposed above in this chapter have already being implemented (fee-shifting). Others might seem a little extreme for the actual European environment (anti-trolls laws), but may become necessary in some years. Nevertheless, the Joint Research Centre (2016) declared its trust in the new patent system as an impediment to patent assertion activities in Europe. The "loser pays" system will be an undeniable deterrent (Love et al., 2017).

Conclusions

Companies, that purchase and license innovations, exploit the opportunity provided by the market for technology, contributing to the technological advancement. However, the market for technology is characterized by many inefficiencies that favor the rise of entities, PAEs, whose profit comes from the assertion of patents against potential infringers. This review of the economic literature aimed at answering a question that has been at the center of the innovative debate for many years: what is the impact of Patent Assertion Entities on innovation?

The analysis of the asserted patents and of the targeted firms enables a deep understanding of the PAEs' opportunistic ways of acting. This, combined with the examination of their effects on the quality of the patents and on the total costs for the companies, provides a comprehensive framework to address the core question.

The role of the current PAEs is different from the role of market intermediaries. Patent Assertion Entities are focused on ICT sectors, in order to profit from the shadow areas created by the fuzzy boundaries of complex patented technologies. In addition, the fragmentation of Intellectual Property rights and the intense patenting activity of the last decades generate patent thickets that make PAE operations highly profitable. There is no evidence that transactions occurring around PAE litigations involve the enhancement of innovation. Indeed, assertion entities tend to acquire patents near to expiration date, hence not very useful for innovation's purpose, to increase their bargaining power against those operating firms that have already made important investments in the alleged patented technology. This bargaining power results even higher due to the tendency of PAEs to purchase technologically valuable patents. At this point, the threat posed by these entities is so credible that companies cannot do anything but settle, paying massive licensing fees.

After the transfer to an assertion entity, the patented technologies observe a decrease in their number of citations, meaning that operating firms give up the development of innovation for fear of expensive litigation. Moreover, PAEs are more likely to purchase those patents granted by lenient examiners, since the broadness and the vagueness of the patent's scope are other crucial elements to sustain the business model of these entities. In many cases, these patents are judged invalid or not infringed in courts. This evidence highlights the waste of resources that affects operating firms when they decide not to settle.

Assertion entities target mostly small firms and startups, the key drivers of technological progress, because they rely more on technologies and have lower resources to pursue a costly defensive action. When a PAE starts litigation against an operating company, the development and production processes of the alleged patented technology stop since producers want to avoid the risk of "wilful infringement" and consequent additional damages in the lawsuit. The

frivolous litigations brought by patent assertion entities do not only interest the activities of the potential infringers but also their peer companies, whose innovative efforts are redirected toward technologies with a lower risk of litigation. This change in the patenting strategy, operated both by operating companies and by independent inventors, leads to preferring incremental technologies over disruptive innovations. Therefore, PAEs encourage the development of incremental inventions that overlap already existing technologies, favoring also the assertion activities to protect them, thus increasing the number of litigations. Clearly, this vicious cycle created by PAEs' activity is not compatible with the improvement of innovation.
The benefits that independent inventors can obtain through the intermediation of these entities cannot offset the large amounts of costly litigations that damage the market for technology. It is hard to sustain that markets might be somehow enhanced by observing thousands of patent lawsuits that incur billions of dollars in losses. Operating firms that suffer a 20% reduction in innovative R&D expenditures and that have lost over 80 billion dollars in wealth are not incentivized to further innovate.
This difficult situation is the depiction of a predominantly American context. Nevertheless, the European scene is rapidly conforming to it. The introduction of the Unitary Patents (UP) and the "Unified Patent Court" (UPC) might be game-changing for the PAEs diffusion in Europe, even if cannot be defined the direction and the magnitude, yet. Significant reformations are necessary to regulate both the American and the European context. The most accredited options regard the imposition of an early disclosure of information by PAEs, in order to weaken information asymmetries. Many authors claim also that an adequate training of granting examiners to patentability standards and the application of anti-trolls laws, to deter the mass operation of trivial demand letters, would effectively limit the activity of assertion entities.

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