Università
Ca’Foscari
Venezia

Master’s Degree
in Management

Final Thesis

The strategic value of Intellectual Property in the automotive industry during the digital transformation: a patent-based analysis

Supervisor
Ch. Prof. Alessandra Perri

Graduand
Giulio Bassan
Matriculation number 851503

Academic Year
2019 / 2020

Table of contents

Introduction

To date, the technological progress expressed through innovations has reshaped society and the marketplace, facilitating the formation of new business and job opportunities cross-industry. Similarly, Intellectual Property, or IP, has witnessed and potentially hastened new technological applications' adoption process. Especially in the last century, inventions such as the internet and other digital technologies have shifted both the nature of IP and the strategic purpose. The development of global networks and the acceleration of information transfer through new means of communication have enhanced the relevance and speed of knowledge, also expressed by patents.

Being on the front line when it comes to the latest technologies may be challenging. The development of flexible capabilities that assist companies in implementing business strategies is crucial to promptly react to ecosystem and resources' composition changes (Piccinini, Hanelt, Gregory, & Kolbe, 2015). Several firms across industries may be struggling to adjust their business models if, previously, they have been reluctant towards change (Wyman, 2017). In fact, the advent of the Fourth Industrial Revolution (4IR) technologies and their exponential growth in adoption and complexity provoked difficulties in incumbent firms keeping the pace of rising business opportunities (Lorenz, Benninghaus, Friedli, & Netland, 2020). As a result, it becomes tricky to own the totality of R&D outputs relevant to an organisation's product or service. Thus, by time, an increasing reliance on external providers of technology has surged. This concept has been theorised by Chesbrough (2003) with the term "open innovation", as it describes a model in which companies and organisation exploit both internal and external flow of knowledge in order to boost their product development process and build a reliable network of business partners.

In this composition, the focus points at the automotive industry as a sector in which the product development process typically requires the collaboration of different knowledge source, even if apparently not related to each other (Agostini & Caviggioli, 2015). Lately, the sector observed a surge of open innovation business models due to technological advance, globalisation and customers' preferences sophistication. The upsurge of new technological trajectories as well as a broader set of components implementable in vehicles could have contributed to the convergence of different technologies under the same innovation process. The traditional belief of internal knowledge generation and exploitation seems to fade. Carmakers used to build long-lasting relationships with their suppliers, also increasing their bargaining power. With the advent of 4IR technologies, extant relationships could be at stake as manufacturers, playing the role of system integrators, cannot internalise all knowledge flows any longer, considering that today's context encourages outsourcing competencies. Therefore, new players could take advantage of the rising of unique opportunities and increase their profit share, threatening current supplier-manufacturer relationships.

The purpose of such composition is to shed light on the variables majorly affecting the manufacturers patent strategies in the automotive industry, highlighting emergent trends and supporting the derived hypothesis with quantitative data retrieved from private patent litigation databases. Throughout the discussion, the phenomenon of the emergence of new technologies is analysed, along with the technological convergence among industries. Such a phenomenon could cause difficulties to incumbents if their traditional knowledge base is clearly distinct from the emergent one.

The dissertation has been structured as follow. In the first chapter, a literature review is provided around the theoretical background underlying the presented issues. In particular, this first section discusses the concept of innovation at the firm level. It starts with Shumpeter (1934) that introduces a science-push model where research activities are considered the real driver for innovation (Schumpeter, 1934). Later, this perception evolves into a demand-driven model (Schmookler, 1962) until the actual definition of innovation seen as a process that may also involve external knowledge flows as a new source of information. Each innovation experiences different phases. The Abernathy-Utterback model (1975) presents a trifold framework that describes the innovation life cycle from the experimentation phase until the emergence of a dominant design (Abernathy & Utterback, 1975). However, when disruptive innovations occur, the formed discontinuities may alter the market equilibria and even deviate the technological trajectory, namely a number of innovations bringing benefits towards a common issue (Dosi, 1982). In the second part of this chapter, the analysis is broadened on an industry level, stressing companies' role when they deal with disruptive innovation. Teece's Profiting from Innovation model (1986) explains how to maximise the return from potentially disruptive innovations and which variables need to be taken into consideration to catch as much value as possible through innovations' promotion (Teece, 1986). Then, the origin of the inputs that generate innovation is investigated. In particular, the open innovation model is presented. It concerns a different way of doing business involving external sources of knowledge within the product development process thanks to new instruments and data availability (Chesbrough, 2003). In this regard, the role of this framework in the Fourth Industrial Revolution is stressed. This last paragraph discusses the genesis of the phenomenon and its effects and benefits to society.

The second chapter focuses on Intellectual Property protection. It debuts defining what patent means and the criteria that make an innovation eligible for legal protection, namely novelty, inventiveness, and industrial applicability. Then, the diverse, viable proceedings through which a firm could enforce its Intellectual Patent Rights (IPRs), as well as the European patent landscape around the Unified Patent Court (UPC), are investigated (European Patent Office, 2018). Instead, the remainder of the chapter centres on IP protection used as a strategic tool against competitors. More in detail, it stresses the variables that need to be taken into account when assessing patens' value (Caillaud & Ménière, 2014) and which aspects highlight when designing an IP strategy, either defensive or aggressive (Frank, 2006a). In addition to this, a particular concern is brought on the disputes locations, particularly significant for safeguarding IP in national markets, as the lawsuit outcome may have effects on the whole value chain (Beukel & Zhao, 2018).

Furthermore, the third chapter presents the automotive industry and its particular characteristics. Significant relevance has been attributed to the sector's emerging technologies and the consequent organisational and strategic challenges that incumbents have to face to keep thriving in the marketplace. The new tools available to automotive incumbents are then explained, together with the unique potential applications and benefits that the latest technologies could bring (Teece, 2017). In front of an ongoing change in introduced innovations, patents potentially responded with incremental demand (Somaya, 2012). Thus, the patent landscape's recurrent trades and licensing favoured the birth of patent markets (Carraz, Nakayama, & Harayama, 2014).

Along with this system of patents' exchange, IP intermediaries make their appearance. For its constitution, an IP intermediary acquires knowledge from third parties to increase its revenue streams. In such a context, particular kind of intermediaries have arisen; some examples are Patent Assertion Entities (PAEs) and Defensive Patent Aggregators (DPAs) (Hagiu & Yoffie, 2013). In particular, they both exploit a certain degree of uncertainty in the market to monetise or license patents, respectively. The convergence of multiple technologies from unrelated sectors in the automotive industry may have brought this situation of ambiguity, although it could be clarified by establishing market standards. In the hand of policymakers, these instruments have the power to sensibly reduce uncertainty around investments and lower barriers to participation, in turn enhancing innovation (Teece, 2017).

Lastly, in the fourth chapter, the empirical analysis of patent lawsuits occurring between 2006 and 2019 for granted patents in a 25-years-period (1990 – 2014) is provided. The intent is to provide reliable knowledge around the behaviour of Original Equipment Manufacturers (OEMs) that now have to face a series of challenges related to the convergence of non-traditional technologies in the industry. Moreover, the second section of the analysis focuses on 4IR technologies that are likely to alter the market status quo. Equilibrium is expected to change, especially when dealing with an increasing number of filed patents and the emergence of potential new players, in addition to other entities that aim at monetising their acquired patents through alleged infringements.

1. Drivers of innovation

We are experiencing a chaotic period of transition, shaped by intense competition, rapid change, lightning information and communication flows, increasing business complexity and pervasive globalization. The speed of change has become so fast that it has ushered in a new era of business. As a result, completely new firms began to dominate today's market, which quite recently did not even exist yet, and of the old-world giant leaders, only those that managed to learn to move faster, survived. This new economic and business environment is also characterized by frequent technological breakthroughs that are rapidly changing the rules of the game in the market. Also, it favoured the formation of a new type of customer who has adapted to rapid changes and whose priorities have changed at the speed of television ads (Paliotta & Pannone, 2001).

The "new economy" is characterized by the development of a global information society, that is, the creation of a worldwide system of mutual relations, covering a significant part of the globe through modern communication systems, such as the Internet. The new economy opens up unlimited opportunities for entrepreneurship. It blurs boundaries allowing firms to reach larger audiences and the barriers created by geographic distances instantly get lowered. So that, the consumer is put at the centre of the new economy (Despujol & Stansbury, 2017) in a way that it can be distinguished from the mass consumer born in the twentieth century, and from a segment-based one. Rather, it is considered as a character with immense buying power, established thanks to a series of long-standing trends (Paliotta & Pannone, 2001).

This phenomenon finds its roots in the new economy when the lack of products and services in the marketplace, typical of the previous society setup, has been replaced by a goods' surplus. Among the main reasons there is the continuous emergence of new technologies that continuously disrupt the market increasing the productivity of enterprises, in turn, reducing the cost of goods and giving birth to unthought expansion possibilities in many industries. Second, globalization has led more companies trying to win over the same customers. Whereas, at the same time, shoppers have become more informed and sophisticated. Information technology has empowered buyers to find and analyse competing products and make well-informed choices straight from their smartphones or laptops. Third, many products have become virtual, and the rapid technological change has dramatically reduced the product life cycle. As a result, many similar offers appear on the market, and it becomes very difficult to differentiate offers from competitors in customers' minds. Collectively, these phenomena have transformed a supplier-dominated economy into a buyer-driven economy (Paliotta & Pannone, 2001).

Therefore, whenever a company is willing to succeed in the marketplace, it has to face a high competition level, thus entrepreneurs should be encouraged to act more efficiently. It has been commonly acknowledged that established incumbents may be subject to technological obsolescence, favouring the entrance of new operating figures attracted by the rising business opportunities as technological progress takes its natural course (Eggers & Park, 2018). Hence, the emergence of new technologies represents a serious menace to the marketplace equilibrium. During the discussion of such topic, several theories and strategies will be presented in order to better define the theoretical framework around the concept of innovation and how incumbents deal with it.

Throughout this first chapter, a review of the literature on the topic of technological innovation will be provided and structured as follows. In the first two paragraphs, after introducing the concept of innovation at firm level (Schumpeter, 1934), the attention will be brought on technological trajectories and how they relate to discontinuities. In particular, it will be discussed the due course of an innovation's life cycle and how it may be shortened by unexpected discontinuities. Two kinds of discontinuities could be identified: competence-enhancing or competence-destroying (Abernathy & Clark, 1985). Notoriously, the latter are capable of altering the market *status quo* and, if they catch incumbents off guard, even compromise their entire business. When a discontinuity finds fertile ground and start to be considered as an implementable solution by innovators, the Abernathy – Utterback model (1978) depicts the stages occurring during an innovation life cycle before and during the emergence of a dominant design. It is structured in three phases: liquid, transitional and specific phase (Abernathy & Utterback, 1978).

In the third paragraph, it will be investigated the similarities among the technologies that bring disruption to the marketplace: the so-called General Purpose Technologies (GPTs) (Bresnahan & Trajtenberg, 1995). Although, innovations do not stand alone. Surely, they are capable of radically change the marketplace but the GPT's profitable success is entirely in companies' hands and their ability to enable complementary assets. Teece's Profiting from Innovation (PFI) model (Teece, 1986) addresses specifically this issue and tries to give a reasonable explanation about how usually late majority adopters succeed at the expense of first-movers. Also, it outlines how disrupting technologies are embedded in a broader context and which factors are likely to influence the ability to properly catch value through innovation's promotion, namely complementarity, appropriability and timing (Teece, 2018a).

As the PFI framework describes how to maximise the return from innovations, the open innovation model conveys knowledge around the diverse origins of the inputs that generate innovation (Carraz, Nakayama, & Harayama, 2014). It has been advocated that, a vertical integration among production factors and the rise of new ways of recording and monitoring data favour a bilateral exchange of information and knowledge between external players and companies enabling more informed decisions about product development and asset investments (Chesbrough, 2012).

Lastly, the fifth paragraph stresses the role of open innovation in the Fourth Industrial Revolution. The origins of this phenomena will be briefly described, as well as the main benefits that could derive from it and how it applies to the automotive industry.

1.1 The concept of innovation

In this everchanging world people got used to the advent of new tools that bring small improvements in their everyday lives and have shaped the society. The evolution and the large-scale use of these instruments have not always been as frequent as today. The practice of the first successful commercial application of a new device, process or system is called innovation (Nightingale & P., 2018). Different from inventions, identified as an enlightening event resulting from a flow of ideas and experiments thought up for the first time; innovation is more conceptual. Freeman (1982) defines it as a process that leads the invention to its first application in the market (Freeman, 1982). Various types of innovation have been identified depending on market disruptiveness, swinging from incremental to radical. The former simply enhance product or service features the latter, is more drastic and capable of shifting the market balance.

The ground-breaker of the innovation analysis was Schumpeter in 1934, highlighting the dynamism of modern economies increasingly affected by marketed goods and production methods. He developed the "science-push" model of innovation, making R&D the cornerstone of his theory. Primary research was recognised as the main driver of innovation, especially in the post-war period when the reformed society opened up to new market opportunities derived from insufficient industrial capacity and low competition (Schumpeter, 1934). Nevertheless, a significant flaw stood out: the theory had difficulties in explaining the reason why some businesses were not receiving enough support, for instance, universities were considered as a less important source of knowledge than suppliers and customers (Rothwell, 1992). Later on, in the history of innovation, many attempted to design a framework around this concept, focusing on how patents, the first tangible assets of research output, may be demand-driven (Schmookler, 1962). Many others developed several theories, although all of them advocates innovation as uncertain land. To date, it is widely recognized that innovation development could not be exclusively science-push or demand-driven; instead, it may involve knowledge coming from outside the firm's boundaries to find new sources and new ways for commercializing innovation, for this reason it has been named open innovation (Chesbrough & Borges, 2014). Gradually, the remainder of the chapter will deepen how established companies deal with innovation and the digital revolution by now all-pervading.

1.2 Technological trajectory

Before getting to the heart of the discussion, it is crucial to understand what kind of barriers a company needs to overcome in order to manage the emergence of new technologies from outside of a certain field of expertise. Serving this purpose, the concept of technological trajectory will help comprehend how firms tend to be locked inside a pattern of technological development, even though more efficient solutions could be provided by external players, hence they would be easily outsourced or internalized. As a matter of facts, from this concept awareness may be arisen around the issue of incumbents sticking within the same technological trajectory, causing sensible struggles in coming up with new options and, as a result, limiting its market potential.

The combination of practical solutions aiming to solve a common problem of a given technology and, indeed implemented by engineers and scientists, defines what we call today a technological trajectory. It was modelled in 1982 by Giovanni Dosi to create an alternative to the leading theory, plotting innovations' performance as a production volume function constructed over cumulative effort, and taking for granted a steady and proportional increase in both quantities and progressive behaviours (Fusfed, 1970).

The technological paradigm defines which are the relevant challenges and, at the same time the extent to which feasible technical solutions could be implemented, thus constraining the possible variety of R&D activities designed to figure out those same problems. Only some resolutions will be selected within the model and eventually implemented, disrupting the market. In other words, continuous changes following the direction of a technological trajectory are defined by the technological paradigm, specifying how the innovation's evaluation criteria, either technical or non-technical, change over time; whereas discontinuities are associated with the emergence of new paradigms (Dosi, 1982).

In order to describe this phenomenon on a single innovation basis, it comes convenient to introduce the Abernathy – Utterback model (1978), where it is explained that every innovation experience three distinct phases throughout its life cycle: fluid, transitional and specific phase (Abernathy & Utterback, 1978). Experiments and prototypes, reflecting the high level of market and technological uncertainty, are the main components of the fluid stage (Utterback, 1994). At first, experts struggle to find the right combination of factors to improve a service or a product that matches market demand but also attempt to maximise the gained know-how through failure. However, these trials should not be narrowly focused around a specific process or a particular product but rather take into account more possibilities. It has been demonstrated that overall innovation degree of improvement would suffer if excessive specialisation has been implemented. Organisations that explore similar leads, limit their opportunity's potential and risk to end up to be in the way of general progress and lose the chance for significant profits and market leadership. Since technological growth comes at the expense of the prior art, each time an innovation is launched, it broadens the market, creating a spare place for new entries to start operating. As it might be expected, different types of novelties trigger diverse competitive market reactions (Aboulnasr, Narasimhan, Blair, & Chandy, 2008). Incremental innovations could facilitate established firms to raise entry barriers and make it tremendously difficult for new entities to benefit the industry. In contrast, radical innovations, disrupting the market, give birth to brand new opportunities that new entrants could exploit way more effortlessly than an incumbent.

Their attitude results in being more flexible, increasing their surviving odds in new-born niche markets (Utterback, 1994). In addition, it is understandable how a potential cross-disciplinary convergence would enhance product development and speed up the technological trajectory curve's progress. To be more precise, firms' ability to combine successful factors coming from distinct industries could help throughout the learning process and lead to an original and winning outcome even capable of adding significant value to an emerging market (Utterback, 1994).

Secondly, once a technology has been tested enough and organisations can implement a practical application, a transitional period occurs. It is then, up to each company to decide whether and when to implement new processes or practices and choose the right moment to emerge amongst the other challengers. The ability to foresee discontinuities, spot potential competitors and time the beginning of a new technology cycle is crucial for a company willing to ride the wave of a market opportunity (Afuah & Utterback, 1996). Attention should be brought, especially on the timeliness of decisions; incumbents tend to wait too long before committing completely new investments. They potentially prefer to redouble funds on standard technology rather than burden switching costs and start the transition. This event has been named myopia (Foster, 1986) and it may be one of the main chances for a new entrant in the industry to take a significant advantage from long-established firms. As a matter of facts, sector's incumbents put a considerable amount of financial effort on innovations already at their mature stage. Usually, these companies are more likely to get as much as possible from a successful process or product until replaced, instead of considering a quick adjustment in their vision and investing in advance (Matthews & Brueggemann, 2015). Although, during the transitional phase, it may occur that a dominant design establishes and subsequently supported by product standards or production practices. The new competition dynamic changes the market, allowing who has been more forward-looking to succeed and the rest to plod on (Abernathy, Klein, Dopico, & Utterback, 1982).

After the advent of a dominant design, the firms' attention will move from differentiation to product performances and costs. At this point, companies and organizations can clearly distinguish who is part of the target segment and, therefore, focus on serving specific customers. Manufacturers will gradually abandon highly specialised resources, stated the commoditisation of the innovation, in turn, increasing suppliers and customers bargaining power. Now that more companies start adopting the technology, competition intensifies and the market may shift towards an oligopoly system. As a matter of facts, the general level of expertise increases, allowing incumbents to consolidate their market position through frequent business relationships with suppliers and securing distribution channels. All these just mentioned variables contribute to rise entry barriers for potential new entrant, until the emergence of a new discontinuity (Abernathy & Utterback, 1978).

1.2.1 Technological discontinuities

Considering the rise of a design that establishes the general market rule, it is notable how a technological discontinuity may divert a technological trajectory. In 1942, Schumpeter claimed that discontinuities are translated into an innovation that brings a tangible improvement to products' qualities and correlated costs, affecting the derived profits (Schumpeter, 1942). While a regular process innovation occurs within the economic system through R&D practices, an unforeseen shock may change the market equilibrium diverging the incremental technological progress. For this reason, this kind of innovation is called technological breakthrough as it is capable of changing the trajectory direction, involving not only the product itself but also the underlying process (Freeman, 1992). High-intensity technical development usually follows technological discontinuities stroke, up to the point of the establishment of a dominant design (Srinivasan, Lilien, & Rangaswamy, 2006). Companies and organisation operating in the same sector rush to succeed before others; the first-mover advantage might open a new market and make the right timely choices result in a lifetime opportunity.

Incumbents see themselves negatively affected by discontinuities. Some observe a potential increase in the competition levels, and others denounce an irreversible shift in the economic equilibria. In general, innovation discontinuities affect differently firms' resources, competences and knowledge, whether they belong to the competence-enhancing or competence-destroying category (Abernathy & Clark, 1985). Usually, incumbents produce competence-enhancing discontinuities so that their business could thrive from an already known product with small improvements (Henderson & Clark, 1990). Through improved product, they aim at reinforcing their position, rising even more entry barriers for possible new entrants and mastering their market capabilities (Tushman & Anderson, 1986).

On the other hand, competence-destroying discontinuities are usually promoted by new entrants, bringing a radical change that shocks the market. They help lower the entry barriers due to the loss of almost all competitive advantages held by incumbents based on obsolete capabilities (Murmann & Frenken, 2006). In turn, previous paradigms restrain actual incumbents' actions, making it difficult for them to promptly respond to new changes in the surrounding business environment introduced by new players. Feasible solutions left for incumbents are mergers or acquisitions, staying competitive investing in new resources, forming an alliance with business partners or even competitors or forcedly developing the technology either (Rothaermel, 2001).

1.3 General Purpose Technologies

All considered, emerging technologies potentially enable radical innovations that, in turn, undermine the market *status quo* and might represent a threat to already established companies. The key to positively face such challenges may reside within the notion of General Purpose Technologies and, in particular, how these could help incumbents to foresee market discontinuities. The General Purpose Technologies (GPTs) are a concept introduced by Bresnahan and Trajtenberg in 1995, which identifies potential technology breakthrough that could drastically change the market in which it is embedded. They must own three fundamental characteristics: they have to be pervasive as in wide use, capable of continuous technical improvement and enable complementary innovation in application sectors (Bresnahan & Trajtenberg, 1995). It goes without saying that whether a firm can spot and take advantage of a possible GPT could seriously affect its business. Thanks to its last feature, namely the trigger of complementary inventions, a GPT could have limitless impact and applications. For this reason, due to its cumulative effects, the evidence for widespread applicability could take decades (Jovanovic & Rousseau, 2005). For instance, after the second world war, a pattern emerged when the whole weapons industry had to recalibrate its production volumes, besides their main clients switched back from the army to entrepreneurs (Vatter, 1985). As it might sound obvious, they had to face colossal switching costs but, almost surprisingly, the real added value did not rely on the production level, instead several benefits arose from the mechanical knowledge applied to the work machines. Simply put, the same machines' design used to manufacture weapons could be rearranged to various uses in other sectors (Rosenberg, 1976). This kind of technological application can produce both vertical and horizontal externalities; the first enhances the overall sector efficiency while the latter lures investment's flows to improve the quality of the industrial field (Carlaw & Lipsey, 2002).

Unlike dedicated technologies in which investments tend to stay within the same industry without possible cross-industrial applications, Bresnahan and Gambardella (1998) tried to figure out when GPTs flourish depending on the market scale. It tuned out that fragmented markets are more likely to be breeding ground for GPTs as buyers and sellers are willing to trade technologies with potential uses in different sectors (Bresnahan & Gambardella, 1998). On the other hand, an oligopolistic market restrains technology exchanges since big companies develop dedicated technologies on their own and deal internally with R&D practices (Moss, 1981). The outcoming externalities affect several sectors vertically and horizontally either (Joskow, 2012). Numerous applications can be found, and the investments' benefits in one particular industry rise along with the benefits in another one, and vice versa. In contrast, dedicated technologies attract specific investments only, preventing the spread of cross-sectorial knowledge and resulting in a greater specialisation of the industry.

It has been established that such exclusive and strict features for a GPT risk to excessively analyse only a few inventions and wrongly ignore others. A midway solution must be determined: the enabling technologies, or junior GPT (Teece, 2018a). According to Teece (2018), an enabling technology does not have to respect all the characteristics of General Purpose Technologies, two of them are enough: ongoing improvements and complementarity, comprehensively broadening the category. Like the original concept of GPTs, they can disrupt the *status quo* and bring considerable turnover and social surplus to whoever decides to implement them in their business model. Even the European Commission drew up a list of "key enabling technologies" belonging to non-software fields (micro and nanoelectronics, nanotechnology, industrial biotechnology, advanced materials, photonics, and advanced manufacturing) aiming at promoting innovation studies around these topics and support cross-industrial research (Commission of the European Communities, 2009).

All in all, GPTs' key concept unlocks significant profits for their suppliers, giving them the chance to operate in different parallel industries. Then, it assumes particular relevance to monitor emerging technologies taking into account the competitive position of a company since disrupting technologies could open to new incoming business opportunities. Generally, GPTs effect on the marketplace may result, not only in the emergence of new competitors, translated into an increase in market fragmentation, but also in a greater provision of competitive tools. For instance, ICT technologies supplied companies with faster and more efficient instruments to monitor and control others' market operations, allowing them to make more informed decisions and take proper counter-measures. As the application's fields seem be countless is crucial to investigate further which are the variables that drive a firm to success, how to spend capital in basic research and why some thrive while others get overtaken in the natural market selection.

1.3.1 The Profiting from Innovation framework

Assuming that an entrepreneur successfully produces a potential disrupting innovation, the invention does not stand alone. It needs to be backed with appropriate investments to avoid any dispersion in terms of profits and market share either.

So far, the most effective way to investigate innovation profits' drivers got theorised by David J. Teece in 1986 with the Profiting from Innovation (PFI) framework, later revised in 2006. The readapted theory takes into consideration the significant environment changes occurred since 1986, in particular he built a whole theory to prove why innovation pioneers' market shares sometimes suffer due to late arrivals. More in detail, he advocated that all innovations need to be supported by complementary investments in order to build a long-term advantage. Also, he noticed that profits tend to migrate towards the "bottleneck" asset, namely the hardest resource to replicate: innovator's IP for instance, or precisely a complementary asset (Teece, 2018b). In this sense, the iPod case is emblematic. When first launched, it was not the only option available among the digital music players, but it conquered and mastered the market leader's stable position over the years (Cooper, 2011). A few viable concepts lie under this theory: appropriability regime, industrial evolution, complementary assets, system integration and industry structure.

Starting from the first one, the extent to which an innovating firm catches value, later turned into profits depends on the appropriability regime. Two types of appropriability could be distinguished: weak and strong. The former identifies an innovation that is tricky to protect, easily imitable with ineffective intellectual property or licence protection; the latter instead highlights the protection easiness (Teece, 2018a). However, it is remarkable how rapidly the technology value changes due to its uncertainty, and so does the appropriability regime. Moreover, the inability of the innovator to represent a credible threat represents a danger for the business. For instance, making profits on GPTs could be trickier as the technology's broader applicability weakens the innovator's bargaining power. Therefore, partners reliance lowers profit share and, consequently, personal return (Winter, 2006).

The key to succeed in the business ecosystem is to rightly spot the so-called "bottleneck" assets or rather the toughest asset to reproduce, and intellectual property well represents the category (Pisano & Teece, 2007). This division evolves along with time until, error after error, one dominant design emerges and establishes a standard. Here new market joiners have the unique opportunity to modify or imitate pioneers' products with the chance to improve them and leave the incumbents at a disadvantage thanks to positive adoption externalities, increasing return to scale and switching costs (Teece, 2018b). Although, a sublime technical knowledge is preferable for implementing winning market solutions and enhancing other intangible assets such as viable business models, customer relationships, reputation and organisational culture or complementary assets.

These last-mentioned factors represent the main competitive advantage an incumbent could trigger, namely its superior commercialization capabilities (Teece, 1986). Across a series of competence-destroying innovations, it has been demonstrated that an established firm possessing specialized complementary assets is able to properly adapt to technological discontinuities as long as the assets do not get depreciated (Tripsas, 1997). Hence, complementary assets could be thought of as a prism through which companies spot technological opportunities. Moreover, redundancy in branding promotion and customers uncertainty could be sensibly reduced if incumbents keep adapting to the context and partner with emergent startup that mastered the new technology. These organizational resources need to be coordinated, even though the implementable features in a product are numerous. As a matter of facts, not all of them match customers' preferences and desires. The fundamental activity to undertake then is to brainstorm a tailored "system integration" to arrange at best the assets and attract as many customers as possible (Teece, 1984). It could be accurate to define what it is meant by system integration function. It consists in the demanded skills to manage global resources. It is to say that an innovator needs to decide how to combine different components in order to make the product more appealing in the market.

Referring to some industries more exposed to the digital transformation for own characteristics, it comes convenient to introduce the notion of platforms. A set of complementary assets is named platform; each ecosystem consists of several platforms. In this case, a platform is "any combination of software and hardware that provides standards, interfaces, and rules that enable and allow providers of complements to add value and interact with each other and users" (Teece, 2018a, p. 444). A platform helps reducing costs in designing functional parts exploitable in various models. The auto industry had mastered this concept since the sixties sharing common mechanical or electrical parts and have them installed in different automobiles (Simpson, 2004).

Today, platforms can be exclusively digital, and operating systems are now integrated with most circulating cars directly affecting the customer's experience onboard. Two distinct kinds of digital platforms exist: transactional platforms and innovation platforms. The former, the most common type, eases the collaboration between fragmented groups of companies and consumers through the proposition of online buying and selling, like eBay (Evans & Gawer, 2016). Opposed to the latter platforms that provide a base system upon which third parties can develop an ecosystem made of complementary products or services sold to customers or other businesses, a prime example could be the ecosystem that Apple built around its products (Cusumano, Yoffie, & Gawer, 2020).

To be more specific, the upcoming digital revolution embeds all these just mentioned examples. Now the general trend is to switch from analogic information towards a digital format. The switchover allows information to be volatile, transferable across considerable distances and replicable without limits, thus facilitating the flourishing of new organisational arrangements. A particular bottom-up approach emerges: each engineering generation works on previous generations' progress adding cost savings and organisational simplifications and, at the same time, facilitate the integration with ecosystems that become the streets upon which information pass along. The concept could be summed up in the definition of "Great Convergence" (Teece, 2018a). As the word itself might suggest, a convergence happens when multiple industries come together under one mean of access. One of the most suitable example is the automotive industry where cars have been rethought of as smartphones equipped with wheels. The superior penetration of communication technologies in this sector has changed how automobiles communicate between themselves, with the user and with the surrounding environment. New solutions are possible thanks to the development of a communicating ecosystem with significant strategic value, capable of advanced interactions (Hazlett, Teece, & Waverman, 2011).

It occurs that platforms, the main component of ecosystems, usually enter in competition altering the marketplace balance. Three competition levels could be distinguished: among complementors that rival for a privileged position within an ecosystem, between the platform and its partners and between one platform to another (Cusumano & Gawer, 2002). Examples for the last case can be found in today's dualism between Apple iOS and Google's Android racing for years to thrive at the other's expense (Venkatraman, El Sawy, Pavlou, & Bharadwaj, 2014). In particular, it produces winner-takes-it-all outcomes favouring large-scale enterprises and leaving no benefits for niche markets. Furthermore, it measures openness in the market: many companies implement strategies to attract new customers collaborating with other well-known brands. Thus, the more the openness, the bigger the opportunity to capture value directly (Cusumano & Gawer, 2002).

1.4 Open innovation

Simply put, platforms are able to combine both inbound and outbound knowledge flows from collaborations among companies (Enkel, Gassman, & Chesbrough, 2009). Firms' networks, as a matter of facts, favours the formation of business relationships where a central entity lead and coordinate others through the innovation process (West, Salter, Vanhaverbeke, & Chesbrough, 2014). Such strategic alliances may give rise to joint value creation for prospective customers derived from the knowledge sharing among allies (Vanhaverbeke & Cloodt, 2006).

As a consequence of great openness, innovation permeates the market more efficiently. Players can make more informed business decisions due to voluntary disclosures of rivals' information although facing more costs. Besides, release more information about a company might inspire and enhance customers relationship with the brand. It increases its reputation and sensibly reduce the duplication research efforts putting in scientists' hands more information to deepen their knowledge and, in turn, innovate even more.

The "open innovation" model is about how an organization utilizes knowledge flows that cross the organizational boundaries to improve the success of the organization's innovation efforts (West, 2018). It assumes that the company, when developing new technologies and products, not only relies on its own internal corporate R&D, but also actively attracts innovations and competencies from the outside. In other words, in open innovation, companies willingly disclose some reserved information hoping to receive positive feedback from the market and trigger positive externalities (Morck & Yeung, 2001). The information just revealed becomes an open resource as anyone can enjoy it without anyone else's permission or, more precisely, the real owner has no control on who access it. A supply becomes open when the permission is granted naturally and not at someone's discretion (Lessig, 2001). However, it is worth of mention the difference between an open resource and a free resource where the first fosters progress and economic growth critically. To cite Newton "If I have seen farther, it is by standing on the shoulders of the giants", in other words, the concept of cooperation is one of the keys to scientific progress and today's achievements are built entirely upon predecessors' work base (Carraz, Nakayama, & Harayama, 2014).

One might further argue that different degrees of openness exist within the market. A company chooses innovation upstream investing in internal research or partner with external entities to support its business. Moreover, openness is the central element of two institutional arrangements, on one side, "open science" brings evidence on how scholars are the most suit to validate and evaluate their own work and how the notions disclosure induces rewards and incentives within the economic system (Dasgupta & David, 1994). All in all, open science could be thought of as a set of activities brought on by public investments with the support of private funding and carried on by universities and non-profit institutes (David, 1998). The second institutional arrangement strictly affected by open innovation is "open source". The most famous examples are open-source software:

they come equipped with licences, give the user the right to use, edit and distribute each one's work to others (Raymond, 1999). In particular, they display a specific development process led by project managers where different coordinate inputs come from external project contributors.

Many historical events support the positive impact of open innovation on the economy and society. It all started from England in the 19th century with the furnace industry blast when data about the design and performance were published and spread through word of mouth resulting in a public social surplus (Allen, 1983). Even more remarked during the Industrial Revolution in the mining industry (Nuvolari, 2004) until contemporary examples of sequencing human genome (McElheny, 2010) that could lead to crucial discoveries and be part of a collective innovation process.

The father of open innovation paradigm is Henry Chesbrough that in 2003 published his first Open Innovation book. The composition offers the proper definition of open innovation where "firms can and should use external ideas as well as internal ideas, and internal and external paths to market" (Chesbrough, 2003, p. xxiv). Chesbrough underlines innovation diffusion among stakeholders putting at its core shareable intellectual property without any charge (Chesbrough, 2003). Thus, the transferable nature of knowledge and intellectual property becomes the crux around which he built the whole theory. It opposes from the definition of closed innovation where all business endeavours are vertically integrated, from research to sales and affected by economies of scale (Panagopoulos, 2018).

Furthermore, he introduced horizontal cooperation with business partners, mobility of highly skilled workers acting as intermediaries, developing intellectual property networks and markets and global value chain. Even the final abandonment of the Not Invented Here (NIH) syndrome that forced the whole R&D practices to be processed inside the firm (Carraz, Nakayama, & Harayama, 2014).

Undoubtedly as the intellectual property finds itself playing a significant role in the attribution of innovation, an intellectual property strategy is required (Morck & Yeung, 2001). An IP strategy aims to convey new ideas towards other entities, thus profiting through licences and royalties, or import external knowledge to catch value and promptly respond to market needs. These two approaches have taken the name, respectively, inside-out and outside-in flows (Chesbrough, 2012). To deepen the concept just introduced an informed and thoughtful use of licencing is advised. This practice can work as prevention against free-riding behaviours that might occur during business (Penin, Hussler, & Burger-Helmchen, 2011), and adapt to the technology life cycle stage. At this purpose, Abernathy and Utterback developed a theory where instead of a product ruling the market, once it overtakes a certain adoption threshold, organisations and companies behave differently based on a particular technology's maturity stage. Generally, every product launched in the market experience four different stages: early stage, growth stage, maturation stage and decline stage (Abernathy & Utterback, 1975). Companies should seek IP protection differently depending on the cycle; in particular, a patent owner might apply his property to other sectors at the maturation stage. In contrast, at the decline stage, all efforts should be addressed exclusively to value capture. For instance, Microsoft willingly let the pirated version of its operating system spread in the Chinese market only to preclude the installation of competitors' so that new business opportunities would arise from complimentary products at an already advanced stage of maturity (The New York Times, 2009).

1.5 The Digital Revolution

During an era of international specialized knowledge exchanges and vertical integrated value chains, technology supports and enhances elicited positive externalities. They come into the world as the fruit of simple business relationships that empower social benefit and reward whomever promptly invested in the right future technologies. New approaches to data gathering and analysis take shape and even more investments are moved to encourage the development of advanced technologies. The Digital Revolution is the result of such phenomena.

Digital Revolution is a synonym of Fourth Industrial Revolution or, as first claimed in 2011 in Europe, Industry 4.0. To be fair, it owes its birth to Hannover's exhibition revising companies' strategies and promoting a new production chain based in Germany (Maci, 2020). At the time, it was presented a new organizational structure that involved the collaboration of highly specialised and skilled workers with robots, stated the required high level of precision and advanced technologies adopted. It becomes clearer now that they designed a system that balances human labour with machines' precision and automation. Germany's outcomes attracted others' interest since new models were measured to benchmark against the latest technologies and public policies embedded in the social and economic context. Once reached this milestone and the results correctly assessed, the Industry 4.0 organisational model could be legitimately named as a proper Industrial Revolution.

The name comes from a European initiative aiming at investing huge sums towards a more integrated digitalisation of the member States, hence pushing joint investments through strategic partnerships and firms networks (Probst, et al., 2018). The term generally refers to a digitalisation process addressed to the manufacturing industry, radically innovating the value chain and shaping economic entities' organisational nature. Today Industry 4.0 could mean also smart manufacturing as the integrated management of information retrieved through digital means (Sjödin, Parida, Leksell, & Petrovic, 2018).

One of the reasons why smart factories are succeeding in the market is the adoption of flexible implementation models for disruptive innovations since technologies that mark significant progress make older ones obsolete (Sjödin, Parida, Leksell, & Petrovic, 2018). Here, plenty of room for discussions could be found about the technology property and its theoretical fairness. The digital revolution instead goes straight at enhancing services' quality thanks to technological improvements. A strategic view with innovation, knowledge sharing and cooperative implementation at the horizon has been considered, resulting in practical competitive advantages in the long run. The open innovation could be the paradigm around which the Digital Revolution revolves and allowed this quick evolution. As a matter of facts, it promotes less defined organisational boundaries, many ideas come incredibly convenient to share and implement from external agents then internalised, improved and resold by companies.

The central concept lying behind Industry 4.0 is a cumulative and ongoing progress that, through the latest technologies, fosters its three principles: Smart Production, Smart Services and Smart Energy. Without going too deep in details, the first consists of integrating all productive factors thanks to technology, from employees to the tools and machines. Secondly, Smart Services build digital infrastructures and processes to allow agents to work and coordinate themselves throughout the value chain. Finally, Smart

Energy, as a sustainable strategic management approach, aims to set up more performing energetic systems and lower wastefulness (Energy efficiency and innovation, 2018).

The keystone of the Digital Revolution is the full integration between physical and digital systems. The virtual communication between the two is feasible thanks to new connectivity standards evolving over the years and named Internet of Things (IoT) as the actual vehicle for spreading smart manufacturing and smart supply chain. At the base, the idea of joined sectors and productive factors operating in complex systems and interacting with the market and the supply chain in real-time. Forecasts suggest that robots will multiply in the next years, enhancing their abilities and their interactions with complementary features opposed to human skills (Industry 4.0: Transforming auto manufacturing landscape, 2018). The whole infrastructure could not work without any information supply. However, the new technologies can store and analyse loads of data in a fraction of seconds, thus making informed decisions. Certainly data, Big Data, stated the volume of information, give insights about an alleged subject matter and can make firms review their business models and correspondingly adjust them (Probst, et al., 2018).

By the time, the design of solutions considering climate change and energy efficiency will steadily increase. The objective is to lower costs by exploiting the digital world and providing simulations to avoid useless squandering and errors. In brief, the digitalisation favours the integration and cooperation within and among firms, allowing consistent volumes of information flowing upstream and reducing the time-to-market (European Commission, 2019). The revolution passes through the introduction of intelligent machines and sensorial tools, empowering monitoring abilities and better controlling the value chain. Processes, then, result optimised, efficient and easily adjustable. Data, stored in electronic systems, give the unique opportunity to derive informed market decision invisible otherwise, in turn, products improve and precisely meet customers' needs (Bricco, 2017).

1.5.1 Effects and benefits

Industry 4.0 brings new approaches on a technological and organisational basis either, forming unprecedented competences. At the production level, digital technologies and components' interconnection will be implemented favouring innovation of supply chain and processes. What has been discussed so far is happening, and in the next future will become the standard routine. Managers, then, need to adapt to be ready to change as competitors will do the same. Companies that want to keep up have to invest in more efficient technologies and labour models.

The digitalisation path could take more than expected but is crucial to pursue flexibility, productivity, quality and competitive objectives. The Industrial Revolution is affecting the last trend technologies. The convergence of several practices already adopted within the same organisation aims to integrate the factory model with the supply chain in one single system (Bartodziej, 2017). The final blueprint could be described as a union between technological progress and organisational operating processes. High performance and flexibility will be required, and new competencies and knowledge will be developed with top-notch involvement throughout the value chain.

The evolution of Industry 4.0 demands for a lighter set of processes, elimination of wastefulness and unvalued activities. One might recall the Lean Production concept with at the base agile and efficient process management, strict quality control aiming at minimising the impact of resources' purchase within the organisation, especially inventory costs (Allmag, 2020). It could be thought of as an oriental tradition brought in and tailored for the occidental culture so far severely conditioned by the Fordism, characterised by economies of scale and mass production (Sanders, Subramanian, Redlich, & Wulfsberg, 2017).

Modularity and endless configurability have to be the cornerstone upon which a digital revolutionised business model is created (Weyer, Schmitt, Ohmer, & Gorecky, 2015). It has to be reminded that each company should consider adjusting its plans, market projections and manufacturing processes to correctly respond in front of demand and customers' preferences variations. Along the whole supply chain, the general rule complies with extreme efficiency in the resources used to foster the value chain to make clients and stakeholders profit. The labour organisation should facilitate teamwork and other collective soft skills (Giannini, 2017), ongoing formation and rigid quality control to follow Japanese firms' steps that throve through the just mentioned philosophy (Sanders, Subramanian, Redlich, & Wulfsberg, 2017).

The trend is to customise even the manufacturing process: clients' requests are seriously considered and consequently implemented as soon as possible. The newest technologies come in handy to design the most competitive product; a large amount of data available gives a clear overview of the customers' desires and facilitates the job of monitoring agents. Another key concept of the new movement is how data are exchanged: a prompt communication of production capacity allows all the interconnected firms to identify potential partners and better cooperate with the existing ones, accelerating the response time and reducing costs (Giannini, 2017). Value chains result in being highly connected and up to date with market trends (Lund, et al., 2020). It represents a massive opportunity for organisations to evaluate themselves. The capillary distribution of advanced tracking technologies gives valuable tools to measure performances and the chance to turn over their business models and production methods and logistic processes. It has to be remarked, though, isolated adoption of such methods does not take anyone farther. Instead, full round resources integration can generate added value and lower inefficiencies. Being keen to change any integral aspect of the company, if necessary, might be a viable solution (Giannini, 2017).

To sum up, the new available technologies introduced by the Fourth Industrial Revolution, whether implemented correctly, will allow organisations to be more competitive in the market thanks to renovated approaches. Diverse solutions are recommended to reach achievements unimaginable so far. If the implementation method of Industry 4.0 has been mainly digital, now a completer integration would be advised. Each new method requires a trial period to be thoroughly analysed in benefits and flaws. It emerges the need for a proper walkthrough that guides companies in the digital transition capable of involving private and public sectors. An intervention from more prominent entities such as governments may be necessary to offer the fairest market conditions. New policies ought to be launched, even considering youngsters' formation first. They could be the key to a radical shift towards digitalisation and a good investment in future (Giannini, 2017).

2. Intellectual Property Rights as a market strategy

The previous chapter sheds light on the dynamics related to the introduction of disruptive technologies in the market and how these thrive in today's open innovation landscape. Various models have been pondered, analysing the emerging technologies' evolutional trend and their impact on incumbents' dominant strategies and structures in the digital transformation era.

In this concern, today's market conditions in which companies and organisations operate are exceptionally competitive and complex. Globalisation is capable of alleviating geographical borders and increasing the number of potential competitors so that new market opportunities uprise. The cumulative technological innovation process shortens products' life and the time-to-market forcing all players to rush the development stages (Kline & Rosenberg, 2010). Customisation, instead, redirects firms production to satisfy customers' needs rather than theirs. Such dynamics compel companies to continuously adjust their business models based on the ongoing changes happening around them. Consequently, a radical revision of offered products and services, production processes, business objectives and target markets may occur.

It has become crucial for business activities to keep an eye on the competitive horizon and redefine their strategies functionally to market changes. The rearrangements vary depending on the industry's innovation degree and the target audience. To survive and thrive in such a context, the only pursuable way is to follow along with innovation. Therefore, especially in high tech specialisation sectors, the innovator's role increases the likelihood of gaining a competitive advantage (Adhikari, 2011). The safer the market positioning, the more it will be based on scarce resources challenging to obtain for competitors (Fontana & Caroli, 2003).

Furthermore, the competitive advantage becomes tricky to impair if companies' portfolio is mainly composed of intangible assets, thus renewable. They can sensibly increase the added value making resource exploitation more efficient and effective (Nonaka, Tomaya, & Konno, 2000). However, pure innovation turnover does not seem to be enough. New business ideas' birth is unquestionably satisfactory, but the derived gratification may not be fair financial-wise. For this reason, a need to properly acknowledge inventive protection has been instituted. The Intellectual Property protection addresses specifically this issue.

Henceforth the attention will be brought on such topic, more precisely on patents and their playable roles when designing an effective IP strategy in an open innovation landscape. The chapter may be divided into two sections. The first stresses the definitions and composition of the Intellectual Property Rights protection in terms of patentability criteria and feasible disputes in case of an alleged offence (World Intellectual Property Organization, 2020), particularly deepening the concept of the new-born Unified Patent Court to better describe the actual legal landscape around Intellectual Property and its enforcement (European Patent Office, 2018).

When building an IP strategy, companies and organizations need to take into account several factors, potential legal disputes included. The second section will describe valuable methods to assess patents and how to make more informed decisions about the IP portfolio (Caillaud & Ménière, 2014). Then, which aspects to prioritize when implementing the strategy based on the approach: offensive or defensive, firm's industry and available technologies (Frank, 2006b). To conclude, whether the firm opts for an offensive approach to the market, the crucial role played by the dispute's location and the court's proficiency in specific technology areas (Beukel & Zhao, 2018).

2.1 The Intellectual Property Rights protection

Intellectual Property protection offers a viable solution to safeguard the authors' inventive ability for future uses. Distinct from secrecy, IP protection constitutes a contractual tool that, whilst allowing and ruling the spread of inventions, offers authors the appropriability of risks and costs. Traditionally, the term "intellectual property" defines a legal protection system of immaterial assets created by inventors (World Intellectual Property Organization, 2020). Examples of creative inventiveness could be artistic works and masterpieces, industrial inventions and utility models, designs and trademarks.

Every country recognises the rights for Intellectual Property declined to protect people against counterfeiters and imitators. IP protection is guaranteed at both the national and international level thanks to several conventions and agreements. To make the idea, the first internationally signed agreement is dated back to 1883 and named "Paris Convention for the Protection of Industrial Property". The concept behind IP lies inside the concept of appropriation rights (Grindley, 2018a). It concerns inventions or creations derived from the human intellect that, for their nature, are characterised by ambiguity in their assignment. For instance, patents institute a valid title of information thought of as an intangible asset. Patents, thus, could be depicted as formal contracts between society and inventors (Biagioli, 2019). The first guarantees the latter the chance to secure a return on the initial investment through a temporary monopoly; the second commits to spreading the inventive idea to pursue a general technological improvement in application industries.

Lately, Intellectual Property assets gained even more economical and strategic value. Many studies have proved how, in the last thirty years, they became one of the most valuable resources that a prominent company may have had (Parr & Smith, 2009). As a matter of facts, today, the entity's market value is majorly based on intangible assets' portfolio assessment (Cardoza, Basara, Cooper, & Conroy, 2006). The variables that drove IP to such importance in business are essentially two: excessive competitiveness and technological innovation (World Intellectual Property Organization, 2020). The higher average rate of competition in every industry is due to globalisation and market deregulation combined with progress, or to put it another way, the launch in the market of new technologies. They created a mix that altered the previous natural marketplace balance. In other words, intangible assets, way more volatile than material ones, are likely to be the driving force behind the modern economy (Madhani, 2012). Therefore, they need protection and enforcement on behalf of companies that manage them. As a result, the profits generated from royalties could be reinvested within the firm's activities accordingly.

All in all, intangible assets are subject to embezzlement from those who compete unfairly, making a profit at the expense of others' ideas. In this regard, several forms of protection have been instituted to avoid unpleasant circumstances as industrial designs, trademarks, geographical indicators, copyright and related rights (World Intellectual Property Organization, 2020). It is ought to distinguish IP rights from obligations created by contract, custom, or other law. For instance, the fruit of an employee's work may belong to the employer, and it might be patentable. Although IP rights fall outside the employment relationship and the job contract's obligation, it becomes a subject matter tricky to manage (Frank, 2006d).

2.1.1 Patents

A patent guarantees the right of exclusivity to an invention. It offers legal protection for a limited time, an averagely of twenty years from the application date. It applies within the countries in which it has been deposited in exchange for the public disclosure on the owner's behalf. The holder has the right to choose who can or cannot use the invention and at which conditions through licensing. Patent rights are transferrable, and their validity lasts until the expiration date or until the owner stops paying the maintenance fees; after that, the invention becomes publicly exploitable. Also, IP rights are in force only when a formal document has been issued. It typically occurs in a period from one and a half to three years. Meanwhile, competitors can freely use the technology, and the only defensive weapon available for the applicant is to claim "patent pending" to discourage anyone else from using it (Grindley, 2018a).

Patents can be considered as binding contracts between the state and the applicant in which the country guarantees the owner the exclusive use of the invention for a certain amount of time (Biagioli, 2019). In other words, it is a technical and legal document made of a descriptive report that explains how the device works and which are the functional parts involved. Thanks to the official paper, the holder prevents any third party from producing, selling, or using the invention within a certain period. The time interval is generally twenty years long conditional to a maintenance fee paid each year, pain the forfeiture of the cover (Grindley, 2018a).

It has been thought of as a tool in the hands of companies and organisations to support innovation, growth and increase the quality of life, benefiting everyone. The invention protection assumes managerial relevance as it secures investments and encourages innovative production and products' launch in the market (World Intellectual Property Organization, 2017). The whole IP protection system fosters competition among companies always seeking the latest trends and technologies. Only the first to arrive gains the exclusivity right; thus, it enjoys competitive advantage and new funds to reinvest in R&D activities in order to keep the advantageous position in the market. Competitors, instead, rush to find new solutions to safeguard their shares. Hence it has been modelled how, through innovation, firms possibly reach an improved market result. It all starts with the invention, then protected through IP rights, enabling the product's launch. From the obtained royalties, new funds become available ready to be reinvested and, in turn, create new inventions (Meloso, Copic, & Bossaerts, 2009). The role of competitors is then to bypass the patent's claims proposing similar products.

In conclusion, patents become the real asset upon which companies can leverage. Not only it facilitates knowledge transfer and fuel investments in R&D, but also it becomes a tremendous defensive strategy against counterfeiters. In this regard, the entities owning large patents portfolios choose to license them to receive benefits gaining additional financial resources and keeping the right to use. Patents become a valuable source of information about the industry's latest discoveries and how supplementary innovation could be brought in.

2.1.2 Patentability criteria

Not everything invented is patentable, and it has to match some requirements, listed in Article 52 of the European Patent Convention (EPC) and replicated in national laws. It is subject to patentability matter if the item is an invention, new, with a certain degree of inventiveness, susceptible of industrial application and not fall within a list of "excluded" subject matter (Article 52 - Patentable inventions - The European Patent Convention, 2016). As already mentioned above, to stay in force, regular renewal fees must be paid. Patents' requirements gain significant relevance in legal disputes as patents become strategic leverage for companies. For this purpose, when disputed, patents get meticulously examined to find any ground for their revocation.

Novelty, together with inventiveness and industrial applicability, assumes great importance in such circumstances. "An invention shall be considered to be new if it does not form part of state of the art" (Article 54 - Novelty - The European Patent Convention, 2016). State of the art, essentially, is everything available to the public. Other words could be used to explain that everything is not new, whether it has been divulgated before; therefore, sometimes it might come in handy to sign secrecy contracts to preserve such a feature. A critical test could be run to prove if the requirement has been met, named the two-limb test (European Patent Office, 2018). Stating that prior art disclosure eliminates novelty principle, if a skilled person can perform it using exclusively common general knowledge, the invention might not be labelled as new.

Not every country has the same regulations. In the United States, the novelty's inventor has one-year time to file a patent application after the first public disclosure or the first offer to sell (35 U.S.C. 102 Conditions for patentability; novelty - United States Patent and Trademark Office, 2019). That does not include licensing; however, even the licensee's disclosure is enough to make the one-year clock ticking. Sometimes, in particular circumstances, an accidental revelation could happen. The "beta agreements" are one of these cases (Frank, 2006d). Allowing technology trial before commercialization is likely to trigger disclosure, or if the originator receives compensation, the beta agreement leads too quickly to a sale or confidentiality fails.

Furthermore, "black box" usage could lead to disclosure too. Whether a product has been presented in a fair or exhibition, and no divulgation happened, secrecy remains intact (Frank, 2006d). Otherwise, if the owner explains how the mechanism works within the demonstration, it might not be a patentable subject matter anymore. Lastly, even a simple presentation to potential investors can be irreversibly harmful if the inventor does not pay enough attention to the pitch's contents (Frank, 2006d).

Secondly, inventiveness is validated if the invention is not evident to a person skilled in the art. An assessment method practised by Spain and Germany's courts called the "problem-solution approach" aims at reducing the risk to wrongly judge patents (T 0939/92, 1995). It consists of finding the "closest prior art", or an art reference that discloses the claimed invention starting point (T 0632/02, 2003). Then to identify an "objective technical problem" derived from the differences between the claimed invention and the closest prior art (T 0606/89, 1990). Finally, analyse whether for a skilled person in the art it would have been obvious. Unlike novelty, inventiveness is a subjective and interpretable requirement from different viewpoints; therefore, they result in a weaker defence in court. Another possible approach practised by UK courts tests an expert under cross-experimentation to clarify the obviousness at the relevant priority date (Windsurfing v Tabur Machine, 1985) (Pozzoli SpA v BDMO SA, 2007).

Lastly, an invention to be patentable needs to respect the industrial applicability principle. The invention is susceptible to an industrial application if it can be made or used in any industry (Article 57 - Industrial application - The European Patent Convention, 2016).

Apart from this, patent claims should be written to be carried out by a person skilled in the art (Article 83 - Disclosure of the invention - The European Patent Convention, 2016). Particularly in the United States applicants have to fill the "best mode" to make the invention work (35 U.S.C. 112 – Specification – United States Patent and Trademark Office, 2020). The reasons why governments set the obligation of a clear description lie in the arguments discussed above. The state allows the inventor the exclusive use of a claimed invention in exchange for information disclosure. Intuitively the whole mechanism works if the disclosure is sufficiently reported. Vice versa, excessive exploitation could lead the inventor to enjoy an exclusive right without adequately inform the public (Pallini, 2008). In such a case, the inadequate description is marked during the application phase, and it could be rejected, whether not accordingly amended. Sometimes it happens that the court grants the patent anyhow, then third parties have the right to prove the impossibility to reproduce the invention; otherwise, it cannot be distinguished from state of the art. The described proceeding is called opposition.

In order to effectively lay a claim for IP rights ownership, a few concerns ought to be better explained. First of all, the employee-employer relationship previously discussed does not apply if the idea has been solely carried on by employees independently. The US legislation provides employees with the Freedom To Operate (FTO) principle (World Intellectual Property Organization, 2005). It means that employers cannot claim the ownership of employees' inventions as far as they were developed in their spare time and without using the firm's resources. Therefore, employers must claim IP rights ownership for each invention, assuming a timely and effective innovation identification. Taking a broader point of view, the FTO allows entrepreneurs to verify, through a careful research in the related patent literature, the chances to invest in the development of a new product without infringing others' patent rights. Intuitively, this practice helps avoiding to pay damage fees to third parties for alleged infringements or to withdraw a ready product, already on sale, on which considerable resources have been spent. In fact, it should be recalled that incur a violation of intellectual property rights does not mean to be aware of the alleged violation. Therefore, in order for a firm to launch its own technology in the marketplace, it may require to exploit technology patented by others. In this regard, prior knowledge should be gathered and eventually additional patents will be purchased or licensed in (World Intellectual Property Organization, 2005).

The resulting math to assess the patent value would be structured as such: total expenditures to date, plus the net present value of expected future costs (Frank, 2006b). This formula considers a prompt reaction to technological changes, but it might be inquired at what point of an invention's life cycle the patent process begins. Stating that it depends on the invention's relevance, some innovations require more prudence and tangible proof of concept without losing priority. Before market launch, the steps an invention goes through are divided into prototype creation, beta testing, budgeting, and market introduction achievement (Frank, 2006b). The former – prototype creation – proves the idea's viability justifying the expense of a patent filing. Beta testing is used to gain confidentiality with the project and its potentialities. Instead, budgeting activities show the firm's full support to the project, while market introduction usually takes place in trade shows or exhibitions where customers are involved.

The last measure to efficiently manage IP rights consists of industry-standard participation. Although the subject will be deepened later, following market standards and adjusting firms' patent portfolios might ease the company's competitive pressure and bring new funds ready to be reinvested. Industry standards need to be exploited by market players for their double function: they lower both customers' switching costs and resistance to adoption while enabling new revenue streams from the offered product or service and its complementary products (Frank, 2006b).

To sum up, companies enforcing IPR as a relevant strategy in their businesses need to consider the surrounding competitive environment carefully. Patents need to meet some requirements before approval, and those same requisites can be triggered differently from country to country. In order to avoid unpleasant circumstances where IP rights cannot be enforced due to a lack of novelty rather than inventiveness, companies and organizations have to plan their market strategies meticulously. As a matter of facts, market operators can exploit Intellectual Property as a value appropriation tool. In this way, patents could strengthen the firm's positioning, depending on the industry's degree of IP usefulness in the industry (Cohen, Nelson, & Walsh, 2000). Once this very last point has been established, the type of patented knowledge also matters. It is common practice to mix tacit and codified knowledge to effectively safeguard market shares, chiefly in competitive environments characterized by a high imitation rate (Arora, 1997). Partial disclosure could actually result in a winning choice as a way to control competitors' acknowledgements. For this reason, small companies prefer secrecy and speed rather than long waiting periods for patents in order to operate smoother and with more agility (Leiponen & Byma, 2009).

Another frequent use of IP serves as a defensive measure from the strategic competition. Firms can use IP to manage the competitive landscape. For instance, companies use to file the so-called secondary patents to protect fundamental Intellectual Property at the business core and, consequently, become the target of legal disputes by competitors as they cover broader subject matter (Lanjouw & Schankerman, 2001). Intuitively, also market fragmentation influences the litigation rates in a specific sector. It has been acknowledged that the more players are competing in the market, the higher the frequency of disputes is likely to be (Ziedonis, 2004).

On the other hand, IP could be exploited to counterattack competitors. Then, along with a careful study of the patent's characteristics, a conscious choice of the location where to initiate the legal proceeding turns out to be crucially important. National patent systems work differently, and some courts have more sectorial knowledge than others (Somaya & McDaniel, Tribunal specialization and institutional targeting in patent enforcement, 2012). It would be curious to investigate how and why companies prefer specific bars based on the single national market's relevance in their financial statements.

2.2 Patent disputes proceedings

Besides the strategic reasons that a firm could consider before implementing IP enforcement, it might be helpful to provide a general overview of the legal proceedings. For this paper's purpose, not every kind of legal action will be described in detail; instead, a quick peek of the most functional to the analysis will be provided. The feasible solutions to which a firm could resort are divided into two macro-categories: pre-grant and post-grant proceedings. As the name itself suggests, pre-grant proceedings address patents not issued yet, vice versa post-grant. Examples for the former are invalidity and infringement, for the latter opposition or appeal proceedings (World Intellectual Property Organization, 2020). It has to be remarked that every jurisdiction distinguishes these two macro-categories, adapting modalities and functional operativity to the applicable law. Every legal action presents a plaintiff and a defendant arguing on an alleged illicit where the first sues the second. Except for the infringement, the sued entity corresponds to the patent holder.

Each legislation dictates its procedures within the limit of the applicable national law. However, generally, they trigger mainly three reasons: lack of patentability, insufficient disclosure or inadmissible extension (European Patent Office, 2018). At the European Patent Office (EPO), it has been named opposition, while the United States Trademark and Patent Office (USTPO) calls it Inter Partes Review (IPR). *Stricto sensu*, work similarly towards the same objective: allow a third party to challenge a granted patent's claims within a certain period of time (World Intellectual Property Organization, 2020). The critical factor is the threshold that a challenger has to overcome to commence the proceeding. It can be requested soon before the grant of the patent or right after. The European version has a not extendable nine-months-after-grant limit compared to IPRs that can be filed any time after the "America Invents Act" in 2012. Further, the patent owner has the right to amend claims appealing against the judge's final decision in a procedure called administrative revocation (World Trade Organization, 1994) (Partington & Calvo, 2017). Generally, an opposition may be filed by any third party but the patentee. For patent revocation, opponents may meet some requirements, for example, bring proof of being adversely affected by the court's decision.

Secondly – infringements – a patent owner, co-owner or licensee is entitled to sue an alleged infringer whether this one has presumably taken economic advantage from others' Intellectual Property without permission. The scope of such a proceeding is to alleviate the damage under the shape of injunction or money compensation (Helmers, 2018). Two types of infringement could be distinguished: direct and indirect infringements (European Patent Office, 2018). Direct infringement refers to patent claims' content, and it triggers whenever someone has been proved to manufacture, import, use, sell, or offer to sell a patented technology without approval. On the other hand, indirect infringement befalls when the alleged infringer induces someone else to infringe, provides instructions or encourages the activity. As mentioned above, the patent's validity broadens up to the country's borders in which it has been filed. Thus, the national judging court could arrange a pecuniary remedy for the injured party whenever proven the infringement. In such circumstances, the paths undertaken by patent bars consist of a cash settlement derived from a reasonable estimation of the owed royalties or the lost profits. Intuitively, it comes easier to estimate the not-payed royalties rather than commit to a full assessment of the potential lost profits depending on numerous variables that cannot be fully proven (European Patent Office, 2018).

The sole pre-grant practice covered here is the invalidity procedure. The patent invalidity ground is considered valid if the claimed invention is not patentable under Articles 52 to 57 EPC (Article 138 - Revocation of European Patents - The European Patent Convention, 2016). In particular, invalidity procedures are subject to national laws; therefore, they slightly change from country to country and subordinate to community legal procedures. Concerning this paper's purpose, the Unified Patent Court, under the EPO, will be discussed.

2.2.1 The Unified Patent Court

The Unified Patent Court (UPC), established in 2013, is the first significant effort by the European Union to unify the patent regulation under a single jurisdiction (Article 63 – Term of the European patent – The European Patent Convention, 2016). It regulates the disputes around the European patents, and it has been created to guarantee centralized management of patent litigations without losing the benefits given by local adjudications. Homogeneity around decisions turns out to be significantly important; the need to level out all verdicts under one method of judgement could truly bring tangible benefits to the system as a whole. Therefore, decision-making speed would steeply increase with further diminishing the differences among legal procedures and eliminating the necessity for parallel litigation involving local and European patent authorities. All these elements combined are likely to lower the costs involved in patent proceedings (European Patent Office, 2018). However, they might trigger mala fides situations where companies and organization could unfairly intimidate others with several suing threats.

UPC consists of a Court of First Instance and a Court of Appeal. The former has its Central division seats in Paris and several other smaller regional divisions, albeit it provides a specialized section in London regarding chemical and pharmaceuticals patents and Munich for mechanical and engineering patents (European Patent Office, 2018). In this concern, the Unified Patent Court must be considered a proper patent court, regulating and judging the patent filed within its jurisdiction. Patent owners, therefore, are entitled to use the previously discussed procedures to enforce their Intellectual Property. The German patent court's configuration has inspired the UPC patent system: a bifurcated system that assigns to two different courts respectively, the management of pre-grant and post-grant proceedings (Cremers, et al., 2017). In order to better understand the key variables and the potential risks around the European litigation system, it is essential to deepen the Unified Patent Court litigation system.

UPC and Germany's systems are similar to each other as they concern managing the numerous legal proceedings available. The bifurcated system holds separate procedures assigning the whole process to competent entities with different priorities. The patent validity shall be proven before the Central division or a local division, while infringement claims would be filed only at regional divisions. Whenever a counterclaim for nullity is filed to counterattack an infringement procedure before a regional division, the local division itself has the right to refer the dispute to the Central division. However, invalidity proceedings are fileable exclusively at the Federal Patent Court after an opposition has been registered, thus further delaying the judgement. In short, a national revocation or nullity proceeding is forbidden whenever an opposition is pending or possible (Section 148 - Suspension in the event of preliminary proceedings - Code of Civil Procedure, 2013). In Germany, patent infringement victims have available two appeals to turn over the first instance's outcome, all of them conferring upon a higher hierarchy level of the tribunal: the first instance is discussed in a regional court while the last appeal is assigned to the Federal Supreme Court. In response, alleged infringers can file an opposition within nine months after the grant and call the involved parties to debate the patent validity further. However, this judging system encourages some opportunistic endeavours; for instance, the validity challenge drop (Cremers, et al., 2017). As the sole success of an invalidity proceeding is enough to produce positive externalities for all competitors, it happens that firms refuse to carry on some procedures to avoid producing even more. For this reason, the challenging firm, once clarified its position, has strong incentives to drop the challenge.

Additionally, competitors strengthen their market position as soon as they acknowledge the result of a proceeding such alike. The outcoming information derived from a nullity procedure could have strategic relevance since the case disclosure gives additional information to market operators on what strategy the firm is pursuing. It also creates an opportunity to take advantage of the verdict as the case details might unveil valuable unknown business clues (Cremers, et al., 2017). Another barrier that patentees have to face is the prohibitive proceeding costs. The authorities raised the costs high to discourage excessive use of counterclaims and consequently long-lasting legal disputes.

Further, some patentees are likely to engage in opportunistic behaviour and exploit the Angora cat paradox at other expenses (European Patent Office, 2018). Following the UK courts' lead, the model consists of adopting opposite approaches during prosecution and litigation. During the patentability assessment, the claims are presented narrowly as a wet Angora cat to distinguish them from the prior art. Whereas, once the patent has been granted, the same claim become far broader, like an Angora act with thick, dry fur. In other words, it appears that the same patent claim could have a dualism of interpretations. For infringement's sake, the patentee argues for a broader claim scope than when it comes to evaluating novelty.

The European patent system might still undergo a series of reforms without creating additional incentives for opportunistic behaviour from what just discussed. On the other hand, it offers some valuable advantages crucial to today's market dynamics (Unified Patent Court, 2015). First of all, the exclusivity of a single jurisdiction offers the chance to increase specialization. The Federal Patent Court charged with validity cases can train and involve technical judges, thus favouring consistent knowledge building over time. Decision after decision, the legal certainty increases, and so do disputes' costs and risks due to the separate patent revocation proceedings. Hence, alleged infringers are more likely to desist from filing an excessive number of actions without considering in advance the actual chances of success. Lastly, at the core of European patent disputes, there is the presumption of patent validity that streamlines the weight of numerous proceedings pending in courts. It also enables a rapid assessment of infringement claims as validity does not need to be contextually assessed (Cremers, et al., 2017).

One ought to consider some concerns before concluding the topic's discussion. The premises upon which the UPC is based aim to reduce the judicial fragmentation across the European Union members and accordingly establish a unique manner to proceed to simplify the patent system processes. Moreover, its objective is to lower legal procedures' costs guaranteeing greater access to patent enforcement services like Defensive Patent Aggregators, later discussed, without enhancing opportunistic behaviours for welfare-reducing litigation activities. If these last-mentioned measures will not be implemented, is predictable an increasing in "forum-shopping" by patent litigants (McDonagh, 2014). It is now known that some organizations exploit the patent system configuration to sell and purchase patents aiming to threaten litigation against other companies. As a matter of facts, small and medium enterprises (SMEs) might not have sufficient financial resources to support an enormous potential infringement proceeding; therefore, they are likely to accept a settlement before trial. On the other hand, even though big and established companies have more bargaining power, they might fear an infringement procedure as well and prefer settlement over long-lasting and financial bleeding legal actions. Through these mechanisms, Patent Assertion Entities (PAEs) thrive at others' expense, drastically affecting the competitive market dynamics and IP strategies.

2.3 Patent litigation for strategic purposes

The so-far described measures give the reader a general overview of the operating mechanisms in the patent world. Apply for a patent has implications; the patentee must follow the competent patent office's rules and timing. At the end of the process, if granted, the invention will be publicly available. The information disclosed has significant strategic relevance. It essentially constrains the competitor's viable solutions since if they are likely to launch a similar product in the market anyhow, they will assess first whether it infringes any patent or not. Depending on several factors: from the company size to the product development progress, the competitor firm could choose to adjust the product development accordingly and avoid any infringement threat. A viable solution could be to sign a license contract with the patent owner, achieve at least the right to use but sensibly increase costs, or even decide to file a proceeding to undermine the other's business. Simultaneously, the sole patent disclosure could give essential clues during the development process of the competitor's products, thus facilitating imitation. Hence, it becomes fundamental for a company or organization to foresee which patents file and what knowledge keep secret instead. Today, Intellectual Property strategies are gaining more relevance in business, especially in industries like the automotive sector, in the middle of a disruptive change process. Firms have to learn how to predict R&D activities' future outcomes of R&D activities precisely, assess the potential economic added value, and then exploit the right tools to enforce and defend their intangible assets.

2.3.1 Strategic instruments to assess the patent value

Companies use patents as tools to defend their businesses from potential new players and already established competitors. One should specify that patents offer certainty around the concept of property. Once a patent has been granted, the invention becomes an applicant's property and is thus eligible for exclusivity rights. A patent guarantees exact coverage about the subject matter, and whether discussed in court, the broadest range of eligible subject matter is applied. In short, it means that during the process of patent evaluation, the most extensive interpretation is considered valid. Also, the independent development of an invention does not mean safe protection against infringement. However, applicants do not imitate others' work; there still is a chance that similar products or processes have been already filed.

The downside of patents are costs, time and information disclosure. The costs involved in a patent filing can be enormous. If the firm is willing to create an extended portfolio, averagely the price fluctuates from $2000 to $5000 depending on various variables (Frank, 2006d). When considering enforcing the firm's IP rights, legal fees should be added and other litigation expenses that jack up the price even more if the dispute ends with a defeat. When planning a strategy to implement, time becomes a significant crossroad. Every jurisdiction has its timing and awaiting periods; therefore, companies should be on point when organising several deadlines and the needed documentation. Waiting time spans tend to be very long as the competent patent office must scrupulously evaluate all claims during retention. As a result, it elapses a long time between application and grant. Once the whole long process is completed, the patent effectiveness is likely to be at stake. As soon as the disclosure phase occurs, the patent should have already brought added value; otherwise, competitors could exploit these new bits of knowledge at the firm's expense. In this way, the company cannot take full advantage of the situation, and additional procedures might be necessary to adjust the operating results (Baker & Mezzetti, 2005).

Alternatively, a company or organization could opt for keeping the patentable subject matter secret and, as it might sound intuitive, the practice is called "trade secret". It naturally involves some preventative measures afterwards reflected on total expenses. For instance, a firm should take some precautions like strict access controls and site security to monitor who access restricted areas (Frank, 2006a). Furthermore, employees should be great at dealing with confidentiality; thus, employee non-disclosure agreements and rigid exit interviews seem only a few fair measures to implement in order to keep up with competitors' pace and consolidate the firm's market position.

Generally, trade secrets are adopted in unique situations. When the market environment is fragmented, it has large, diffuse competitors, and many solutions could resolve the problem to which the trade secret addresses. In summary, trade secrets could be seen as an extreme defensive measure against the competition, way more high-maintenance than patents. Stated their confidentiality, they become convenient in particular conditions because tricky to enforce before an ever-changing judicial landscape with definitely high conservation costs (Grindley, 2018a). Further, risks of an independent development that would bring down the whole house of cards need to be taken into account. Oddly, an individual researcher could reach the same conclusion autonomously or exploiting the reverse engineering approach. This concept consists of achieving the same functionality goal of a selected item starting the inventive process from the final product, thus reconstructing the process development backwards.

As it concerns the differences between trade secrets and patents: the latter is conceived for longer life products as maintenance fees should be paid, up to twenty years of validity. Nonetheless, it results in more agile in miniature competitive landscapes where companies might not have enough time and resources to elaborate brand-new solutions. Lastly, patents are fully exploited when there is only one way to solve the research problem (Frank, 2006c). As a matter of facts, if a company or organization manages to patent an essential solution for the industry's business, it would put itself in a dominant position where to license to competitors or raise higher entry barriers would be a daily choice. To avoid such circumstances, one might further explain how some companies use to pay nominal fees to journal to make them publish ideas too hypothetical or uneconomical to patent, but might be useful one day. In facts, early publication prevents anyone from obtaining a patent on an invention forever (Hedge & Luo, 2018).

Another gimmick thought by Original Equipment Manufacturers (OEM) in the automotive industry are design patents (Frank, 2006a). Sometimes these rights cannot be extended to copyright enforcement due to the patented article's usefulness, although they include ornamental items. Hence, they can be allocated in the middle ground between patents and copyrights. The automotive sector's players have used their further similarity with utility patents in covering functional, industrial attributes to protect automobile spare parts and mechanical interfaces. Besides, some of them cannot qualify as utility patents; thus, design patents, cheaper in application costs, result in a valuable option.

In order to make an informed decision on whether patent an invention, keep it secret or leak out potential breakthrough innovations to scientific journals to fight back aggressive competitors, it is fundamental to acknowledge the latent patent value (Reitzig, 2003). It is probably one of the most challenging processes of the entire Intellectual Property strategy. The firm's business needs to assess the real economic value of a patent as narrow as possible. In the current "open innovation" era, where patents are denoted as the first signal for innovation, firms increasingly rely on third parties to acquire and commercialize the technology. Therefore, companies and organization cannot afford to adjust their development processes on the run simply. However, a proper appraisal of each R&D endeavour's potentiality is the only way to efficiently turn investments into actual profits. Even researches by experienced professionals do not assure all essential patents to be identified. Additionally, patent descriptions seldom deliver a complete picture of the invention (Hall & Harhoff, 2011). In summary, it is incredibly tricky to spot patented invention with real economic value.

One might advocate that, before deepening quantitative tools to assess patents' value, three key variables that drive the patent value's fluctuation should be considered. As in effective scope and patentability, legal strength is the first element of uncertainty that should be carefully evaluated before choosing whether to start working on a project or buy a licence (Caillaud & Ménière, 2014). Adequately addressing all these shortcomings requires a skilled professional to classify and assess relevant patents that could take a long time and copious financial resources.

Another parameter that makes this task so difficult is the surge in patent applications every year. A large number of filed patents raise the odds that an invention could infringe prior patents (Caillaud & Ménière, 2014). However, as is happening to the music industry with the streaming platforms dealing with copyright enforcement, to have more available patents does not correspond to an overall quality increase as they appear more heterogeneous. Surveys report that in Europe, around one-third of granted patents are not exploited to commercialize products, processes or services but used exclusively as a weapon in patent litigations to hinder competitors. Otherwise, their applicability is too broad, and they possibly might not find any present utilisation (Gambardella, Giuri, & Luzzi, 2007). Undoubtedly, a sign of misuse of patents could accentuate opportunisms in specific companies. PAEs, for instance, are ready to destabilize the automotive market balance at their benefit. Usually, low quality corresponds to weaker and more legally breakable patents. As such, information asymmetries challenge the firm's ability to exploit patents effectively. A knowledge gap between the two parties becomes crucial when it comes to patent trading, later discussed. Also, it will be further analysed how firms' network beneficially impacts some entities while it makes room for unfair practices that potentially harm competition.

Meanwhile, the ongoing evolution of markets in the open innovation landscape facilitates the diminishing of information disparities. In the long run, it is foreseeable the direction towards the whole movement is going: the democratization of patents. The advanced research and monitoring technologies allow companies and organizations to enhance transparency for all stakeholders. Thus, all operators should be able to make informed decisions, and welfare-reducing behaviours would drastically stem (Caillaud & Ménière, 2014).

As previously discussed, quantity is not a sign of quality. Sometimes identify an area of interest for the company's IP strategy might not be enough in the automotive industry. According to PatVal's survey, two-thirds of the granted patents are effectively exploited to commercialized products or services, whereas the remaining part has been filed for strategic purposes only (PatVal, 2005). This drastic split is due to the non-introduction of international standards in the sector that would shed light on both sides' missing information. Therefore, the financial assessment of patents tends to be even more uncertain as, during the final negotiations, parties' evaluations are likely to be still far apart (World Intellectual Property Organization, 2009). However, skilled industry professionals have thought and modelled some tools in order to achieve an assessed value that would be as close as possible to the real one. They can be divided into three categories. The most conventional tool sets the sight on rating technical, legal and commercial parameters affecting the resulting patent quality. Practically, the model classifies and grades the commercial parameters affecting potential invention's market; then, it weights with the ones derived from the legal and technical analysis (Caillaud & Ménière, 2014). One might do the math and conclude that getting an unconditioned rating seems improbable since companies do not use standardized approaches. Hence, the grades mirroring an invention's potentiality could only be used within the company due to the lack of sufficient global information that could be leveraged to refine the rating better.

Further, the European Patent Office offered small and medium enterprises a tool named IPscore. It claims to singularly rank each portfolio, answering a questionnaire that evaluates several parameters on a grade from 1 to 5. Results should finally enlighten the potential applicant on the viability of the patent filing. Nonetheless, this quite exhaustive questionnaire might be mind-numbing to fill when the patents to analyse are more than ten. It appears to be too subjective and small-scale sized for more significant patent portfolios (European Patent Office, 2018). In brief, currently available statistical methods are too widely utilized in such an open-innovation context; therefore, evaluate patents potentiality in this manner might not be the best alternative.

Technological progress allows by now to store an unquantified amount of data about whatever, obviously patents too. The best way to analyse such information and acquire fundamental knowledge to steer the IP strategy better is to apply the following statistical methods. The Generality Index aims to capture the patent's influence on consequent innovations, taking into account the assortment of fields in which the patent is cited. The higher the index, the more likely it will be to find licensees in varied domains (Caillaud & Ménière, 2014). The Originality Index, contrarily, calculates backward citations and the higher the index is, the more market penetration has reached (Caillaud & Ménière, 2014). These two tools combined could give a relevant overview of the patents worth of more detailed evaluation.

Furthermore, the acceleration coefficient is able to compare numerous companies' portfolios in a specific sector and analyse how many patents have been filed within a time range. The higher the index is, the greater the likelihood of identifying a promising innovation, namely one of the best methods to spot a potential breakthrough innovation.

Another evaluating tool is the company-specific patent signature: it has been demonstrated that the cumulative application of patents forestalls a product launch; through this calculation, one is allowed to predict a new launch in the market by the analysed competitor (Caillaud & Ménière, 2014). Last, cross-citation: as a tool to compare patents evolution over time between players of the same industry. It is able to spot early clusters advent of operators collaborating to develop products built on the same ideas. One ought to spend some words on rarely exploited tools that today are still considered too hypothetical and uneconomical to invest. Automated tools are disappointing when it comes to evaluating specific industries. They do not consider the sector's business models, patents' several types of use, and the geographical area of interest (Germeraad, 2010).

To conclude, in the near future, a further evolution of statistical and automated tools is expected, parallel to the technological progress likely to ease the development of new assessment methods. Along with them, more information transparency between operators should alleviate transaction costs as well as the likelihood of making quick decisions will steeply increase. However, the strong presence of traditional methods highlights the lack of necessary information and training among the vast majority of specialists. On the other hand, innovative instruments would enhance strategic intelligence expressed through data visualization and quality assessment at both macro and micro levels. The key to changing current practices resides in acknowledging the experts about statistical methods, to entitle them to correctly evaluate the bearing, and the boundaries, of the diverse foretelling factors (Caillaud & Ménière, 2014).

2.3.2 Building an IP strategy

Once the relevant patents have been evaluated, it would be already possible to draw the first conclusions. At this point, the firm ought to know whether to move more investments in R&D activities, valorise the owned patent portfolio or purchase patents from other market players. The risks of competing without following a planned IP strategy are predictable enough. A patent portfolio that grows chaotically will finally diverge from what is essential to business success, looking at the past rather than predicting the future and causing no harm to competitors (Frank, 2006a). To properly build an IP tactic, it would be more accurate to define the IP roles that the strategy can play first. It exists a dualism between the different roles played: offensive and defensive.

Offensively, an IP strategy could be implemented to wall out competitors. As mentioned above, people seeking IP protection want to have a tangible and legally substantial advantage from competitors. Firms resort to trade secrets only in particular circumstances since they are not enforceable (Grindley, 2018a). To patent technologies in the bottleneck of the industry's technology before others do, it might turn into the best offensive measure, but also it would drastically increase the barriers to entry. Whether this is the case, install a tollbooth in the wall and use licences as a toll to join the industry's players, it is a profitable solution (Buermeyer, 2005). The best-case scenario would picture the licence option as a bottleneck technology. However, it comes in handy to implement in non-core technologies, thus becoming a resourceful stream of income (Frank, 2006a).

Defensively-wise, structure a grounded strategy affects several factors that would strengthen the company's position. The first consequence of proper IP rights enforcement is intimidation. As a matter of facts, in court, a company with an extensive portfolio sounds less appetible than a "naked" competitor (Spinello, 2009). Going on, valuable patents give the chance to access others' technology as patents are tradable and can be used as a bargaining chip. If the firm possesses valuable intangible assets, it could cut deals with other owners in order to prevent potential competitors from accessing the technology (Frank, 2006a).

Furthermore, one should consider the deal-making power during partnership or joint ventures negotiations. What firms bring to the table are all available assets, IP exclusive rights included. A strong patent portfolio also offers potential market partners exclusivity rights and discourages others from partnering with direct competitors or independently developing the technology. Once again, IP is a full-fledged asset, and it could be significantly valuable to potential acquirers and reliable support for anxious investors relying their capital on the firm's performances. On the other side, customers might demand patents too. If they bought large procurement with high integration expenses, they would not appreciate finding their businesses undercut by lower competitors' prices. Lastly, some inventors might expect to bestow recognition through IP since, when huge investments are at stake, politics always takes its share (Fabry, Ernst, Langholz, & Köster, 2006).

All considered, a valuable IP strategy should focus on the firm's core technology, namely what the company does best. Then, a targeted strategy should be deployed in a series of circles matching diminishing priorities zones. Three circles could be identified. Around the bull's eye, the first ring encompasses implementations of the fundamental technology or features that optimize performances, costs, and ease of use. The second ring represents the potential applications, while the last circle incremental improvements (Frank, 2006a).

On the other hand, another feasible approach is named "picket fence". It lends itself to various interpretations: for some, it means filing families of patents around a critical product in order to protect it, similar to the above-discussed secondary patents concept. For others, it means filing patents around competitor's technologies aiming to constrain their businesses. For others still, it means erecting obstacles around a weak core technology (Buermeyer, 2005). For example, if the chip is not patentable for a reason whatsoever, it is strongly suggested to patent the interfaces and communication buses around it. Anyhow, IP protection should be aligned with the company's business core entirely and continuously (Frank, 2006a).

In case the market-dominant positions would have been already taken, a firm could partner with more significant entrepreneurial realities and, through collaboration, carve out space in the competitive landscape. The best way to undertake such a strategy is through licensing. Licensor's side, two approaches have been identified, namely traditional and alternative. The former suggests affiliating with an industry giant and letting them take care of product development, marketing and crushing the competition in exchange for royalties and equity investment (Frank, 2006b). Within this framework, it is crucial to perform proper patent research as licensees tend to be suspicious about other firms' work since, in their situation, they cannot do anything but trust the quality of patenting efforts. Thus, the holder has to convince them of the needed precautions to ensure patent strength have been taken. Present a real and valuable opportunity to licensees is the key to maximize the number of licensing contracts. They usually seek the broadest interpretation, and thus, in order to sell them the idea, it is important to picture the patent extensive enough to cover any credible implementation. In this regard, preserving international right helps licensors attract potential new licensees as well as spot probable overlapping or complement patents that might enable total freedom of action, whether absorbed. In other words, if on one side, the broader the applications are, the more likelihood of selling. On the other, firms have the choice to sort the IP portfolios by geographical region, product type, market and field of use. Therefore, specific patent claims could be licensed through contractual agreements (Grindley, 2018c).

Second, the alternative licensing approach involves industry standards, further debated afterwards. Companies that find themselves in a strategic market position when the industry standard establishment occurs have a unique opportunity to chase. Own a patent that covers such a matter could beneficially trigger substantial profits. Standards make a selected technology available to all, guaranteeing to reach the whole market possibly (Grindley, 1995). The technology itself should match a few requirements first. Its price should be appropriately low to lure a significant section of the industry to adopt. Then, the campaign becomes self-enforcing, what suppliers adopt, grows in customers and complementary products makers and so forth. The most representative example is the mobile and networking industry, which converges with other sectors like automotive. The information technology world has already experienced standards' seizure, where recognised standard organizations keep growing and flourishing (Grindley, 2018b).

To a licensor, the implemented IP protection sounds more like a defensive measure than a profitable asset. For this purpose, firms should extend a patent's coverage exclusively to relevant markets without overdoing foreign enforcement. Once the geographical range has been established, they focus on the commercial implementation to broad as much as possible the patent's coverage since narrower claims mean weaker built-in defence before the court (Frank, 2006b). In doing so, new licensing opportunities might present and possibly open unexplored markets. The US patent regulation reaches out of this case.

Along with the market landscaper evolution, firms are entitled to file incremental innovation applications referring to a granted patent. This principle is called "continuation-in-part" (CIP). It allows owners to file additional matter not yet disclosed (35 U.S.C. 120 – Benefit of earlier filing date in the United States – United States Patent and Trademark Office, 2019). Hence, keeping a continuation or divisional pending helps the patent owner promptly respond to new hazards or occasions emerging in the marketplace.

As noted earlier, if a firm wants to pursue an international IP strategy, the first stage of the evaluation process would categorise countries where the resulting patent's economic values top the application costs. At this point, the second step would dictate to rank those same potential markets in the available budget function. The classification would take into account essential selection criteria about countries' market conditions, promptness to business and enforcement context (Beukel & Zhao, 2018). Following this order, with market conditions, one means the strength of IP coverage enforceable in different states. Specific legislations are likely to behave differently before the same proceedings as previously discussed. Thus, it is likely that countries popular with infringers may not offer the best legal protection and put the IP strategy at risk (Javorcik, 2004). For instance, local policies and GDP growth could dramatically affect the outcome of IP protection measures. In order to mobilize and control resources across countries, firm handling is required (Branstetter, Fisman, & Foley, 2006). Further, protection should be sought in countries likely to materialize substantial business within around a year and a half or with realistic licensing chances.

2.3.3 Choosing where to locate patent disputes

IP litigations take place locally, but their consequences affect firms' activities globally. The litigation per se is set in a court ruled by the local laws, and the outcome may bind actions only within the same jurisdiction. However, patent officers and judges may refer to previous verdicts and litigation results in other countries when making their own, even though they do not cite each other. Besides, defendants and plaintiffs happen to reach settlement agreements over IP that might involve foreign countries in which the patent family is registered. Most likely, then, the achieved agreement or verdict in one country deters similar would-be litigators from suing the firm abroad as long as the aforementioned decision is communicated through the company's information channels. Here discussed the effects produced by transmitting the signal on the competitive landscape (Beukel & Zhao, 2018). The first variable considered is the decision's impact on the country level. More prominent companies, Multinational Enterprises (MNEs), can choose in which court litigate to maximise the positive externalities produced over a potential win. In other words, whenever a firm wins a dispute in a relevant market, the information is conveyed to competitors, then potentially arousing different reactions.

This signal is affected by several factors. Predictability is indeed one of the driving ones. Courts' track record is duly noted in written documents; therefore, it gets to be known in the industry if the result is easily foreseeable. The parties can then decide how to pursue the case further, stated the experienced judgements. Anyhow, reducing uncertainty over the court's decisions is a sizable advantage, and it clears out the parties' chances of winning.

Secondly, the strength of the court also matters. Spillovers among courts are common; they influence each other over case argumentations. Companies then need to be punctual and skilled when choosing in which court to file the litigation, since a local market, both financially and legally stable, represents a valuable resource. Hence, choosing the "right" court becomes crucial for a successful business. It goes without saying that a patent to be litigated in a given tribunal must be filed within the same national borders. Therefore, as MNEs are globally present, it is reasonable to expect more litigations in longer experience courts. Thus, companies can predict the possible outcomes and impact probable procedures in other parts of the world (Cremers, et al., 2017).

Before, one mentioned that the signalling effect increases as the global company presence does. For this reason, the information is thought of as transferable across countries and competitors, either bringing to reputation reinforcement (Agarwal, Ganco, & Ziedonis, 2009). At the case level, if the proceeding dispels further doubts around the technology, it sheds light on competitive dynamics happening in other countries as well (Somaya D. , 2012). Thinking about MNEs operating in oligopolistic markets, they would carefully choose the location, timing and the subject matter of the dispute. Contrarily, fragmented industries where numerous players elbow their way into the market are not an ideal breeding ground for strategic litigation; instead, proceedings result to be filed in niche markets and geographically isolated. This is called the industry effect (Beukel & Zhao, 2018).

The last dimension affected by IP strategy layout lies behind the portfolio's characteristics. Patent litigations are complicated, especially when they involve cutting-edge technologies (Merges & Nelson, 1990). The more radical the innovation is, the more litigations are likely to occur. To be more precise, disputes around new and advanced technologies result to be more challenging as prior verdicts may not exist, and the patent scope tends to be broader. Acknowledging that MNEs with a portfolio dominated by radical innovation seek IP enforcement in courts where judges understand the technology having familiarity with copious patent cases. Since radical inventions are likely to be filed with broader patent scope, they would attract more litigation actions because they are claiming more of a territory (Merges & Nelson, 1990).

In summary, big companies like MNEs plan their IP rights enforcement based on several factors: geographical location, industry characteristics and portfolio composition. All these three factors combined to give an overview of how these entities behave in the marketplace. The country effect helps companies strengthening their reputation in defensive measures against would-be litigators. Industry effect measures the degree of concentration of legal activities in a specific market. Last, firm effect targets radical patent portfolios, moving the focus on a small number of countries able to rightly assess the most advanced patents' value (Ghemawat, 2007). As such, strategically preferring some courts' locations and, in turn, make general business decisions based on the outcomes could be considered as part of the harmonization goal set by policymakers.

2.3.4 Alternatives to IP disputes

Before suing another company and engaging in a long and exhausting legal dispute, every company should perform some internal searching. As part of the evaluation process, a firm should acknowledge first the realistic scope of its patents, detect potential weaknesses, gather as much information as possible around suspect infringes and, finally, set the goal it wants to achieve through litigation (Frank, 2006e). In contrast, licensors do not have such freedom of choice, and they are often bounded to contract commitments. Some clauses may obligate the licensors to sue free-rider infringers, namely figures who do not pay the agreed tax undercutting licensee's expenses (Bannon, 2008). Some penalties are imposed as well in order to invite further violations. Thus, litigators should seek favourable settlements rather than outright victory.

As a matter of facts, parties could choose "alternative dispute resolution" (ADR) or instead called arbitration and mediation (Frank, 2006e). The primary goal of the latter should be settlement: a procedure flexible, private and fast. However, it could be subject to misuse, and parties could engage in egoistic behaviours. For this reason, a third party can be called to arbitrate among the two. The process is relatively straightforward:

parties agree on ground rules and accordingly select an arbitrator. Whether the parties could not even agree on which arbitrator to appoint, two of them will be called to name a third. Following the lead, the arbitration climaxes at the bar at which each party picture the case. Then, a decision is taken. This procedure has the advantage of being quick and reasonably cheap, private, and leaves the arbitrator's freedom of choice. Regular patent litigations, instead, are likely to be long, quite expensive and also, depending on the case's relevance, media might be involved (Frank, 2006e).

On the other hand, give up on the judge, a formal and neutral participant may lack robust central control and institutionalized authority. To conclude, one might remark that polices against IP litigation exist on both defensive and offensive approaches. Thus, smaller companies could avoid bearing unthought-of costs, unaffordable over the long run.

3. Threats to the incumbents' status-quo in the automotive industry

The automotive industry has been extremely proactive in enhancing and promoting technological innovation ever since. Progress seems to be capable of setting in motion the engine of modernization gradually introducing the latest machineries all over the value chain. Besides, technological and scientific innovation had a relevant impact on the development and production procedures, safety and the ability of designing smarter vehicles either. Taking a closer look to automotive sector, it becomes evident how the whole competitive landscape is continuously evolving and improving. For several decades, trends were positively recorded by growth indicators and today the industry is facing one of the most radical and interconnected challenges ever experienced. As a matter of facts, from the 21st century on, the business players are handling profound changes in marketplace. Society has developed strong sensibility towards an environmentally sustainable way of life affecting firms' strategies and business goals as well. Stricter rules regarding carbon dioxide emissions enriching the green technologies portfolio and the launch of car sharing services addressed to traffic issues and diverse customers' needs, may progressively shift the concept of owning a private car towards a service (MacDuffie & Fujimoto, 2010). As a consequence, MNEs are adjusting their business models and patent collections to catch at best new business opportunities.

The discussed premises are not only favouring the adoption of innovative technologies and boosting emerging markets, but also endorsing new environmentally sustainable policies, usually guided by regulations that establish greenhouse emissions (GHG) reduction objectives to be achieved within a certain period. After all, some of the most significant drivers of such transformations are customers and their choices that mirror the socioeconomical background where values have been shaped differently and a dissimilar conception of property has been acknowledged (Schulze, MacDuffie, & Täube, 2015), as well as the crucial role of public policies in supporting the adoption of latest technologies. For instance, the Zero-Emission Vehicle (ZEV) program promulgated by the California Air Resources Board (CARB) in 1990 that not only established stricter emissions standard, by now followed by ten other states, but also ensure that carmakers progressively explore, adopt and commercialize cleaner vehicles (California Air

Resourses Board, 2018). Therefore, young businesses could potentially influence incumbents with their fresh vision and business model applications. These emergent trends are converging to each other and risk to abruptly disrupt the market as it has been known until today (Schulze, MacDuffie, & Täube, 2015). Hence, companies, especially established players, should be concerned about their extant business relationships and eventually react in order to keep safe their market shares.

In this chapter, it will be outlined the existing trends in the automotive industry and how carmakers have adapted their business and organizational models. OEMs find themselves in the middle of a disrupting change in the automotive world, facing both organizational and strategic challenges (Bensaou, 1999). The former issue is questioned in function of the network operating around the product development, thus in which manner manufacturers should rely on external suppliers or which components are more appropriate to outsource. The latter, instead, concerns the viable strategic resolutions to adopt when dealing with typical open innovation hurdles. In other words, how companies deal with the decrease in strategic relevance of economies of scale and leverage Intellectual Property assets (Meyer & Utterback, 1993).

The second paragraph debates the origins of such challenges as in the role of new incoming technologies in the automotive sector. To date, it is experiencing a disruptive convergence of different instruments and technologies coming from industries far apart from incumbents' core competences (Assurant, 2018). Therefore, anyone who is operating in such context is going to collect as much knowledge as possible, even via purchase in the IP market (Carraz, Nakayama, & Harayama, 2014). In this regard, the following paragraph aims to provide a closer look to the players actively operating in the IP market, from carmakers, to new entrants, until the discussion of particular entities whose core activity concerns the transactions of patents. Hereinafter, a dualism of organization is analysed: Defensive Patent Aggregators (DPAs) as the answer to the emergence of Patent Assertion Entities (PAEs) famed for welfare reducing behaviours in patents trade (Guellec & Ménière, 2014) (Papst, 2013). The remainder of the chapter denounces an excessive uncertainty around safe technologies in which invest due to a lack of established standards in the automotive industry (Teece, 2018). As a matter of facts, standards help companies and organizations in recognising the best technology to promote facilitating a common reach, lowering the searching costs and directing research expenditures (Grindley, 2018b).

3.1 Current trends in the automotive industry

Alongside the premise and bringing further proof to demonstrate what just enounced, it may be undoubted that the whole automotive industry keeps reforming with the continuous introduction of new measuring system and more advanced technologies. The firms' challenge stands in dealing strategically to adopt innovations and keeping a proactive attitude to change. All considered, the mobility sector is likely to be highly affected by the advent of more advanced and complex development processes like the above discussed digital manufacturing. For argumentation's sake, the example of mobility comes in hand as in the early nineties the whole business landscape failed to implement a radical shift towards complete automation. The main reasons why this never happened lie in the importance of human handwork. Back there, companies and organization did not have enough technological support to implement fully automated machineries (Pardi, 2019). Therefore, the human teamwork was still the best option when dealing with complex and flexible tasks involving complicated assembly processes. Today, thanks to new measuring tools and the availability of more precise technologies, it could be easier for companies to adjust their product development processes accordingly to the latest technologies.

By now, new technologies presented as disruptive are positively affecting all existing players in terms of production capacity, better and more diversified products and fairer work conditions. They have been gathered around several names that differ from country to country: Industry 4.0 in Europe, Advanced Manufacturing in the US and Made in China 2025 but all have in common the general definition of "second machine age" (Brynjolfsson & McAfee, 2014). Along with reputable studies, the automotive industry is expected to be one of the most reformed sectors by the Forth Industrial Revolution, concentrating more than 40% of the world's stock of operational robots but still employing a variable amount of unskilled human workers (Sirkin, Zinser, & Rose, 2015).

As enounced in the first chapter, it might be useful to recall which are the manoeuvres conceived per single macro development plan. In Europe, where Industry 4.0 is attracting considerable public funds and private investments, the project was launched aiming at speeding up the technological modernization and innovation of the area (Pfeiffer, 2017). The vision has been thought of as a global advantage built upon the mixture of manufacturing and Information Technologies knowledge (Kagermann, Wahlster, & Helbig, 2013). Overseas the so-called Advanced Manufacturing project does not differ as much from the European example. Consortiums of dominant industrial companies and organization provided additional equity capital to finance R&D activities and support market seeking strategies. On the other side of the globe, the Chinese government wants to enrich emerging sectors, boosting electricity as main source of power, although slightly including automotive sector in the picture (Zhang & Li, 2020).

The prime contact point among the three listed solutions is the target category. The measures are tailored to the same group of workers, both skilled and semi-skilled, who occupy a strategic position in the labour market and companies' power of relation. However, deskilling is an omnipresent risk, either segmentation and polarisation act as a workaround to decrease labour costs. Worth of mention is the political reason why these projects were born. They responded to the 2008-2009 crisis and aimed to facilitate the economic recovery. As a matter of facts, the ultimate achievement has been set on developing the latest technologies to generate or regulate the resulting emerging markets and capture state action and resources. Anyhow, the three options do not have to be seen as national modifications of the same policy concept. Rather a diverse set of industrial applications and development accordingly customized to satisfy operating players, available technologies, financial interests and business objectives (Pardi, 2019).

3.2 Organizational structure in Open Innovation framework

As discussed, the whole automotive industry finds itself in the middle of a technological convergence that will guide a new era's competitive landscape. Cars' development now requires mechanical and electronical skills and numerous resources from a wide assortment of actors and businesses. Automobiles are multi-technological products made of components forged by several technologies. Components are then linked to each other through a set of interfaces that guarantee the performance of specific functions (Brusoni, Prencipe, & Pavitt, 2001). The digital convergence in this particular sector opened unprecedented market opportunities for potential new entrants, starting from the broadening of the car's technological components implemented, like electronic and monitoring mechanisms, to finally reach the rise of new technological trajectories, exemplified in the electric engines trend. Thus, an increasing number of carmakers need to master a broad variety of technological skills in order to keep the pace of competitors (Maxton & Wormald, 2004). Besides, the market pressure and high competition rates forced OEMs to further accelerate the development process while persistently dropping costs and increasing quality (Clark & Fujimoto, 1991).

One may add that in order to efficiently respond to the technological and market challenges, carmakers reformed their product development organization. First, they introduced a figure that would play the role of knowledge and development integrator within teams, so-called heavyweight project manager (Wheelwright & Clark, 1992). Then, they provided these new employees with multi-project management tools to co-work efficiently and benefit from knowledge sharing (Cusumano & Nobeoka, 1992). Moreover, the integrated development of product families through platforms and other common project base helped exploiting economies of scale and scope (Meyer & Utterback, 1993). In short, to speedily react in an everchanging business landscape, companies introduced new managerial roles supported by worthy instruments and product development process innovation (Clark & Fujimoto, 1991).

Secondly, in a marketplace characterized the by establishment of global networks and ongoing long-lasting business relationships, OEMs find easy to secure a large number of external connections with suppliers. These, in turn, allow manufacturing companies to rapidly access to specialized knowledge drastically lowering new products' costs and development activities (Nishiguchi, 1994). Here, it comes back the previously discussed concept of outsourcing specialized activities also involving suppliers' engineers, whose goal is to render the car's development process, per se already complicated, efficiently organized and cost cutting. In this respect, it is crucially important to design and integrate at best every single component to form a product that must be highly reliable and satisfy customers' desires. However, market segmentation and customers' preference volatility represent two factors that may put investments at stakes. Market players, then, leverage on key variables such as time-to-market reduction, quality improvement and spending-cut, to reduce uncertainty around products' future performances (Krishnan & Ulrich, 2001).

3.2.1 Organizational challenges to OEMs

All in all, being able to rely on a global network of external suppliers offers several advantages to OEMs assisting them in R&D efforts. Involve external resources allows carmakers to access specific and inferred knowledge that would be challenging to replicate in-house otherwise. Further, suppliers' know-how and comparative advantage in the performance of specific assignments diminishes costs and time during the design process. Finally, since carmakers are embedded in such global networks, they easily get access to heterogeneous and varied technological skills (Clark, 1989). As a matter of facts, in the automotive industry carmakers are assisted in the product development process by a vertical integrated network of fragmented activities. This approach enables firms to keep their cost structure flexible and also improve organizational and structural complexity.

Despite the mentioned benefits, carmakers have to face a series of challenges as well. Throughout the discussion of such topic, two relevant choices need to be taken into account. The first consists in perfecting the ability to manage varied portfolios of relationships with external suppliers picking the appropriate governance model to encourage inter-firm collaboration and reduce opportunistic behaviours as much as possible. The latter concerns which tasks outsource and which retain in-house. Following the enounced order, a firm have to adequately assess which organizational conformation addresses best its needs in order to establish smooth and efficient governance mechanisms. In order to avoid any opportunisms or knowledge leakage, some governance's forms might lead to better organizational results in term of resources coordination and knowledge sharing. An informed decision needs to be taken considering transactional costs and appropriability hazards (Oxley, 1997). Literature advocates that the higher the complexity of the traded product, the more likely the correspondence has been overseen by hierarchical mechanisms (Kogut, 1988). Hierarchical forms, as a matter of facts, increase the chance to constrain opportunistic behaviours and deal positively with operational issues. In particular, they aim at keeping under control knowledge streams, avoid accidental information spillovers and bypassing innovation issues. Such practices are further influenced by the degree of overlap between parties' technological competences involved in the transaction (Colombo, 2003).

Conventionally, OEMs manage networks of external resources' providers through a differentiated portfolio of pre-signed agreements. Researches identify four models of business exchange between suppliers and manufacturers in the automotive industry (Bensaou, 1999). The first, market exchange, comes in handy when dealing with standardized mature products with little engineering efforts. Stated the regularisation and high penetration degree of the core technology, the parties do not need to considerably invest in the occurring transactions nor it requires particular coordination abilities. Different from the mode just outlined, captive buyer relationships present asymmetries in the extent of commitment of the partners. Basically, the supplier has complete control over a relevant technology in the manufacturer's business, hence it benefits from its strong bargaining power. For instance, complicated components that entail customization but encompass stable technologies (Trombini & Zirpoli, 2013).

Strategic partnerships, instead, involve jointly OEMs and suppliers with highly specialised assets into the business relation. This is the case where a carmaker commits to invest copious resources on both tangible and intangible assets related to the provided resource. On the other hand, the provider tailors components and production skills on client's needs, thus linked hand-in-glove to manufacturer's organizational mechanisms (Bensaou, 1999).

Finally, captive supplier ties identified in opportunistic behaviours in which the carmaker emphasizes its advantageous position at the expense of the supplier. This means that it develops with the provider committing with copious investments to hold the customer and stay in the market (Bensaou, 1999). Typically, these circumstances occur when firms are dealing with relatively new technologies designed and developed by the provider but whose launch in the market depends entirely on the OEM.

In summary, a mismatch between an appropriate organizational structure and the relationship supplier-manufacturer, chiefly in the automotive industry, tends to negatively impact business endeavours. One might observe that, since companies are dealing with several projects concurrently, this twofold match needs to be managed at a single-project level implementing a certain flexibility in the decision-making process. As a matter of facts, each project features different level of involvement and new development processes, hence a mismatch could bring drastic consequences and make impossible to establish any mutually beneficial business relationship.

Once determined how to efficiently deal with the organizational issue, a carmaker needs to distinguish which activities outsource and which develop and produce internally. In performing innovative endeavours, manufacturers are willing to achieve two goals. On one side, they are likely to exploit the offered flexibility and economies of specialization contracting out technical disciplines to suppliers. On the other, they need to keep introducing breakthrough inventions and new product architectures to safeguard market share and their advantageous position in the marketplace (Brusoni, Prencipe, & Pavitt, 2001).

In the past decades, colossal manufacturers, like Fiat, sticked to modularity as leading principle in outsourcing decisions (Sanchez & Mahoney, 1996). To be more precise, thanks to modularity's model, the entire components systems is potentially delegable to external contractors although risking to lose focus and technical skills, essential to integrate interconnected components and interfaces (Macduffie, Modularity-as-Property, Modularization-as-Process, and 'Modularity'-as-Frame: Lessons from Product Architecture Initiatives in the Global Auto Industry, 2012). Within this framework, two main disadvantages could be identified in outsourcing competencies based on the modularity concept (Zirpoli & Becker, 2011). The first concerns the product architecture integrity: the overall performance of the car does not depend on specific components only but how these subsystems interact with each other. The second matches with competence accumulation issues. To date, vehicles work as connecting platforms coordinating components and their interfaces (Brusoni, Prencipe, & Pavitt, 2001). Thus, OEMs subcontract design and engineering competences in danger of losing proficiency with advanced and specific technologies and, in turn, lessening the ability to act as system integrators.

All considered, an equilibrium should be sought between economies of specialization and competence accumulation. Such solution could be pursued through the retention of engineering and technological skills within the firm to manage providers' work at its finest (Sanchez & Mahoney, 1996). In this way manufacturers have the chance to promote in-house learning plus spending time and resources to test components' interdependencies while thriving from suppliers' participation.

3.2.2 Strategic challenges to OEMs

By time, some companies operating in the modern automotive industry may gradually reduce the use economies of scale. This approach itself may not provide appropriate tools to respond to more distributed business approaches. For this reason, carmakers do not bear the whole cars development process but a vertical network of highly fragmented activities takes care of it. It allows companies to make their cost structure more flexible and also improve organizational and structural complexity.

Subsequently, manufacturers face new threats as the often-recurred outsourced activities impact the overall marketplace balance. As a matter of facts, they reflect on more suppliers' bargaining power that influences the competitive relationships within the value chain, in turn compounding the integration and coordination among the several actors involved. Therefore, the key to strategic success lies in designing an organizational solution coherent with the firm's strategy. Within the industry some examples could help one to better understand. Toyota, for instance, was able to fully exploit new, more distributed, production mode; on the other hand, Fiat could not keep up with the complexity management and it was forced to back source engineering and design endeavours (Zirpoli, 2010). General Motors and Chrysler, instead, were forced to bankruptcy because, as soon as they spotted heavy difficulties in such practice, it was already too late (Trombini & Zirpoli, 2013).

As mentioned above, the reduction of relevance of scalability allowed carmakers to focus on developing workarounds to save costs during the development process. For instance, Fiat and Ford use to produce the same plant for their city car models so that the equipment for production and repair phases is the same, thus decreasing the break-even points. All considered, the overall complexity of development processes definitely increased. From one's point of view, the technological progress facilitated the convergence and integration of several new instruments like virtual development and simulation tools. As a matter of facts, the latter brought improvements in design quality thanks to new kinds of information that could be analysed and harnessed to early spot potential issues (Thomke & Fujimoto, 1998). Also, they sensibly reduced experimentation costs and the number of physical prototypes used in the trialling process. This unprecedented data stream allows manufacturers to observe and timely intervene to prevent wastes in terms of resources and time. Collect consistent information about critical aspect of product development could have a significant impact on the prevention of functional problems affecting the launch performance. Hence, companies have the chance to enlarge their patent portfolios without forfeiting efficiency.

To do so, the task is taking advantage of economies of scope on both competences and components. The best way to achieve it, takes into account a well-organized model capable of managing the integration among components and platforms keeping the differentiation for customers without risking to loose beneficial business relationships between external suppliers and internal functions. Therefore, over the years, companies learnt how to commandeer external knowledge streams and how to coordinate them with internal innovative activities. Stated the high pressure from competition and distributed innovation processes, it becomes crucial to better investigate how manufacturers profit from their innovation endeavours. Literature advocates several manners through which firms turn expensive R&D investments into tangible profit and growth margin: secrecy, lead time, patents and complementary assets (Cohen, Nelson, & Walsh, 2000). Clearly, the success of these solutions is subordinated to the degree of appropriability of the industry. In other words, the strategy effectiveness is strongly affected by the profit margin a firm can achieve in a certain application sector, in addition with a set of environmental factors (Teece, 1986). As a matter of facts, the more relevance is assumed by patents, thus allowing firms to properly catch profitable returns and earn monopoly profits, the stronger the appropriability regime.

It may be pointed out that in the automotive industry, the greater incumbents tend to adopt defensive patent strategies also through the acquisition of several patents worldwide and abundant investments in managing large patent portfolios. The reasons why such strategies have been implemented by the majority is threefold. On the one hand, patents help in preserving sensible competitive advantage. However, they have been proven to be not as successful as expected in company’s activities protection. Patents, in facts, are unfruitful when it comes to safeguard innovation processes rather than final products, namely the largest OEMs’ output (Cohen, Nelson, & Walsh, 2000). What needs to be remarked though, patents prevent others from commercializing protected innovations thus excluding them from developing, using and selling innovations suchlike. Therefore, barriers to imitation rise exponentially as new overlapping patents are continuously issued (Somaya, 2012). In this respect, the automotive manufacturers deal with ongoing innovation and complexity of their products. By today, cars are multi-technology products made of several components not always under the OEM's control but outsourced to external suppliers or competitors. Hence, more than ever, companies should build large patent portfolios and keep safe their market shares.

Alternatively, some carmakers started to use the concept of co-patenting. The practice consists of assigning the invention's patent to both the supplier and the manufacturer. In this way, the OEM can monitor the provider's activity and, eventually, limit the diffusion of the technology to competitors through licensing. One specific clause, however, may undermine this precarious balance. The general rule of co-assigned patents states that one of the contracting parties is allowed to license without the other's approval. To specifically address to this issue, it is common practice now to stipulate additional contracts and put conditions upon the knowledge sharing permissions (Hagedoorn, 2003).

On the other hand, patents represent an effective defensive strategy instrument. The operational independence may spare expensive litigation costs and relevant delays in development process and product launch. As a result, companies are no longer hostage of competitors and intermediaries threats (Trombini & Zirpoli, 2013).

Finally, enforced patent portfolios favour the strengthening of the carmaker's bargaining power in the distributed innovation process. Patent coverage puts companies in a dominant position where they choose whether to threaten litigation against competitors or closely monitor the tendency on the usage of the patented technology (Somaya, 2012).

In this context, it assumes significant relevance to adopt both offensive and defensive IP measures. Preserve at any cost competitive position may turn in a winning choice (Reitzig, 2004). Furthermore, perfecting management capabilities becomes a key element to improve performance and to grow profit margins derived from innovation activities' (Rietzig & Puranam, 2009). The gradual dismissal of economies of scale forces carmakers to face new challenges every day, the advent of multiple network relationship definitely increased the degree of specialization of the industry but also suggested operating companies to safeguard their Intellectual Property assets and their business connections. The best way to do it is to enlarge firm's patent portfolio. Moreover, the ongoing development of new implementable technologies facilitates the entry of different players, before far away from operating in such context. All embedded within the automotive world, one obtains an everchanging sector with numerous players called to action as new business opportunities arise. Surely, incumbents have to find a defensive manner if they want to thrive in future and it all goes through patents and their exclusivity rights.

As just discussed, the potentiality of technologic discontinuities radically shaped the whole marketplace. The introduction of hybrid and electric engines has been the spark that propelled companies from diverse sectors to pursue unprecedented openings in different directions. Incumbents had to adjust their business models accordingly in order to avoid a resounding market position loss. Hence, carmakers changed their strategic approaches following the "electrification" trend. At the moment, no one is able to rely on a dominant design or industrial standards, thus uncertainty reigns supreme. Manufacturers started experimenting different technological solutions to follow the electrification shift. Certainly, the open innovation landscape involves diverse suppliers and companies playing more and more fundamental roles. As a consequence, value creation and value appropriation models could mutate as well as market equilibrium.

3.3 New incoming players in the automotive industry

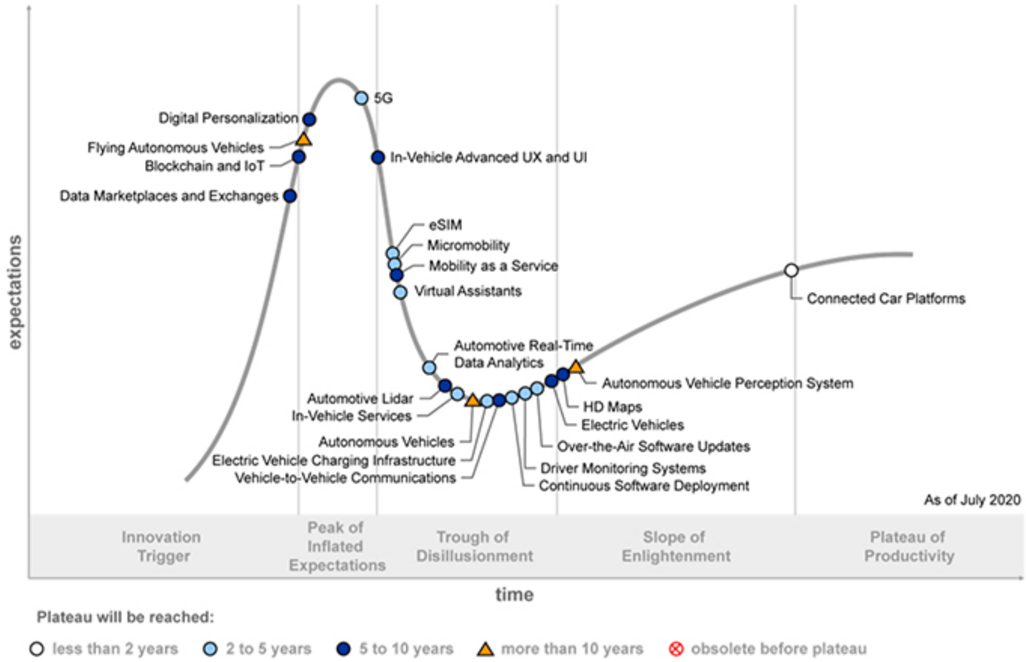
Particular attention should be brought to the development status of each technology since a timely investment in a certain domain could result in a winning market choice or accurately predict the emergence of potential new players. In order to keep pace with an everchanging marketplace, automotive incumbents are forced to continuously innovate their offer. Finding a methodology that support the safeguard of targeted investments, intangible assets and the ability to foresee market changes assumes significant relevance. In this concern, the Hype Cycle aims to assist companies in monitoring the engagement evolution of future large-adopted technologies in specific industries.

The "Gartner Hype Cycle" has been developed by the famous Gartner Inc., a multinational company global leader in research and analysis in the Information Technology industry.

They built core business supporting their clients in investment decisions exploiting probing tools, consulting services and benchmarking. The Hype Cycle is a line that describes the pace of crucial emerging technology and the trend of a specific industry or topic. In other words, a graphic representation of the maturity in the adoption of an alleged technology and its social strength. The notion has been introduced by Gartner himself, explaining the "hype" or enthusiasm that typically arises around an innovation right after its proven feasibility and its subsequent delusional period after the acquaintance of incremental innovations (Gartner Inc., 2020).

As evincible from Figure 1, it consists of five distinct phases. The first step is called "Technology Trigger", it disrupts the market with the launch of products or other events that raise public awareness with significant concern. It is followed by a "Peak of Inflated Expectations", as the logical consequence of a quick spread of the news that fascinates and inspires people. During this phase, it occurs to have many experiments, among which most of them fail. Therefore, a period of "Disillusionment" due to many unsuccessful attempts comes on. The technology cannot satisfy users' expectations anymore, and it rapidly goes out of fashion. Media either use to not talk anymore about the alleged innovative topic. At this point, far from the media's magnifying glass, the most determined companies start to understand some tangible benefits of such technology and practical applications take hold. Consequently, a "Plateau of Productivity" is reached: innovation's benefits are well proven and implemented by the market's players. The higher point the technology reaches, the more scalable it is, distinguishing which one could be adopted by the majority or limited to flourish only within a niche market (Fenn & Blosch, 2018).

Figure 1: The Gartner's Hype-Cycle for Connected Vehicles and Smart Mobility, 2020



Source: Yamaji, M. (2020). Hype Cycle for Automotive Technologies, 2020.

As market opportunities in the automotive industry enlarge for external companies, the degree of competitiveness has no choice but to increase. Thanks to the electrification trend, lately, several companies started investing or taking the lead, drawn in by the technological convergence the movement has aroused. Technology is transforming the automotive industry: tech, semiconductor, ride sharing and electric vehicle companies are just some examples of firms venturing to this everchanging business (Sherpa Technology Group, 2016). As already stated above, the dearth of a dominant design makes business choices and strategy planning extremely unreliable. Therefore, one of the most advisable is to protect the firm's market share by purchasing patents to broaden the IP portfolio; in alternative, by merging or acquiring smaller companies with strategically interesting assets. In this regard, it is essential to meticulously evaluate which national market and bottleneck technology would be more profitable for the company objectives. The digital convergence is paving the way for innovations from other industries, driving the change. New automotive technologies on the rise are 5G wireless communications, used for connected car systems. LiDAR, namely a sensory technology used for safety and autonomous vehicles like gyroscopes. Or, again, lithium batteries: the electric vehicles' sustainable source of power. These all are part of the C.A.S.E. technologies.

3.3.1 C.A.S.E. technologies

Connectivity, Autonomous, Sharing/Subscription and Electrification are the guiding mantra of the recent disruptive industrial shift happening in automotive (Assurant, 2018). Connectivity becomes the true cornerstone around which all these factors revolve. In today's automotive industry connectivity technology, typical of mobile devices and communication industries, made room itself inside everyone's cabins in the last decade. Vehicles have got smarter and safer, enabling unprecedented communications among them and with the surrounding environment either. The latest trends show how industry players will cross new borders, disclosing tremendous opportunities to connectivity companies thanks to faster mobile connections. Considered the Fourth Industrial Revolution's actual promoter, the 5G technology has already been tested with tangible results in developing self-driven and autonomous cars (Baidu, 2020). Companies that made connectivity their core business have the chance to broaden turnovers like never before. Unparalleled opportunities appear in the automotive industry; hence manufacturers and suppliers should be careful. Without an unprecedented pace and volume of data exchanged, vehicles would have never been able to communicate with each other and safely react to environmental accidents. 5G successful experimentation imported superior communication protocols: vehicle-to-pedestrian, vehicle-to-vehicle, vehicle-to-network, vehicle-to-mass-transit and vehicle-to-infrastructure (Teece, 2017). For instance, the technology actually brings significant benefits for the drivers. Considering the issue of traffic jams in highways, an efficient and coordinated communication between the vehicles driving such stretch of motorway can increase the freeway capacity up to 80% whether the gear has been mounted in all motor vehicles, that drops to 20% in case of mixed equipment traffic (Shladover, Su, & Lu, 2012). It is called “high-density platooning”, namely the creation of closely-spaced multiple-vehicle chains on highways resulting in highway flow improvement and fuel consumption reduction. In the best-case scenario, with a critical mass penetration, coordinated lane changes and intersections would drastically enhance the traffic fluidity. A number of benefits arise from a proper management of traffic flows. It translates into less likelihood of collisions on the way, as an increased volume of data exchanged between vehicles or with pedestrians may result in a functional enhancement of cars’ sensing abilities.

Once motor vehicles will be able to rely on each other building a safe infrastructure of instant communication and accidents prevention, then the autonomy will make self-driving cars to totally stand out. Autonomous automobiles are developed to meet a certain level of independence that goes from no automation at all, to full automation, in which the driver's action is no longer required and totally replaced by the onboard computer (Society of Automotive Engineers International, 2018). Also, other tasks' management can be entrusted to the vehicle itself. For instance, automatic parking may shorten the overall journey time. Knowing where parking spaces are located, facilitates the detection of alternatives to on-street parking and, in turn, reduces congestion (Chester, Fraser, Matute, Flower, & Pendyala, 2015). Time savings can easily turn into money savings. Sensible reductions in commuting time, fuel consumption and accident avoidance are able to spare half a billion dollars per year in the US (Diamantis, 2014). Intuitively, it would be capable of bringing also indirect benefits to people health and reduce stress levels, resulting in an overall increase in the quality of life. Other common positive externalities are the diminution of air pollution, thanks to gas consumption savings, and the reduction in carbon-dioxide emissions resulting from a fluid traffic management in expressways (Bose & Iannou, 2003).

Furthermore, another variable that highly impacted the current business models, and highlighted in the Hype Cycle with the label "Mobility as a Service", is the sharing/subscription topic. This innovative way of business allows customers not to own a personal vehicle anymore. Long and on-demand rent contracts are taking hold in the marketplace and successfully meeting customers desires and flexibility need (Assurant, 2018).

To conclude: electrification. This component can be defined as the most prominent as well as one of the biggest hurdles for the sector. The underlying concept is quite neat: Electric Vehicle (EV) technology is likely to be the next large-scaled adopted innovation, especially if adoption is strongly incentivized by promulgated policies and regulations. However, in some specific cases some resistance may be opposed by geographical boundaries. For instance, in China people living in rural areas are likely to access the technology later than their fellow citizens residing in bigger cities as charging solutions at one's disposal would be obviously less numerous. In this regard the government enacted incentives for manufacturers producing EVs aiming to constrain the business within the border, strengthen the charging towers' network and alleviate the carbon emissions rate, there already at alarming levels (FlorCruz, 2015).

This actively demonstrates that the rising technologies are strictly interconnected to each other up to the point where it comes tricky to precisely distinguish between the benefits brought in by connectivity technologies and autonomous or electric vehicles. However, some challenges may rise concerns around such framework. Original Equipment Manufacturers risk to no longer be the true beneficiary of new vertical integrated value chain, rather, stating the complexity and the composition of today's vehicles, software, content and technology producers are now standing in the first row. On the other hand, carmakers still boast many opportunities within the connectivity technologies, chiefly in vehicle-to-vehicle and vehicle-to-infrastructure communications (Teece, 2017). In addition, approaching this kind of innovations it has to be taken into account the rising of dominant design and the establishment of standards that could sharply boost firm's catchment area. These ecosystems benefit from economies of scale in both development and production process and, at the same time, reduce uncertainty around business choices. Thus, platforms are shaped by the standards around which innovation coalesces (Grindley, 1995).

Ultimately, some policies would encourage and accelerate the rising of social benefits (Teece, 2017). In particular the installation of optical fibre as routine part of the maintaining works that roads require would certainly decrease costs and help in building a reliable network of high-speed communications. Also, design specific solutions for autonomous vehicles could improve the integration with human-driven cars, for instance dedicated lanes and parking spaces would enable the aforementioned "platoon". Keeping the autonomous vehicles as polices' major recipient, the implementation of improved location accuracy equipment and faster speed limits would significantly enhance the safety on board and favour the data exchange between devices.

3.4 Market for patents

The technology outside the usual realm of carmakers is evolving, the design and realization of prototypes concerning innovative solutions have speeded up. As mentioned above, the development of autonomous vehicles requires the realization of different components that rely on new generation sensors and connectivity technologies. Hence, firms coming from other industries have enough room to bring their business in the automotive world. Historically, automotive companies have always hesitated to sue each other over alleged patent infringement. This reluctance makes sense as soon as increasingly functional products and new entrants supply technology will not take over. The expansion of scope of IP and the advent of new players is likely to expose manufacturers and suppliers to IP claims (Kantner, 2017). Recently the number of applied patents has increased in the US and abroad, although IP rights enforcement is not always the right way forward. Trade secrets, previously discussed, may provide a more appropriate means of protecting intellectual property regarding key advanced technologies such as automated vehicles, collision avoidance technologies, artificial intelligence and machine learning (Kantner, 2017).

Retracing the open innovation model, where companies operate in a global network with the possibility to exploit specialized knowledge and skills from external suppliers, the volume of IP transactions is expected to increase. Therefore, the occurrence of an IP market becomes a critical requisite (Arora, Fosfuri, & Gambardella, 2001). Recent studies have proved the relevance of knowledge networks and markets as promoter of new business models strictly related to the rise of inbound and outbound know-how flows (OECD, 2012). This actively demonstrates that patents market may assume particular importance in such context. Its presence may trigger two different business behaviours when operating in the patent market. The former treats IP exchange as a trade of technology, aimed at increasing the overall efficiency and performances, thus allocating evenly knowledge across the economy. The second approach exploit predatory attitude in IP trading with the sole purpose of capturing rents at the expense of real innovators (Guellec & Ménière, 2014).

3.4.1 Patent trading and licensing

Markets shape when recurring transactions or exchanges about similar subject matter occur between two entities. More specifically, an IP transaction is defined as the result of negotiation between two parties, establishing the general rule of the game at certain terms of transaction. Different kinds of transactions based on patents may be distinguished. First, the patent can be entirely transferred to the buyer. Second, licensing contracts may be signed in order to allow the use under certain conditions, usually geographical and time wise. In addition to including exclusivity rights, licensing contracts may provide specific conditions for the payment of royalty fees, and even include cross-licensing, enabling the two contracting parties to exploit each other's patents in particular fields. Lastly, patents may be subject to financial transaction that allow the holder to monetize the invention without losing control of it (Guellec & Ménière, 2014).

However, regarding the transactional price, a unique conundrum may arise from such situation. As introduced before, it becomes tricky to assess the value of an invention and its potential transfer conditions when it is about intangible assets (Guellec & Ménière, 2014). The more the negotiations last, the more transaction costs increase, hampering the proper development of an IP market (Carraz, Nakayama, & Harayama, 2014). At the same time, most patent acquirers do not possess enough know-how and knowledge to rightly spot the appropriate patents and eventually, they require external assistance for further advices.

One finds more convenient to classify the transactional costs within three fixed categories: screening, information and contracting costs (Guellec & Ménière, 2014). Following the negotiation's chronological order, screening costs may arise when technology suppliers and acquirers have difficulties in recognizing each other. As a matter of facts, the holder's ability lies in find potential buyers for a given technology and correctly convey the information to interested parties. Although, this information asymmetry could be overcome whether the contact between the possessor and the purchaser are within the same business networks and most likely they entertain some kind of business or personal relationship. In this respect, the survey conducted by the European Commission found the just mentioned business relationships as the most effective channel to find potential partners (European Commission, 2012).

Second, a transaction takes place when the two contracting parties reach a formal agreement, in other words, they agree on the patent's value, a price in some cases. Before bidding on a certain sum, the value must be assessed. Estimating a patent's value, as discussed above, might not be the easiest task to perform. Usually, experts and consultants assist companies in such activities, nevertheless the biggest risks to take concern legal, technological and economy uncertainty, meaning that it does not exist a widely recognized evaluating method (Caillaud & Ménière, 2014). It follows that significant information asymmetries may rise between buyer and seller, most of the times biased towards the holder resulting in the so-called information costs (Guellec & Ménière, 2014). At this point the conditions for a "lemon market" shape up. It consists in a situation of mutual distrust between the two contracting parties, metaphorically represented by the purchase of a lemon. It puts the buyer in a subordinate position where it is impossible to precisely assess in advance whether the traded item is good or bad quality. Thus, the buyer's perception of the purchased patent would be entirely based on owner's presentation (Akerlof, 1978).

Lastly, transactional costs include the costs for contracting the trade's details. They may consist in licensing or sale agreements, cost of lawyers and non-patented know-how. Significant is the latter circumstance, that demands a high-level contractual structure that takes into account even uncontrolled information leakage. A lack in the agreement framework is likely to result in unbalanced benefits from one party or excessive incurring costs (Razgaitis, 2004).

To sum up everything that has been stated so far, there is evidence of the development of a patent market that involves companies cross-industry. It settled since the demand for patents has increased as well as the knowledge exchanges among manufacturers and suppliers. In the actual open innovation's context, firms are used to trade, buy and license intellectual property exploiting global business networks at their fullest. However, some concerns may arise from information asymmetries, welfare reducing behaviours and biased value-assessing methods occurring during transactions. Such practices not only prevent an even knowledge distribution within the economy, but also leave enough room for biased deals at the expense of the buyer. Intermediaries intervene precisely on this issue.

3.4.2 Intellectual Property intermediaries

To fight back these IP market inefficiencies, one may recall Edison's experience. He could be defined as one of the brightest minds in human history. As a matter of facts, he clearly distinguished the activity of entrepreneur, manufacturer and inventor. Declaring himself as part of the last category, he discerned the endeavours of research, innovation and patent filing, interpreting patents as tradable assets that gave origin to the patent market in the first place (Papst, 2013). In this regard, one may classify a dualism of conducts performable in the patent market. A well-behaving practice that entails the enhancement of fluent knowledge circulation contracting on market terms, in contrast with a welfare-reducing one serving as multiplier for abusive patent litigations and opportunistic behaviours.

The technology market started to shape up around the nineteenth century in the US thanks to the advent of many professionals acting as lawyer, specialized intermediary or IP consultant (Lamoreaux & Sokoloff, 2002). Starting from the fact that keep acquiring new knowledge help the firm to stay competitive in the marketplace as well as reduce uncertainty and information asymmetries (Hoppe & Ozdenoren, 2005). The regular learning process takes time and it presents high fixed costs, thus the need for specialized figures that accumulate know-how and scale at full time. In their job, they act as a reference point between suppliers and users, too often subject to information asymmetries or great geographical distances. Therefore, the intermediaries' role consists in finding the right business partner interested in the technology, taking care of the transaction's details as pricing and the contract structure, and controlling the cumulative surplus produced by royalties whether there are numerous parties involved in the exchange (Baudry, 2014).

One may recognize several categories of Intellectual Property intermediaries, acting in different manners although all aiming to evenly distribute knowledge and patents in accordance with law regulations (Guellec & Ménière, 2014). The first group belongs to IP brokers and university technology transfer offices (TTOs) as entities in support of their clients in patent sales and strategy planning. In particular, Intellectual Property brokers built over time both legal and technical capabilities allowing them to meticulously match sellers with potential buyers. They use to work on either point of views of the transaction. On the seller's side, they assess the patents' value and seek to recognize potential buyer exploiting the IP marketplace's global network. On the other side, they seek potential sellers starting business discussion with the owners falling within the acquisition target. Similarly, TTOs play a crucial role in favouring the transfer or licensing of technologies from universities or research institutes to companies and organizations (Weckowska, 2015).

Other entities that facilitate the matching between sellers and buyers are trading platforms. Contrasting TTOs and IP brokers, they do not directly take the reins leveraging their experience in the field, rather ease the entry of a third party in the transaction offering suitable market infrastructures. They divide into internet platforms, Intellectual Property auctions and patent pools (Guellec & Ménière, 2014). The former's main goal is to put in touch potential sellers with buyers, gathering information on internet repositories and offering ancillary services like IP portfolios assessment, assistance in negotiations and so on, thus sensibly reducing screening costs. Auctions, instead, provide pricing services for the negotiating patents, consequently decreasing information asymmetries concerning patents' value, and promoting transparency as well as predictability of the IPR market. Lastly, patent pools are thought of as joint licences, namely an agreement between the two contracting parties that share the right of use of one or multiple intangible assets as a package (Baudry, 2014). Generally, the entity grants non-exclusive rights and distributes the derived revenues among the owners accordingly to a pre-arranged contract. The main consequences involve the reduction of transaction costs since patents are certified as valid and they do cover the exploitation of the licensed technology. Apart from this, one does not have to underestimate the impact at usability level. As a matter of facts, bundle of licenses allow way more companies and organization to have access to patented technologies at a unique price, and, whether wisely managed, they represent a golden opportunity to expand the firm's market (Clark, Piccolo, Stanton, & Tyson, 2000). Examples of such practice are common in the ICT industry, where the use of patented standards is regulated by IPR.

Finally, subject of further analysis in the next chapter, patent funds. They consist in investing entities monetizing acquired patents through sale, licensing or litigation. To pursue such business endeavour considerable screening skills are required, chiefly the ability to cut favourable deals for undervalued technologies. Some types of funds raise money from private investors to acquire patents' rights, in turn, licensed or sold to third parties within large aggregated patent portfolios (Carraz, Nakayama, & Harayama, 2014). More in detail, royalty funds invest in already licensed patents providing additional capital to licensees in exchange for royalty revenues. The practice can be defined as less risky than a regular patent transaction, in fact, the targeted patents are already producing royalties before acquisition hence reducing the uncertainty around the patent's performance in the marketplace (Yanagisawa & Guellec, 2009). Besides, other funds focus on an earlier technology's maturity stage. Technology development funds, as the name states itself, address to development-stage innovations. Bridging the gap between the invention and the IPR enforcement at a prior stage to commercialization, these funds serve as the additional certification needed by other investment providers. This way of working focalizes on the export of the targeted R&D project and the IP asset into a safe context where it can be nurtured without take the risk of owner's bankruptcy (Guellec & Ménière, 2014).

For the purpose of this paper, particular attention ought to be drawn towards the last type of patent funds: defensive patent funds. These organizations act as guardians protecting financially vulnerable companies from aggressive patent rights enforcement. Their mission is to acquire patents that are likely to be leveraged to carry on aggressive infringement threats. For their own beneficial nature, these entities may be non-profit or ad-hoc instruments developed by large groups of companies. The practice is so widespread that even the Korean government funded a public defensive patent fund to safeguard its national industry players (Guellec & Ménière, 2014). Besides, they could be opposed to patent trolls, as entities that exploits firms' financial uncertainties to aggressively enforce their IPRs against alleged infringers (Shapiro, 2001). Such entities, usually belonging to the ICT industry, use to acquire relatively old patents from the patents market and enforce their rights against alleged infringers.

3.4.3 Patent Assertion Entities and Defensive Patent Aggregators

It is ought to be clearly detailed that Defensive Patent funds, or better called Defensive Patent Aggregators, were born to hinder the rising of welfare reducing behaviours by other intermediaries. As a matter of facts, one of the main side effects of the advent of an IP market could be identified in the appearance of entities that, exploiting the legislative framework around IP proceedings, aims to monetize acquired patents through reselling, thus named Patent Assertion Entities (PAEs) (Chesbrough, 2006) (Thumm & Gabison, 2016). The term classifies a set of business behaviours that usually starts with the purchase of patents from companies seeking for liquidity until the threat of an injunction against an alleged infringer (Carraz, Nakayama, & Harayama, 2014). Let there be no mistake, profiting from patents purchase is undoubtedly legal, although forcing the extraction of excessive value from an invention and speculate with it, might be not. Therefore, it becomes crucial to distinguish patent trolls from Non-Practicing Entities (NPEs): organizations actively acting with good faith in technology transactions. For instance, universities and public research organizations, if not producing the inventions in-house, may play the role of intermediaries between manufacturers and technological companies through licensing tools. The concept of "entrepreneurial university" or "academic capitalism" defines specifically such landscape. Thanks to today's continuous exchanges, whenever a research institution sees its research patented and afterwards licensed, it candidates the organization to a potential on-to-one partnership with an operating firm, therefore enhancing the overall involvement of these organizations not directly involved in the value chain (Harayama & Carraz, 2012).

According to the patent law in force, no one is forced to utilize the patented technology although the IP rights keep being enforceable. Comprehensively, in a closed innovation regime where all the value chain's components exclusively rely on vertical integration there would be no reason to address this issue. However, with the expansion of open innovation business models and a more widely distributed knowledge, the phenomenon became more tangible. For this reason, patent trolls tend to keep their IP portfolios hidden waiting to be infringed (Rietzig, Henker, & Schneider, 2010). Following this concern, different media reported US firms constituting an ad-hoc organization that defensively buys patents under the name of Allied Securities Trust (Sharma, 2008). At this point becomes interesting to outline the narrow differences between NPEs and patent trolls and how firms learnt to clearly tell apart these entities. The key element resides in their behaviour. A legitimate NPE, after carrying on good-faith negotiations, usually possesses high-quality patents thus more likely to be declared as valid in a potential dispute. Despite patent trolls that, with low quality or broad patent claims, aim to extort a favourable settlement agreement and put an end to the litigation before its beginning (Dudas & Kline, 2013).

All in all, PAEs and NPEs, aside from their final purpose, propel innovation growth within the marketplace as making the process of knowledge distribution more efficient (Geradin, Layne-Farrar, & Padilla, 2011) and, in some circumstances, even help smaller companies or individual inventors to create a revenue stream from patents through their purchase and the enforcement against infringers (Haber & Werfel, 2016). As a matter of facts, PAEs, specialized in patent enforcement, focus on solving the alleged offence as fast as possible in order to rapidly capitalize the acquired patent, hence sensibly reducing the dispute's social costs (Galasso, Schankerman, & Serrano, 2013). However, the consequence of a recurring IP enforcement before court peaks the legal expenses on frivolous litigations. Obviously, such practice does not produce any value (Luman III & Dodson, 2006), nor it stimulates the market for technology (Fischer & Henkel, 2012).

As stated above, DPAs are the real response to the PAEs' threat seeking to spot patents that could be enforced against others in advance. DPAs can be divided into two categories based in their modus operandi. The first type aggregates patents that can be licensed through auction, hence so-called auction-based. Otherwise, the aggregator cooperates with member companies, identifies the target patents and signs a license at low royalty rate. Nonetheless one may spot some flaws in the DPAs' business model as the subscribers' incentives to innovate lower once they have the chance to easily acquire patents. In addition, in case of alleged infringement DPAs are less likely to sue another company since their mission consists in fighting back the numerous infringement actions filed, thus the risk for legal actions is reduced.

Addressing specifically to this last presented issue, DPAs use "catch and release" strategy (Hagiu & Yoffie, 2013). It consists in keeping the acquired patent for short period of time, after which patents are sold or donated. In this way, potential infringers cannot enjoy their potential free-rider status for long since the assignee of the patent is likely to change. The practice is opposed to the "catch and hold" technique that buy "dangerous" patent rights off the market and stock them in an "IP library" to which every investor financing the aggregator gets access (Papst, 2013).

In brief, DPAs are definitely better in recognising problematic patents and preserve companies from futile injunctions and resources' waste. Instead, they rebalance the operating liquidity upstream, reducing the number of patents on the market (Papst, 2013). In addition, their business model seems promising, encouraging an innovative division of labour. However, even if their way to operate aims at re-establishing symmetry in the IP economy, counteracting the patent trolls' actions, DPAs alone might not be enough to avoid to be outcompeted by PAEs (Thumm & Gabison, 2016).

In today's IP landscape hybrid entities are shaping up: super-aggregators, they have been named (Hagiu & Yoffie, 2013). This form of IP intermediary acts as Defensive Patent Aggregator when it comes to recognize the patents that are likely to be disputed in future and purchase them, consenting its subscribers gain access to their use. Besides, it may operate as a Patent Assertion Entity since a member firm is still suable and the organization does not guarantee the avoidance of legal disputes in case of alleged infringement. As aggregators evolve and change their behaviour, companies' IP strategy adjusts accordingly (Thumm & Gabison, 2016). As a matter of facts, technology firms already started to subscribe only to Defensive Patent Aggregator's services whereas collaborating with PAEs at the same time in order to avoid being targeted by them (Kwon & Drev, 2020).

3.5 Market standard technologies

The most appetible patented technologies in the market affect and get influenced by the rising of a dominant design. It emerges via market competition and establishes the core specifications of a specific product or service. A dominant design can be thought of as a de-facto standard that raises after a considerable large adoption by industry's players. Therefore, it is of the utmost importance to understand first what is the definition of standards. As already discussed, standards are the core specifications for a product or a process adopted by the large majority of market players. They do not explain all the features of a product, rather they focus on the crucial aspect that characterizes it. Its characteristics vary from the most basic as quality standards till the most sophisticated and complex relationships between components, called compatibility standards (Grindley, 2018b).

Quality standards are, for instance, health and safety thresholds that identify performance and material quality, with the function of guarding and supporting customers in reducing risks and increasing demand. Therefore, end-users possess more common knowledge about the products and are able to choose more consciously, thus reducing search costs. On the other hand, compatibility standards manage the technical interfaces to enhance the interconnection between components produced by different manufacturers. These kinds of standards make the product more valuable and favour the access of a larger selection of complementary products. It is called the "network effect" and it leads to multiply the selection and increase the competition level among the component makers, lowering the costs and rising the overall system value. In this concern, the larger the network's reach, the more users raise awareness around the product (David & Greenstein, 1990). In facts, it is common practice for new users to function as the first promoter of the new installed standard, making it more attractive at the eyes of others and, in turn, hastening further adoption.

Once this concatenated phenomenon reaches a critical mass a coordinated adoption towards the establishment of an official standard is required. Essentially, standards can be set through market competition, producing a "winner-takes-all" outcome with a quick adoption and high motivated investments. However, once established the new market balance, a potential duplication of efforts in searching the most attractive design may happen as well as all the switching costs that users with obsolete standards need to face. Alternatively, a standard could be established by a committee before the technology is fully developed. They are set in Standards Setting Organizations (SSOs) composed of producers, users and other organizations (Lemley, 2002). In such circumstance, "bottleneck" Intellectual Property Rights are disclosed or licensed on fair, reasonable and non-discriminatory (FRAND) terms of use even though the identification of a standards does not translate into a guarantee of success in the marketplace (Teece, 2018).

On firm's point of view the establishment of a standard may represent a viable opportunity to enhance and broaden the business turnover. Although, when designing the strategy, the company is required to take into account whether try to stand out and contend the market or support an existing standard and compete within the market with rivals. Obviously, it all depends on the standard's potential and the real chances of success balanced with the cost and delay caused by a potential standard war (Besen & Farrell, 1994). Examples of feasible solutions to adopt, when influencing the market towards a specific standard, may be build an early lead, attract components suppliers, product pre-announcements to influence the standard's credibility and public commitment to low long-term prices (Grindley, 2018b). When trying to set a new standard, numerous resistances could occur, chiefly coming from competitors and customers. Standards, by definition, are expensive in terms of time and financial resources and potentially able to alter the market equilibria. In this regard, the industries where communications seized the core businesses, like automotive, are majorly influenced by SSOs' rules, making compatibility vital for the market success. Anyway, for large-scale adoption, a firm should bring substantial efforts into an open standard hoping to licence to many afterwards or gain a sensible competitive advantage. Sometimes the standard is made of technologies from several companies, in this case whoever possess some "bottleneck" IP may cross-license the asset in order to gain market share (Grindley, 2018d).

To be more specific, standards make products more esteemed at the eyes of customers since compatible items could be interconnected to each other, thus facilitating the formation of a network of users (Teece, 2017). In turn, networks could bring sensible benefits to manufacturers producing standard-based products as they could benefit from economies of scale and reduced uncertainty (Grindley, 1995). In the automotive context, a standard on connectivity technologies, 5G for instance, would create a vast marketplace from which numerous complementary areas could take shape. One of them could be integration with autonomous vehicles, as manufacturers actually find themselves in a privileged competitive position. Whether they will achieve a successful combination between their skills and the development of new competences, in artificial intelligence for instance, it would represent a fundamental milestone in the safeguard of their actual market position, even in a period of technological change. In particular, it would lower the barriers to participation as well as enhance innovation in vehicle-to-vehicle and vehicle-to-infrastructure communications (Teece, 2017).

In summary, the uncertainty around new standards in the automotive world persists. Incumbents, chiefly manufacturers, need to play the role of integrators between suppliers and final users in order to guarantee a product that instils safety, great performances and brand reliability. To date, given the technological progress and the revolution disrupting the sector, suppliers are more likely to centralize more value under their control, hence increasing their business profitability at the expense of OEMs. In fact, suppliers are likely to manage components specific knowledge and in a period of technological convergence, when specialized competences tend to be outsourced, technology providers risk to be outcompeted by their market rivals. However, carmakers will be called to action to validate and properly integrate the new provided technologies. They aim at keeping a pivotal role in the product development process, although outsourcing the components production and design to specialized companies or organizations.

In the next chapter empirical evidence will be brought in support to the enounced market dynamics. In particular, it will be investigated the role of OEMs in patent litigations and how these disputes depict an industry in the middle of a disrupting change, highlighting massive entries by new players and the presence of intermediaries not always beneficing market's growth and an even knowledge distribution.

4. Patent litigations analysis in the automotive industry

In the previous chapter, questions have been posed to examine the emergence of new trends due to a technological convergence beginning to pervade the automotive industry. In this sense, patents, for own nature, could be used to further promote innovation in the sector as they publicly reveal knowledge around a specific invention, thus stimulating the creation of supplementary innovation through the competitors' offer. However, established players of the automotive industry like OEMs succeeded in the market not only possessing explicit knowledge codified through patents for instance, but also exploiting tacit knowledge, where some examples may be the network of suppliers built over years of business and the gained know-how. Suppliers, on the other hand, increased their specialization over components development as the complexity of the patented technologies involved increases as well (Fleming & Sorenson, 2001). Especially within this category, new organizations could grow their market shares in the automotive world and potentially become new OEMs' business partners, as far as they are attracted by the rising of opportunities derived from the technological progress. Alongside, new entities that assist companies in patent portfolio management, are developing and potentially taking advantage of an uncertain industrial landscape, not owning a proper standard-setting technology yet. Acknowledging such considerations, an empirical analysis will be conducted aiming at providing reliable description of the direction and the extent of knowledge flows of the digital transformation in the automotive industry through the study of patent suits, as well as which are the technologies mainly subject to litigation by competitors or potential new players.

After stressing the role of OEMs as system integrators (Schulze, MacDuffie, & Täube, 2015), the analysis is structured in two sections. The first concerns automotive firms' innovative dynamics as mirrored by the engagement in patent litigations. It highlights the litigations through technological domains and geographical distribution, in addition to how suppliers behave in such context. The second, instead, investigates the penetration of 4IR technologies patent disputes in the automotive industry. In particular, the role of plaintiffs enforcing IPR related to 4IR technologies will be stressed to present in a clearer way which organizations are adopting asserting IPR strategies thus potentially representing a threat to OEMs, as well as the presence of non-practising entities in filed cases.

4.1 The role of OEMs as system integrators

Cars are integral products (Macduffie, 2013) that need to ensure high reliability and safety at the same time. They result from the combination of several components, embedding diverse technologies interconnected to each other (Zirpoli & Becker, 2011). In addition, these products are routinely regulated by a set of public policy issues, namely carbon emissions, safety, fuel and efficiency (Schulze, MacDuffie, & Täube, 2015). It is then the role of OEMs, coordinating with suppliers, to succeed in offering a reliable product that needs to keep the pace of technological progress but also ensure compliance with the rules. These factors brought the OEM to dominate over both product architecture and the supply chain, therefore making them play the important role of system integrator. This very last concept is defined as a company at the zenith of the supply chain accountable for assembling components and modules into a whole product. Apart from this, it has also to responsibly coordinate suppliers, consciously manage specialized know-how and enhance brand value and logistics (Linden & Teece, 2016). As a matter of facts, OEMs could be recognised as one of the most important R&D investors in the industry (Schulze, MacDuffie, & Täube, 2015), aiming at maintaining the control over the product architecture and design (Brusoni, Prencipe, & Pavitt, 2001) and setting primary components requirements increasing their bargaining power against suppliers.

Stated their nature, cars are complex products that favours the interconnection of different components not strictly related to each other. Throughout the product development process OEMs offer architectural knowledge, whereas suppliers exploit their component-specific knowledge (Takeishi, 2001). The former type of knowledge aims at guaranteeing an appropriate and efficient cooperation between components, the latter should provide accurate information over a not-established subject matter, that the carmaker may need to fully understand anyway in order to solve possible emergent issues in the components interconnection. Hence, the role of suppliers becomes crucial especially in innovative projects where prior knowledge may not be integrated in OEMs' processes yet. With the technological advance, cars increase the number of interconnected components, implementing also those that may be not directly linked to the manufacturers' traditional knowledge base, resulting in a widening of the potential business partners pool that changes accordingly to society's needs and goals.

As far as today, the automotive industry may have been experiencing instability due to shifts in the market, regulations changes and technological progress enabling the rise of new business opportunities. The OEMs find themselves adapting to all these factors, from increased concerns over oil dependence and climate change (Schulze, MacDuffie, & Täube, 2015), to the emergence of potential new players that started to pay attention to the automotive industry dynamics thanks to the increased amount of electrical components mounted in a vehicle. As the technology advances, new business opportunities are rising for progressive companies, both OEM, like Tesla, and suppliers, as Samsung and LG. Aa a matter of facts, new entrants are more apt to explore markets that may be not attractive to incumbents (Christensen, 1997). For instance, Tesla, as one of the leaders in EV technologies, is aiming at building the needed infrastructure for electrical vehicles and offered to open up its patents on charging stations. While, on one side, it seems that this strategy weakens deliberately its market position, on the other, it is tacitly encouraging the penetration of electric vehicles in the market in order to build a stronger EV ecosystem and potentially position itself as industry leader and standard-setter (Schulze, MacDuffie, & Täube, 2015). Besides, implemented business models are likely to change too, customers' perception of mobility may reshape the concept of car from a product to a service: enjoyable on-demand and at low costs (Schulze, MacDuffie, & Täube, 2015). Lastly, the recent emergence of non-traditional technologies permeating the automotive market has raised the uncertainty over the investments as industry standards have not been established yet, and it becomes trickier to assess which technology will be adopted and how it will be implemented.

Acknowledging such considerations, an empirical analysis has been performed to research findings around the technological convergence that the industry is experiencing and how incumbents are dealing with a possible threat to their market positions through the analysis of patent suits' volumes.

4.2 Empirical strategy

The research approach applies to mapping the latest trends in the automotive industry by rebuilding the patent portfolio of the top OEMs and suppliers of the sector and, subsequently, investigating which one has been involved in a legal dispute and who are the parties involved, thus highlighting where the firms' concern focuses on, in terms of market share safeguard in view of potential new players flowing in the industry due to the digital transformation.

The initial patent-level database has been provided by the research team working under the project funded by the EPO Academic Research Programme 2018. Here explained how the data has been retrieved. To detect the main actors, the research team ranked the OEMs in the automotive industry according to a few criteria. The focal firms have been selected according to four variables: (1) production volume, (2) granted patents, (3) revenue and (4) market capitalization. Applying these filters, the top 25 OEMs have been retained, accounting 90% of the automotive industry production[1] (Moretti, Perri, Silvestri, & Zirpoli, 2021).

Extant literature advocates that patent information allows to quantitatively investigate the cumulative technological development, creation and distribution of knowledge as well as technological skills and endeavours (Patel & Pavitt, 1991). As a matter of facts, the patents codification enables to examine the evolution of technologies at different levels of detail, remarking the uprising trends and which are the firms leading the change.

Building on these grounds, manufacturers' patents, granted between 1990 and 2014, have been retrieved grouping the focal firms' corporate tree by patent portfolios. Such consideration aims at assessing the innovative output of a company regardless of the unit or the individual that developed the technology. Moreover, the inquired database gathers patents by families, where a patent family is defined as a collection of patent applications covering a technological content (European Patent Office, 2017). This procedure has been applied since companies seek protection for the same invention in different countries to enable the patent rights enforcement abroad (Michel & Bettels, 2001), thus an approach

[1] The top 25 OEMs sorted by number of aggregated patent families include: Toyota, Hyundai, Honda, Nissan, Volkswagen, GM, Ford, Daimler, Renault, Kia, Mazda, Peugeot, Geely, Mitsubishi, Suzuki, BMW, Fiat, Dongfeng, Changan, Chrysler, Great Wall, Baic, Saic, Tata and Tesla.

that helps in identifying worldwide litigations uniquely was needed. Some advantages of the patent family approach could be clarified. On one side, it avoids considering multiple patents related to the same invention (Alcácer & Zhao, 2012). On the other, it alleviates any geographical or institutional bias strictly linked to the country in which the protection is sought (De Rassenfosse, Dernis, Guellec, Picci, & de la Potterie, 2013).

This same methodology has been applied also to carmakers' suppliers network, taking into consideration the Relationship Value within the Supply Chain Function computed by Bloomberg, that measures the frequency of business relationships occurring between two companies on a numeric scale. The first results counted 440 suppliers, from which only the top 100 has been retained and their patent portfolios retrieved. Consequently, merging the two lists a first database has taken shape, counting 412,050 and 1,448,320 patent families respectively for suppliers and OEMs granted from 1990 to 2014[2].

4.2.1 Data sample

The next step consists in trimming these raw data considering only those who have been subject to a legal action whatsoever. In doing so, a data provider (Orbit database by Questel) has been enquired aiming at certifying whether the considered patent families have been subject to any form of litigation. Then, in order to offer a more complete dataset on which complementary analysis could be performed, a second data provider (Darts IP) has been inquired as well. The retrieved data contain additional information regarding the sprung of legal disputes, such as: the unique id of the case, the name of both plaintiff and defendant, the relevant dates throughout the proceedings duration and the geographical location of the dispute.

The match has been performed cleansing the original variables offered by Orbit: *plaintiffpatent* and *defendantpatent*, namely text strings that include the number of multiple patents. Therefore, the first step consisted in extracting the variable that classifies each patent uniquely (*XPN*), in other words the patent publication or

[2] To address the lag between the application and the grant of the patent that may be averagely 3 years, during data collection it has been imposed a cut-off date at December 31st 2016, then retained only those patents granted up to 2014. Therefore, the database under consideration truncates data when approaching the last years of the original time period of interest (1990-2014).

application number. Then, the variable allows to link each *Case ID* with a *Family ID*, as a unique id assigned to each patent family and whose technical information have been stored in the initial dataset comprising the patents held by top 25 OEMs and their top 100 suppliers. It goes without saying that some limitations, like incorrect patent assignments or inconsistencies in the input data, may have occurred given the repeated querying of different data providers. Addressing specifically this issue, the match between the data sources has been reiterated numerous times until only 8 *Case ID* could not find *Family ID* associated. The obtained final subsample of the original database comprises 6676 cases of the top 25 OEMs and their suppliers that have been filed between 2006 and the first quarter of 2020 (Q1 2020).

At this point, the variables containing the companies involved in patent litigations have been cleansed and classified to deepen complementary analyses. Each patent assignee whether not precisely reported, has been stored under the variable *FirmName*. Particular attention has been paid with the ones reporting just **Person(s)** or ideograms in the corresponding filed, afterwards respectively replaced with the names of the inventors, if indicated, or simply translating the firm's name. To be more precise, consistency in the reported names has been manually achieved through the consultation of the European Patent Office platform: Espacenet, where all the information concerning patents and their activity are publicly available.

The following phase involves the classification of all the companies engaged in patent litigations. To attain a proper classification of these firms, each entity has been ranked based on the number of cases in which it took part either as defendant or plaintiff[3]. Although, it has to be mentioned that, initially, this process has been applied only to the firms with more than 10 cases. Then, to achieve a more consistent classification, the cut-off has been lowered to 5, expanding the considered entities to 580 units. At first, it has been identified the parent company in the corporate tree of each actor, under the variable *Parent*. Such classification has been performed querying the database ORBIS Bureau Van Dijk, in which companies name have been uploaded, checking whether the database actually picked the right match. After, the data has been downloaded and the text strings

[3] In order to maximize the consistency among data and offer clearer results, all characters in the names' text strings have been capitalised.

reporting companies' business names matched through the *Levenshtein Distance*[4], that measures the differences between two text strings and allows an accurate match between the strings. Whether any valid correspondence could have not be found before a reiterated match, a further research has been found necessary, exploiting different source in the Internet.

Later, the entities correctly classified have been divided into three main categories referring to their parent company, identified as dummy variables in the data sample: OEMs, suppliers and potential new player of the industry. However, during this process, another cluster has been acknowledged, including the remainder of litigating companies and named "Other". It is worth of mention, the genesis of the potential new player's cluster, ranked based on the EPO's approach (European Patent Office, 2017). In particular, the procedure consists in identifying the companies not currently having a central role in the automotive industry, although their investments in Fourth Industrial Revolution (4IR) technologies, relevant for this application domain, may suggest a possible important role in the automotive value chain in future. Overall, the final result is a sample of 6676 filed cases between 2006 and Q1 2020, with 6256 patent families engaged in litigations that encompass 3387 companies.

For each of them, the year of the beginning of each legal dispute has been considered. Over a total of 6676 filed cases, only 5774 reported the first action filing date in a time interval that goes from 2006 up to Q1 2020[5]. Figure 2 represents the yearly distribution of patent litigations by year, whereas Figure 3 reports the cumulated number of filed cases in our sample in the same period. In both figures the data consider the totality of cases in the litigation database, where OEMs and suppliers could play the role of defendants or plaintiffs either.

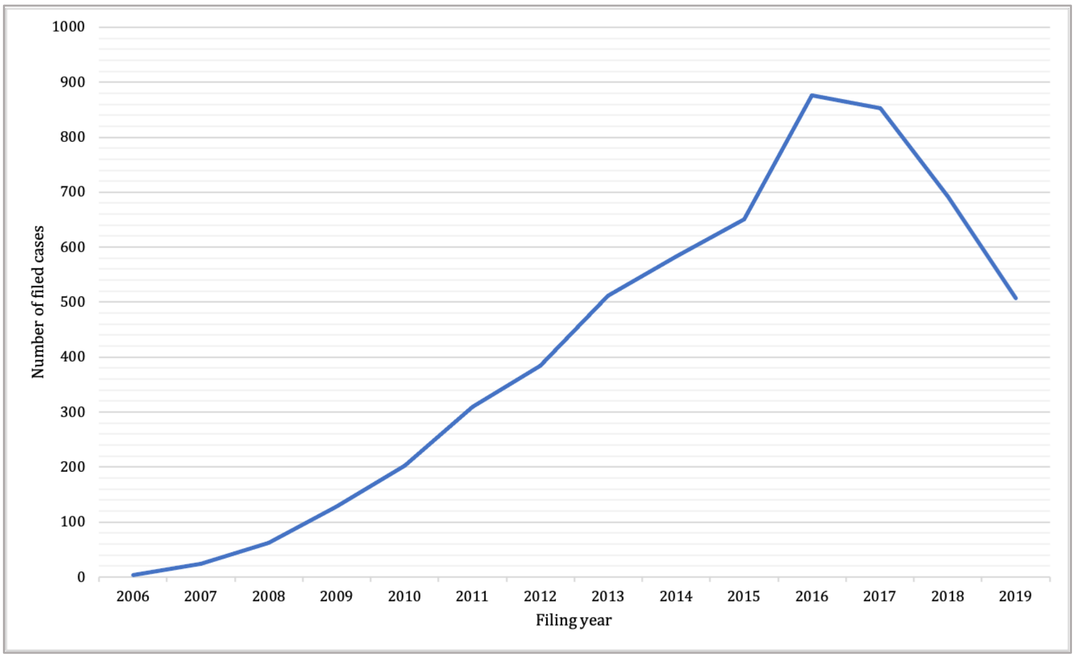
---

[4] The Levenshtein Distance is a metric that measures the minimum number of edits that it takes to change one-word sequence to another (Arias, 2019). This approach, then, enables to minimize the processing time as it allows to rapidly compute great amount of information. It has to be mentioned that such match has been performed through a Python library to obtain a more precise correspondence as the cut-off has been set to 93%.

[5] For clearer and more consistent graphical representation purposes, it has been decided to set a cut-off at December 31st 2019 for the litigations filed for patents granted between 1990 and 2014. Only 38 cases have been filed in Q1 2020, an irrelevant amount as it has an incidence of 0.5% over the totality of records in the data sample.

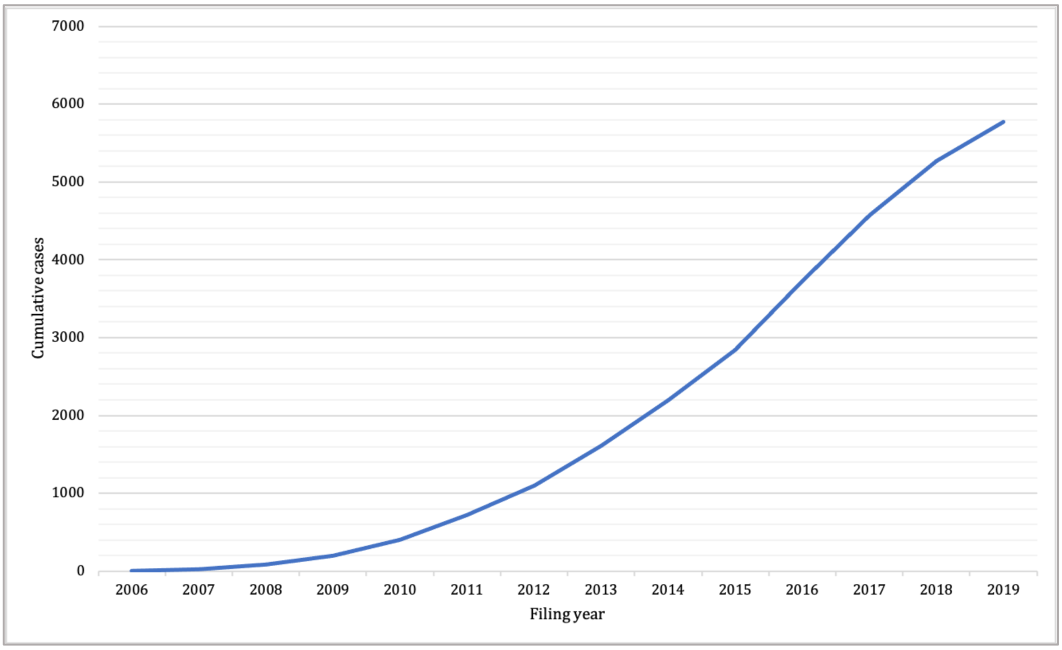
As shown in Figure 3, it becomes evident how the number of filed disputes records a steady uprising trend. In 10 years, the number of filed litigations peaked at 876, with a substantial increase of 3.9% more than three times the increment in previous year. Multiple hypothesis could be drawn to support this rapid increase in patent suit volumes. One of them takes into account the possibility that against a surge in the patent application activities, the litigation volumes may have increased accordingly. Another explanation could be suggested by the increasing complexity affecting registered patents that, covering more subject matter and emerging technologies in the field, are more likely to be subject to disputes. In any case, a clarification of such phenomenon will be tried to be provided throughout the discussion of the results.

Figure 2: Distribution of the number of filed cases by year, on patents granted between 1990 and 2014



Source: Darts IP

Figure 3: Cumulative number of filed cases, on patents granted between 1990 and 2014



Source: Darts IP

Table 1: number of filed cases between 2006 and 2019, on patents granted between 1990 and 2014

Year	Tot. Cases	% of Tot. Cases	Cum.
2006	4	0.07	4
2007	22	0.38	26
2008	56	0.97	82
2009	120	2.08	202
2010	203	3.52	405
2011	310	5.37	715
2012	384	6.65	1099
2013	511	8.85	1610
2014	584	10.11	2194
2015	651	11.27	2845
2016	876	15.17	3721
2017	853	14.77	4574
2018	692	11.98	5266
2019	508	8.80	5774
Tot.	**5574**	100.00	

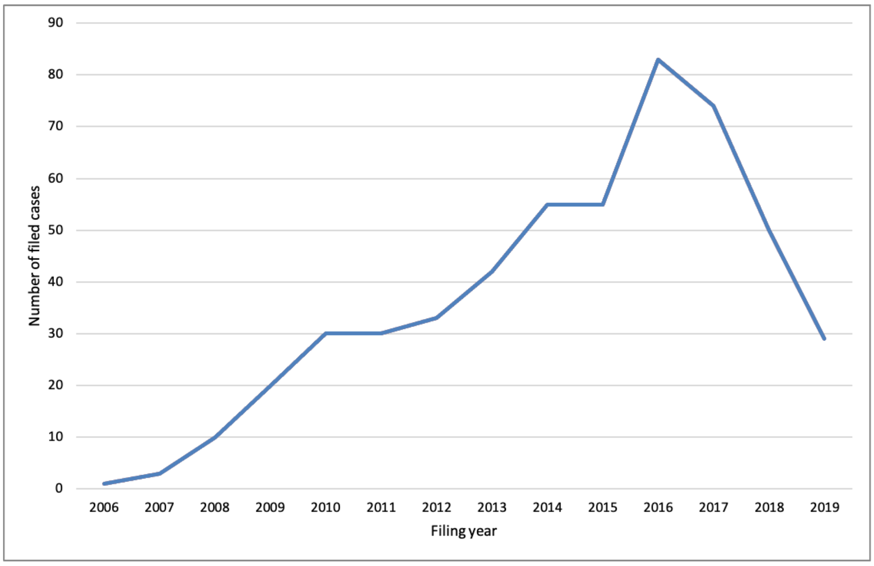
Source: Darts IP

4.3 Results: OEMs and suppliers

At this point, the analysis moves to the patent suits filed against our focal firms, OEMs. The objective is to investigate whether and how the incumbents of the automotive industry may be affected by the emergence of new technological trends. In particular, it has been examined which are the companies more involved in IP legal proceedings, with a special focus on suppliers and the sectors of interest of the disputed patents. The subsample under analysis comprises 522 cases in which, as many patent families assigned to OEMs are disputed. Remarkable is how the volume of the patent suits registered against OEMs patent portfolios represent a small share in comparison to the general sample: 522 cases over a total of 6676.

Figure 4 shows precisely how the volumes of lawsuits with OEMs patent portfolios as defendant evolve through the years. Through a quick comparison, it is intuitive how this curve follows the trend of Figure 2, entailing a general increase in the registered patent suits possibly due to an overall intensification in the patent application activities as well. Moreover, the recorded peak in 2016 and the subsequent *ex abrupto* decrease in litigations volume may be caused by a truncation problem affecting our data. As mentioned above, the provided dataset considered the registered patent suits regarding the patents granted up to 2014, hence, year over year the potential omitted data are likely to increase.

Figure 4: Distribution of the number of filed cases against OEMs by year, for patents granted in the period 1990-2014



Source: Darts IP

As analysing the volume of filed patent suits over the years is important to acknowledge possible time dependencies in the subsample. Also, recognize which subject matter is covered by the litigated patents may help in understanding where concerns are risen in terms of IP protection. To provide an overall view on the technological fields mainly subject to litigation, it has relevant importance to analyse the technological classes' trend of the disputed patent families, classified according to the International Patent Classification (IPC). This subsample includes 141 IPC classes (4 digit) uniquely identified. Although, it has to be mentioned that most of the patent families are linked to multiple IPC codes (66%), thus counted more times, while the remainder is associated with only one. According to Fleming (2001), this finding seems to suggest an increasing complexity in the filed patents, afterwards disputed, attributable to a recurrent cross-fertilization between technological domains (Fleming & Sorenson, 2001).

Table 2 shows the top 20 IPC classes representing almost the 73% of the totality of the distinctive families assigned to OEMs. As expected, the first seven IPCs are related to traditional fields in the automotive world. As a matter of facts, the most frequent IPC classes in the whole subsample are linked to the *Mechanical engineering* sector of the Schmoch's classification (see Table 3). This highlights the fact that strong engineering knowledge and skills are required to operate in a sector like the automotive, in addition to the tendency to search, develop and eventually dispute, new knowledge in sectors close to their core competences and practices (Almeida & Phene, 2004).

Table 2: top 20 most frequent IPC classes (IPC 4level) among OEMs' disputed patents between 2006 and 2019, and granted in the period 1990-2014

Class	Description	Tot. Fam.	% of Tot. Distinctive fam.
B62D	Motor vehicles, trailers	69	13.80
B60R	Vehicles, Vehicles fitting, vehicle parts	58	11.60
F01N	Apparatus for internal combustion engines	57	11.40
B60K	Arrangement or mounting of propulsion units or of transmission in vehicles	45	9.00
B01D	Separation	42	8.40
B60J	Protective coverings specially adapted for vehicles	35	7.00
F16H	Gearing	31	6.20
H01M	Process or means, batteries, for conversion of chemical energy into electrical	30	6.00
B60W	Conjoint control	27	5.40
B60T	Vehicle brake control systems or parts thereof	26	5.20
B60N	Seats specially adapted for vehicles	25	5.00
B61D	Body details or kinds of railway vehicles	24	4.80
B29C	Shaping or joining of plastics; shaping of material in a plastic state, not otherwise provided for; after-treatment of the shaped products	21	4.20
B32B	Layered products	21	4.20
B60H	Arrangements of heating, cooling, ventilating or other air-treating devices specially adapted for passenger or goods spaces of vehicles	21	4.20
C21D	Modifying the physical structure of ferrous metals; general devices for heat treatment of ferrous or non-ferrous metals or alloys; making metal malleable	21	4.20
F02B	Internal combustion piston engines, combustion engines in general	21	4.20
F02D	Controlling combustion engines	19	3.80
F02F	Cylinders, pistons, or casings for combustion engines; arrangements of sealings in combustion engines	19	3.80
B60G	Vehicle suspension arrangements	18	3.60
Tot. Patent families in top 20 IPC classes		**630**	
Tot distinctive patent families in top 20 IPC classes		**381**	
Tot. Distinctive OEMs' litigated patent families		**522**	

Source: Darts IP

In order to provide a clearer view over the most recurrent technological domains assigned to the OEMs and summoned before the court, Schmoch's classification has been chosen. As opposed to the IPC categorization depicted above, the Schmoch's classification aggregates different IPC classes into 35 technological fields, in turn gathered into five main sectors: *Electrical engineering*, *Instruments*, *Chemistry*, *Mechanical engineering* and

Other fields[6]. Table 3 reports the frequency and the percentage of disputed patent families by Schmoch's sector and field.

Results show that litigation activity against OEMs clusters around traditional sectors linked to the automotive industry. As a matter of facts, the most representative sector is the *Mechanical engineering*, in which fields like *transport* (29.09%), *mechanical elements* (9.83%), *engines, pumps, turbines* (8.39%) and *machine tools* (5.59%), combined, account for almost 53% of the total coverage. One plausible reason for the presence of such a relatively high concentration may be linked to the fact that patent suits are likely to be filed in sectors traditionally related to the automotive industry. Thus, these legal actions could be correlated with regular market dynamics among established players. As a result, it ought to be specified the concepts underlying these aggregations of IPC classes. *Transport* field includes all types of transport technology and applications with dominance of automotive technology. *Mechanical elements* refer to engineering elements of machines such as joints or couplings. *Engines, pumps, turbines* field covers the technology applied in non-electrical engines. Lastly, *machine tools* denote instruments that focus on metalworking (World Intellectual Property Organization, 2008).

However, two fields not properly related to old-fashioned automotive applications stand out: *environmental technology* (6.63%) and *electrical machinery, apparatus, energy* (6.11%). The World Intellectual Property Organization defines the first as a variety of technologies addressing to environmental pollution, and the latter as the non-electronic parts of electrical engineering (World Intellectual Property Organization, 2008). Indeed, the two fields together (12.74% combined) could find application in the electrification trend, increasing in social and political relevance from a progressive sensibilization on pollution and carbon emissions. Particular relevance assumes the fact that just Tenneco itself, an OEM's supplier, counts 20 patent suits filed against *environmental technology* patents, probably fruit of its strategic commitment towards the reduction of the carbon footprint on the planet (Impakter, 2020).

[6] As multiple IPC classes could be assigned to patents for potential broad coverage of the subject matter, also patents could report multiple Schmoch's technological fields, thus some patent families are counted more than once.

Table 3: Number and percentage of disputed OEMs' patent families of the Schmoch's classification between 2006 and 2019, and granted in the period 1990-2014

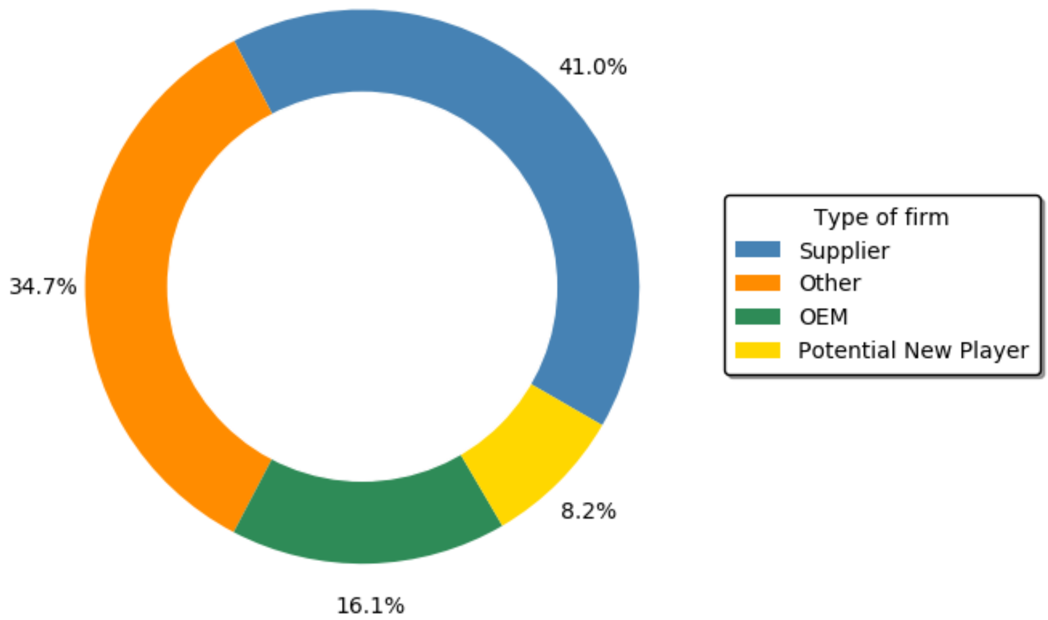
Field number	Sector description	Field description	Tot. Fam.	% of Tot. Litigated fam.
1	**Electrical engineering**	**Electrical machinery, apparatus, energy**	**59**	**6.11**
2	Electrical engineering	Audio-visual technology	5	0.52
3	Electrical engineering	Telecommunications	4	0.41
4	Electrical engineering	Digital communication	5	0.52
5	Electrical engineering	Basic communication processes	0	0.00
6	Electrical engineering	Computer technology	17	1.76
7	Electrical engineering	IT methods for management	0	0.00
8	Electrical engineering	Semiconductors	3	0.31
9	Electrical engineering	Optics	4	0.41
10	Instruments	Measurement	20	2.07
11	Instruments	Analysis of biological materials	4	0.41
12	Instruments	Control	15	1.55
13	Instruments	Medical technology	3	0.31
14	Chemistry	Organic fine chemistry	3	0.31
15	Chemistry	Biotechnology	13	1.35
16	Chemistry	Pharmaceuticals	0	0.00
17	Chemistry	Macromolecular chemistry, polymers	11	1.14
18	Chemistry	Food chemistry	0	0.00
19	Chemistry	Basic materials chemistry	14	1.45
20	Chemistry	Materials, metallurgy	34	3.52
21	Chemistry	Surface technology, coating	47	4.87
22	Chemistry	Micro-structural and Nano-technology	2	0.21
23	Chemistry	Chemical engineering	32	3.31
24	**Chemistry**	**Environmental technology**	**64**	**6.63**
25	Mechanical engineering	Handling	14	1.45
26	**Mechanical engineering**	**Machine tools**	**54**	**5.59**
27	**Mechanical engineering**	**Engines, pumps, turbines**	**81**	**8.39**
28	Mechanical engineering	Textile and paper machines	8	0.83
29	Mechanical engineering	Other special machines	29	3.00
30	Mechanical engineering	Thermal processes and apparatus	14	1.45
31	**Mechanical engineering**	**Mechanical elements**	**95**	**9.83**
32	**Mechanical engineering**	**Transport**	**281**	**29.09**
33	Other fields	Furniture, games	3	0.31
34	Other fields	Other consumer goods	8	0.83
35	Other fields	Civil engineering	20	2.07
Tot. Number of patent families			**966**	
Tot. Number of distinctive patent families			**500**	

Source: Darts IP

As a result, in response to the initial consideration around OEMs being summoned before the court about new technologies patents, it could be claimed that in our period of interest this trend does not seem to be relevant. For research purposes and keeping in mind the five fields just discussed, it becomes crucial to further investigate who are the main actors involved in such disputes and acknowledge over which technological fields they focus, in order to infer the possible emergence of other significant trends. First of all, the classification of the parent companies acting as plaintiff in this subsample, through the four dummy variables, could give a general idea of the area of origin of these entities disputing with our focal firms. Figure 5, in fact, summarises the type of firms recorded in this subsample.

Not surprisingly, the highest share of filed patent suits against OEMs' patents is held by suppliers (41.0%). This means that probably the disputes may reside within the supply chain or simply regular market dynamics could resort to litigation whether an agreement comes tricky to reach. They are followed by the "other" category (34.7%) that comprises not only firms apparently unrelated with the automotive world but also, a surprisingly increasing number of NPEs. These organizations usually threaten the filing of expensive infringement proceedings with the goal of cutting favourable deals to monetize their patents, previously acquired in the IP market.

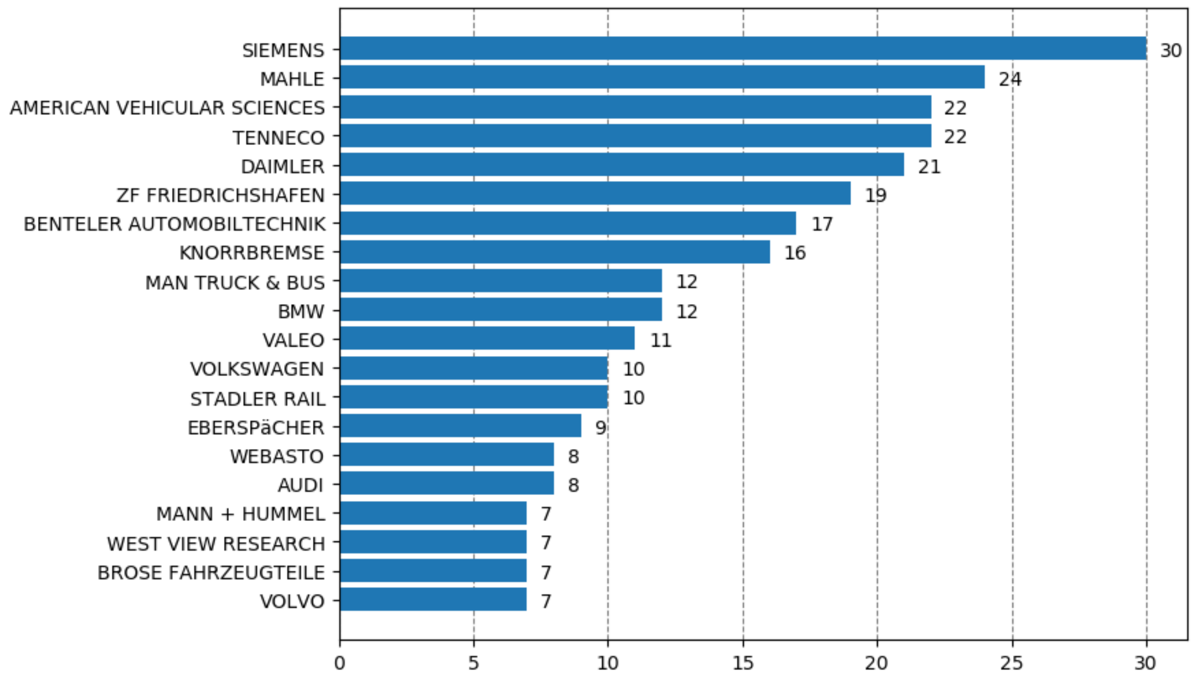
Figure 5: Plaintiffs' parent companies partitioning in patents disputed against OEMs between 2006 and 2019, and granted in the period 1990-2014



Source: Darts IP

Further analysis is brought on who are exactly these entities suing OEMs over mainly traditional automotive technologies. Figure 6 addresses specifically this concern, as it shows precisely who are the most assertive companies enforcing IPRs and with which frequency they summon OEMs before the court. Before it has been discussed that the most enforced IPRs belong to the mechanical sectors technologies. Therefore, it is predictable enough that the actors disputing with OEMs are mainly suppliers, like Siemens (30), Mahle (24) and Tenneco (22) recording more legal activity than the remainder of companies and organizations. However, it is worth of mention the presence of OEMs as well, i.e., Daimler (21), BMW (12), Volkswagen (10), Audi (8), Volvo (7). Their appearance may suggest the propensity to dispute over sectorial technologies, as proved by the Schmoch's classification (see Table 3). Ultimately, the presence of entities like American Vehicular Sciences (22) and West View Research (7), notorious NPEs, may hint at the interest of such organizations towards OEMs and their patenting activities. Traditionally, these entities operate in the ICT industry, thus it seems legit to suppose that they are likely to focus on the electronics part of vehicles and eventually concentrate on suppliers rather than manufacturers. Evolving alongside with technological advance and the mounting implementation of non-automotive technology, their activity focuses on finding older patents that carmakers have ditched and try to bend the claims over new technology. Alternatively, they use to question patents registered with broader claims, arguing their coverage over automotive products' technology (Robinson, 2017).

Figure 6: number of filed disputes of top 20 plaintiffs against OEMs from 2006 to 2019, over patents granted between 1990 and 2014

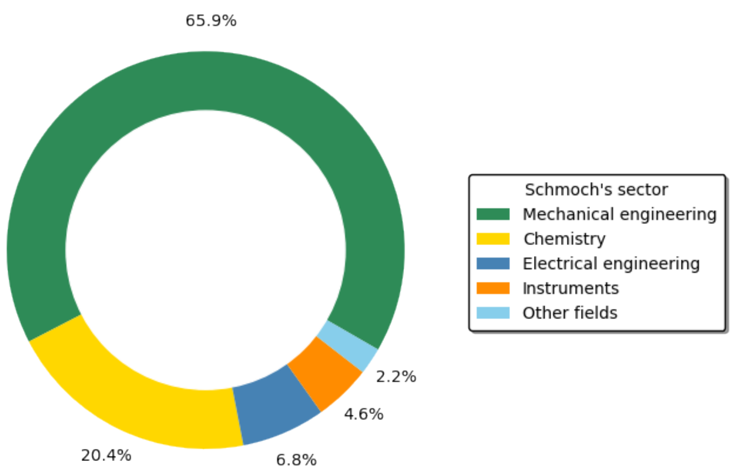


Source: Darts IP

Acknowledging the key role of the above-mentioned companies and organization in our subsample of the automotive industry, similar analyses have been performed for the questioned type of firms in order to shed light on the risen hypothesis and report the most significant findings. The methodology applied to such cases has been performed investigating which focal firms have been targeted and over which patented technologies, using the Schmoch's classification.

Starting from suppliers and their fundamental function in the development of technological innovation for the automotive product (Moretti, Perri, Silvestri, & Zirpoli, 2021), it is relevant for our research purposes to further investigate against which OEMs the most recurrent suppliers file patent suits and clarify whether these disputes occur within the supply chain. For this reason, from the OEM subsample so far analysed, it has been extracted a bulk of data recording all the suppliers playing the role of plaintiff. Performing once more the Schmoch's classification, although using a more intuitive layout, as Figure 7 shows, it could be remarked how suppliers prefer to litigate over familiar technologies within the classic automotive domain. Actually, the *mechanical engineering* sector gains almost 66% of the subsample, while electronical engineering performs only 6.8%. Results are not that far from the ones previously presented about the whole OEMs' subsample, however, in face of these consideration it ought to be clarified whether these patent suits occur within the same value chain.

Figure 7: Percentage of disputed OEMs' patent families by suppliers, by Schmoch's classification sectors

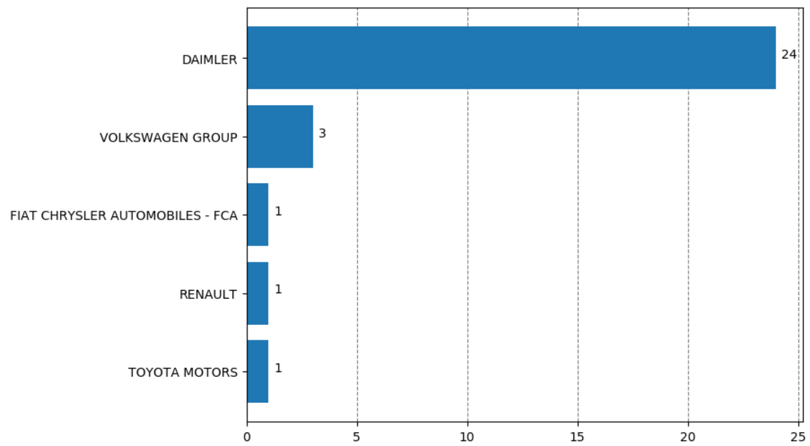


Source: Darts IP

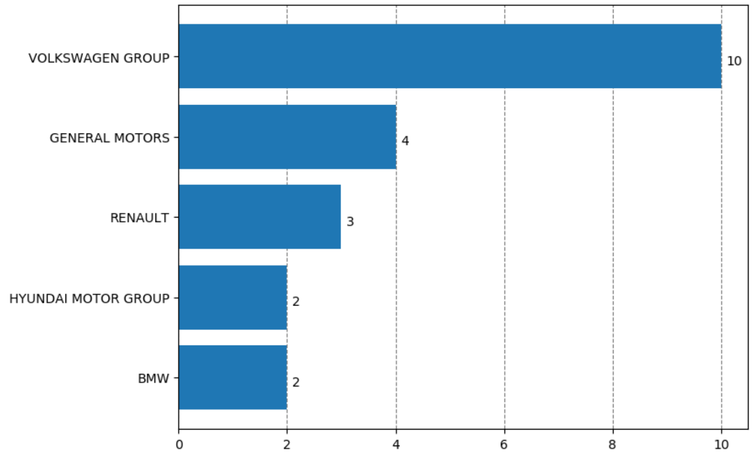
In order to understand whether these disputes are occurring between organizations having recurrent business relationships, a closer look has to be taken at Figure 8. It shows the frequency of filed cases by Siemens, Mahle and Tenneco, namely the three suppliers with most filed patent suits against OEMs. The reported companies analysed through the Relationship Value by Bloomberg used during the dataset construction, do not seem to have long-standing business relationships with these OEMs. Hence, it could be clarified that these patent suits do not involve companies within the same supply chain, and additionally observe that the volume of litigations do not seem extremely high, supporting the traditional reluctance in patent suits between suppliers and OEMs (Robinson, 2017), not only inward but also outward the supply chain.

Figure 8: number of filed disputes against top 5 parent OEMs by top 3 most litigating suppliers

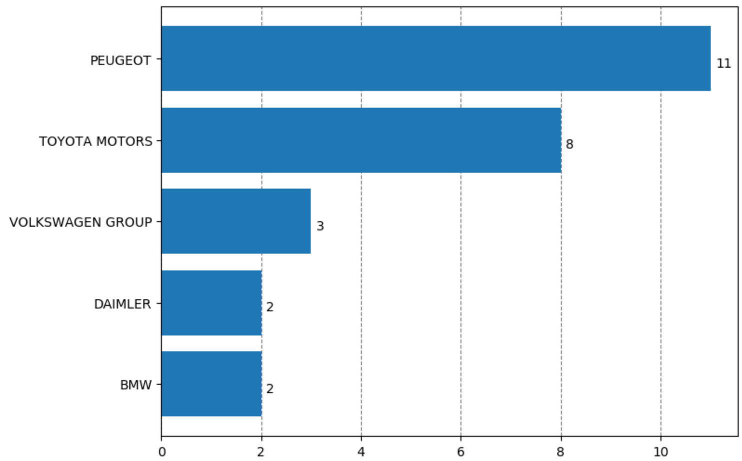
Parent OEMs sued by Siemens:



Parent OEMs sued by Mahle:



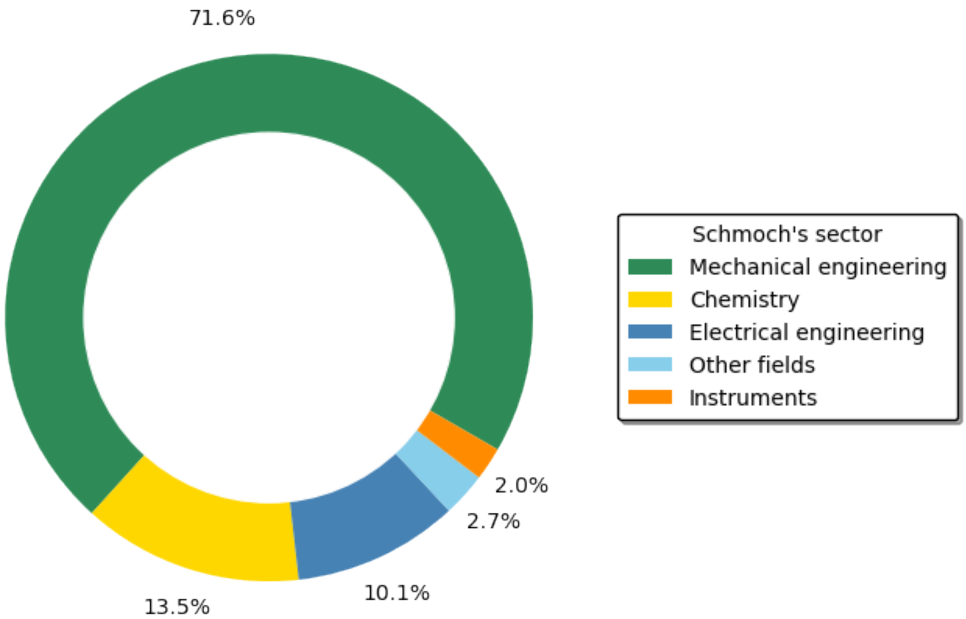
Parent OEMs sued by Tenneco:



Source: Darts IP

A similar conclusion could be drawn for OEMs suing their direct competitors. As shown in Figure 9, the prevalence of the *mechanical engineering* (71.6%) Schmoch's sector could lead to the conclusion that disputes between OEMs are likely to take place on traditional automotive technologies. The remainder sectors of this subsample, namely *chemistry* (13.5%), *electrical engineering* (10.1%), *other fields* (2.7%) and *instruments* (2.0%) count a relatively low incidence over the analysed records. In particular, Tenneco seems to be committed towards sustainability patents, as 20 of the total filed patent suits concern *environmental technology* sector.

Figure 9: Percentage of disputed OEMs' patent families by other OEMs, by Schmoch's classification sectors

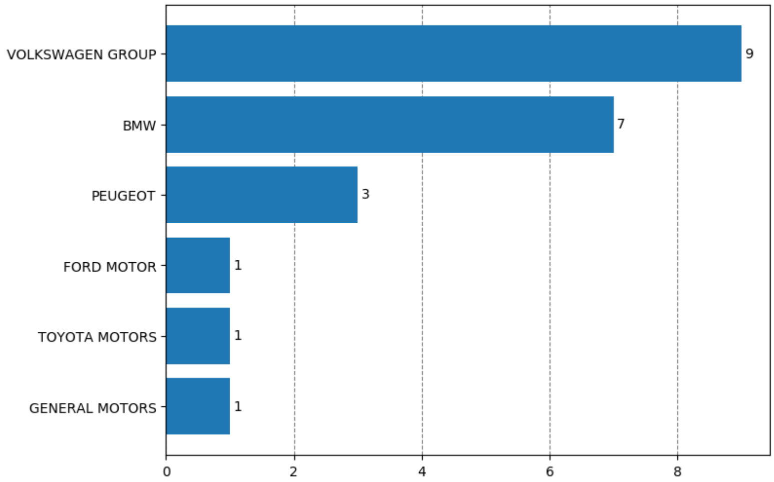


Source: Darts IP

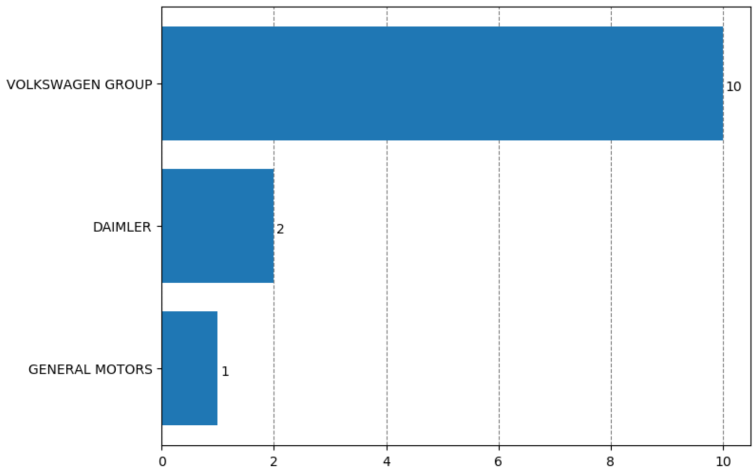
Following the sketched-out methodology for suppliers, also OEMs result to sue on typical automotive technologies, although with lower frequency. The top three parent OEMs disputing with their direct competitors are: Daimler, BMW and Volkswagen. Even though the top 3 most assertive OEMs seem to record relatively low frequency of filed patent suits among competitors, it should be mentioned that all these three organizations are based in Germany. In this concern, evidence shows that Europe may be thought of as one of the main centres around which most of the disputes take place probably driven by the fact that many OEMs are based there, thus most of the patents are originally approved in German or European courts.

Figure 10: number of filed disputes against parent OEMs by top 3 most litigating OEMs

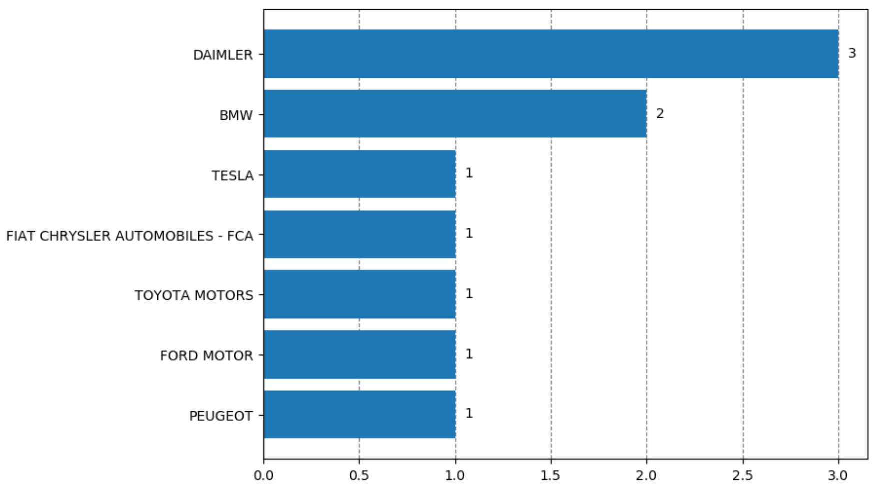
Parent OEMs sued by Daimler:



Parent OEMs sued by BMW:



Parent OEMs sued by Volkswagen:

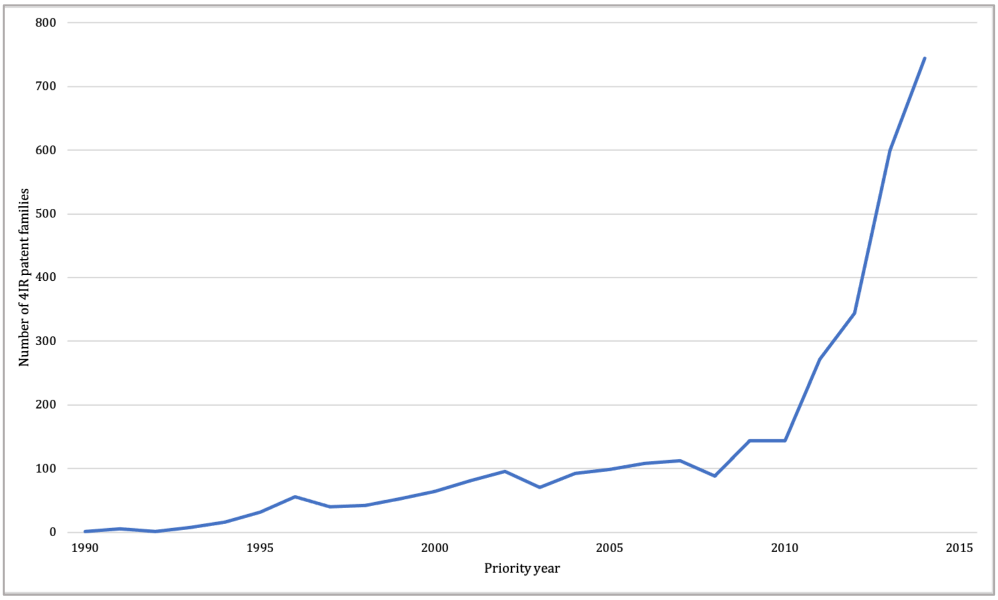


Source: Darts IP

4.4 Results: 4IR technologies

Emerging technologies are increasing their impact in the product development process and gaining a central role over the innovative exertions of today's organizations. Public policy makers refer to these emergent technologies responsible for the digital transformation as *Fourth Industrial Revolution* (4IR) (Moretti, Perri, Silvestri, & Zirpoli, 2021). Although a clear understanding on the distinctive features of the 4IR technologies has not risen yet, the wide usability and applicability of such domains has been acknowledged in different industries. To be more precise, extant literature advocates that 4IR technologies could be recombined with the actual knowledge base of the incumbents and applied in several industrial contexts and technologies (Teece, 2018a). Despite these considerations, few studies properly analysed the pattern of 4IR technologies in established and complex-products industries, chiefly in the patent suits area. However, the steeply increase of these new technologies on the patent applications subject matter cannot be ignored (Figure 11). The second research objective addresses the impact of these patented technologies on legal disputes that involve our focal firms.

Figure 11: Evolution of 4IR patenting activity of OEMs in the period 1990-2014



Source: Moretti, Perri, Silvestri, Zirpoli (2018)

The built 4IR subsample consists in a set of patents derived from the top 25 OEMs and suppliers operating in the automotive industry, the selection process starts with the classification of all patent families, then a subsample has been created picking only the 4IR patents, linked with Big Data, software and Artificial Intelligence, following the methodology described in the report "*Patent and the Fourth Industrial Revolution. The inventions behind digital transformation*" (Ménière, Rudyk, & Valdés, 2017). The approach is divided in two steps. The first takes into account the analysis of CPC[7] fields included in the 4IR applications. Whereas the second involves a text-mining activity via keywords search to identify patent documents included in the 4IR technological domain (Moretti, Perri, Silvestri, & Zirpoli, 2021). Given this dataset further selection has been made opting for only those who were subject to legal disputes and from the intersection of these criteria the final 4IR sample has been shaped.

Our research purpose in this domain aims to clarify which is the incumbents' approach towards 4IR technologies in the automotive industry and how actually the focal firms are facing the digital transformation when it comes to safeguard their IPRs. Stated the exponential increase in the application of patents concerning 4IR technologies by OEMs, our focal firms (see Figure 11), the same analysis previously proposed has been performed. In particular, the performance of litigation volumes regarding the sued patents comprised in the 4IR sample. As shown in Figure 12 where, additionally to the overall frequency of filed patent suits, the trend of disputed patent families assigned to OEMs, suppliers and potential new players has been added. It is evident how the latter category sensibly outperforms the rest. Two considerations ought to be made in view of these results that highlight an increasing tendency in registered cases on 4IR technologies. First, the fact that the cluster named potential new entrants records such high level of litigations may not be particularly significant for the industry's dynamics. In fact, this group has been defined not necessarily related to the automotive world from the inception, as it identifies companies and organization that in the next years may or may not achieve a significant role in the value chain.

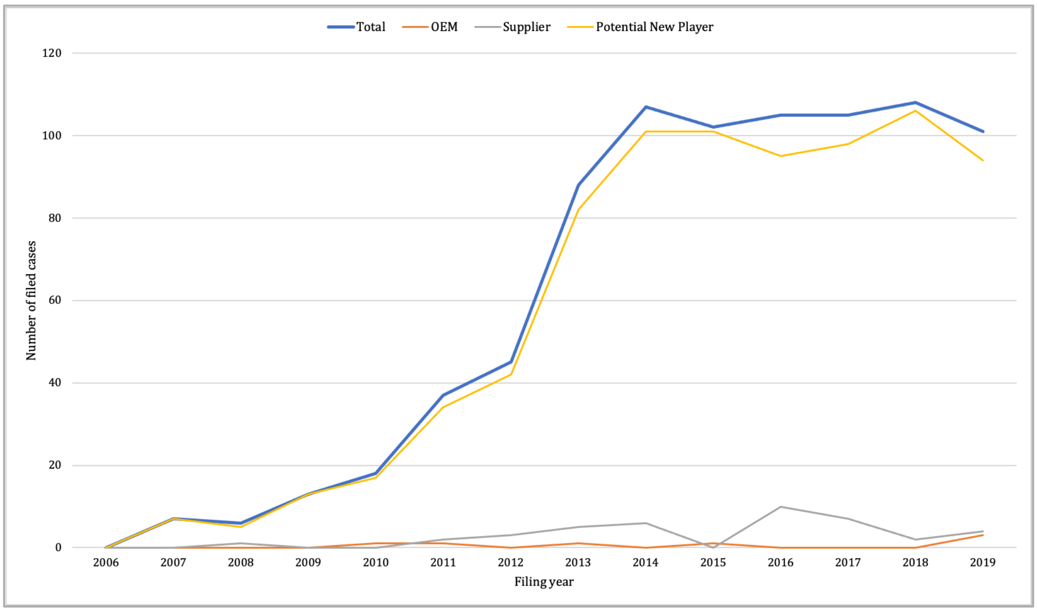
Second, the incredible low rate of legal disputes against patents assigned to OEMs (7 patent suits) or suppliers (40 patent suits) portfolios does not necessarily mean that

---

[7] The CPC classification can be thought of as an extension of the IPC classes, used by EPO (2018) to classify "established" technologies in the automotive industry.

these groups do not manage these technologies, rather they might have mastered over time the concept of licensing and cross-licensing, thus holding all the required rights to stay away from expensive legal proceedings.

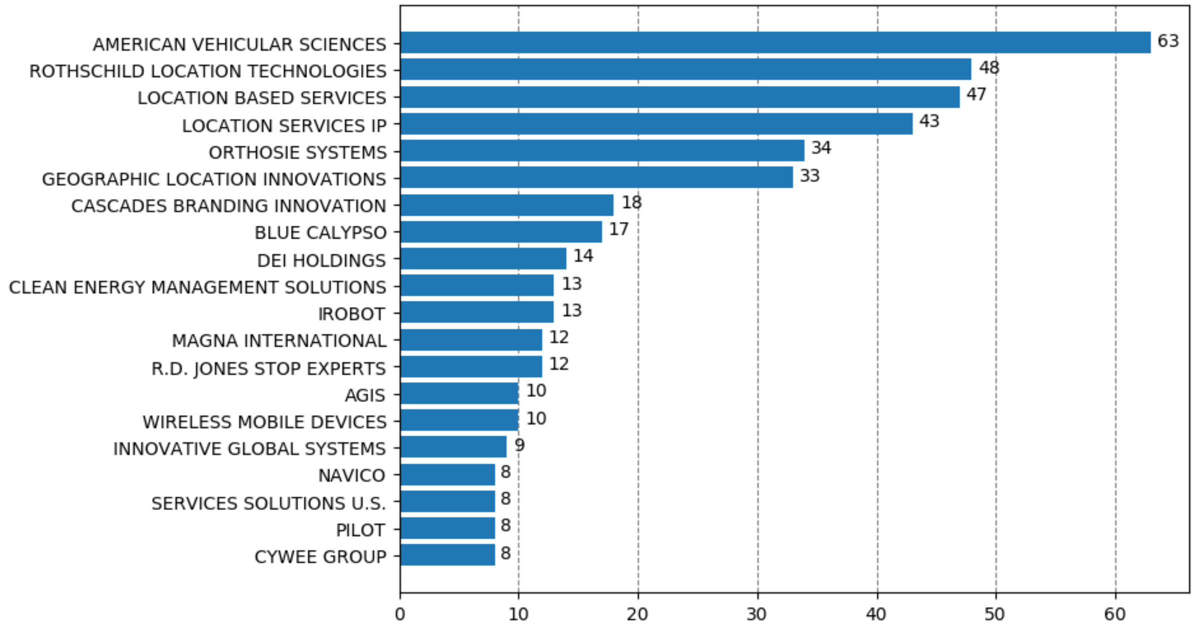
Figure 12: Distribution of the number of 4IR patents playing the role of defendant in filed cases by year, for patents granted in the period 1990-2014



Source: Darts IP

Acknowledging such considerations, an additional task has been performed prior concluding that OEMs seem out of the range of disputes on 4IR technologies. In the IP legal proceedings landscape, it exists a particular type of patent suit that allows the plaintiff, in this very specific case the patent holder, to enforce its IPRs advocating an alleged illicit towards a third party. Such proceeding is called infringement. As it is shaped and subordinated to timing and conditions of the national legal frameworks, it potentially enables a company to summon before the court an alleged infringer whatsoever that has taken an advance inappropriately over a patented technology. Such conformation could favour the proliferation of the above-mentioned NPEs that threaten of expensive legal measures if a settlement is not agreed. Observing Figure 13, it has been portrayed the companies that actually perform this type of legal proceedings on 4IR technologies. Results show that the majority of such entities could be classified as NPEs, except for Dei Holdings, iRobot, Magna International, Agis, Navico, Pilot and Cywee Group.

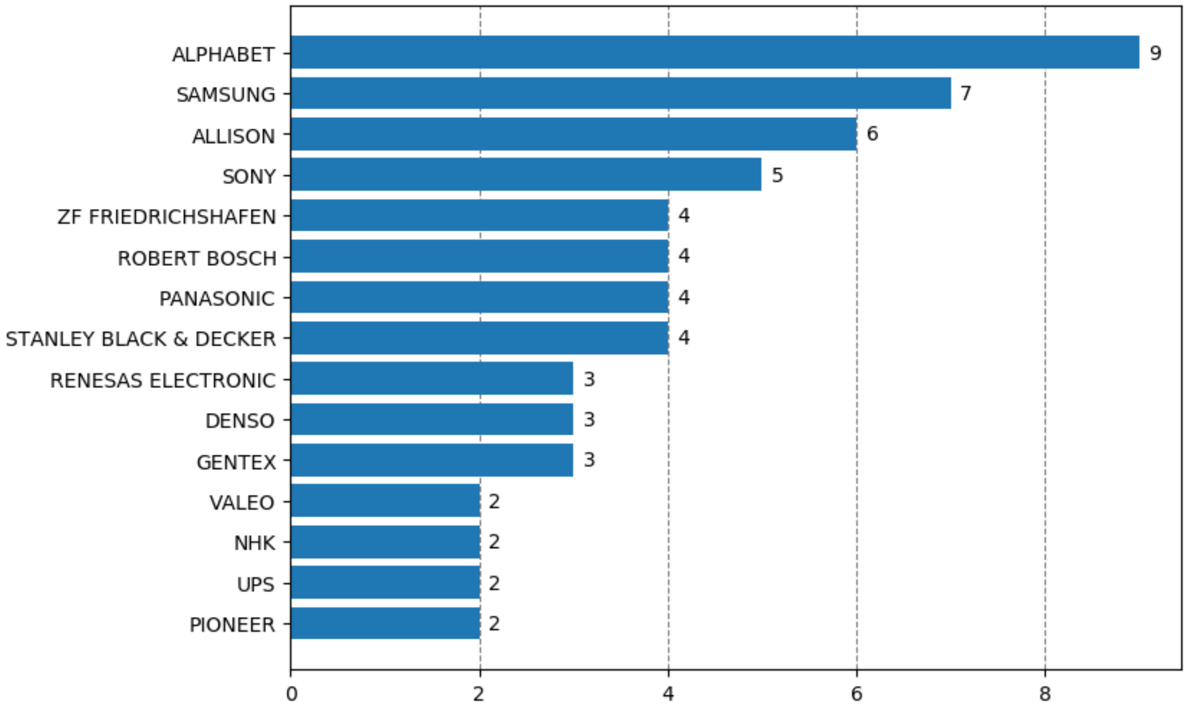
Figure 13: top 20 plaintiffs filing infringement proceedings on 4IR patents granted between 1990-2014



Source: Darts IP

At this point, it becomes crucial to understand whether these entities target only the potential new players, as it may have occurred with 4IR technologies disputed as defendant and not by force related to the automotive business. Or, in alternative, they try to sue also our focal firms and the suppliers and possibly represent a threat to their establishment on newer technologies. Figure 14 and Figure 15 investigate this very precise aspect. Comparing the two histograms it has to be highlighted the higher volume of litigation against OEMs rather than suppliers. Moreover, the suppliers involved do not seem to belong to traditional automotive technology providers, instead firms like Alphabet by Google, Samsung and Sony are more likely to operate with electrical components of the products.

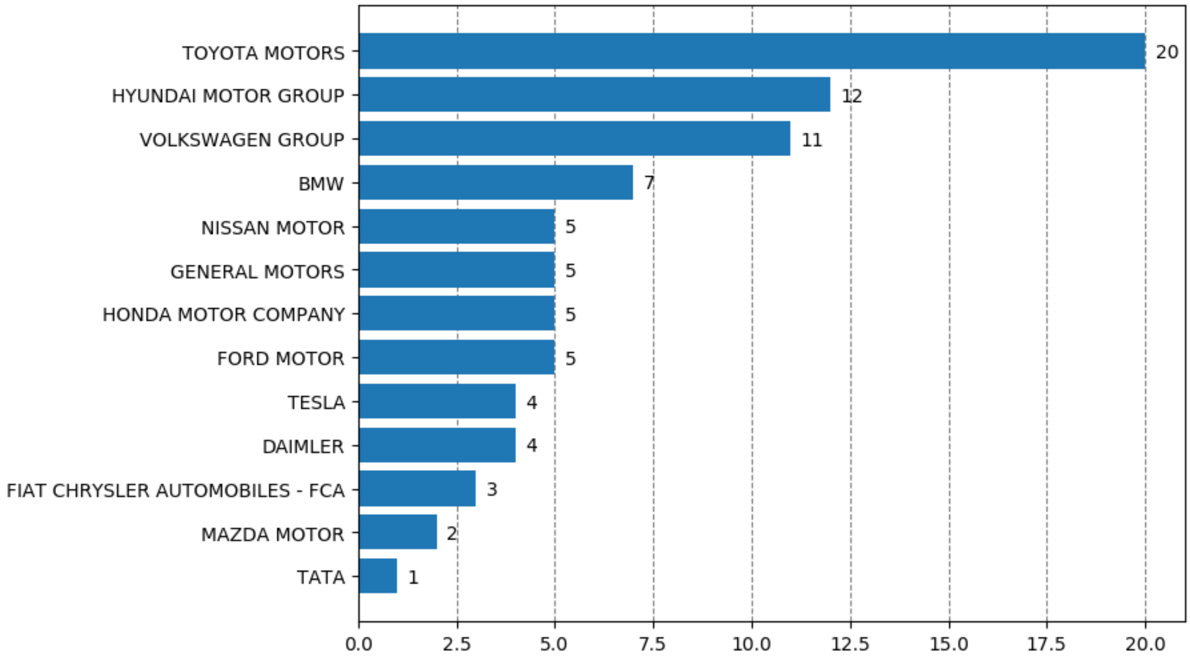
Figure 14: top 15 suppliers sued on 4IR patents granted between 1990-2014 through infringement proceedings



Source: Darts IP

Different concerns could be risen for OEMs that, in Figure 15, record a higher frequency of litigations. In particular, Toyota has been the most targeted by infringements actions, probably because of its traditional commitment towards newer technologies as it has been the first to build a successful commercial strategy on hybridization and internal combustion technologies (Schulze, MacDuffie, & Täube, 2015). Hence, NPEs that recurrently hold mainly patents linked to electrical components, may find more fertile ground on which base their charges.

Figure 15: top 13 OEMs sued on 4IR patents granted between 1990-2014 through infringement proceedings

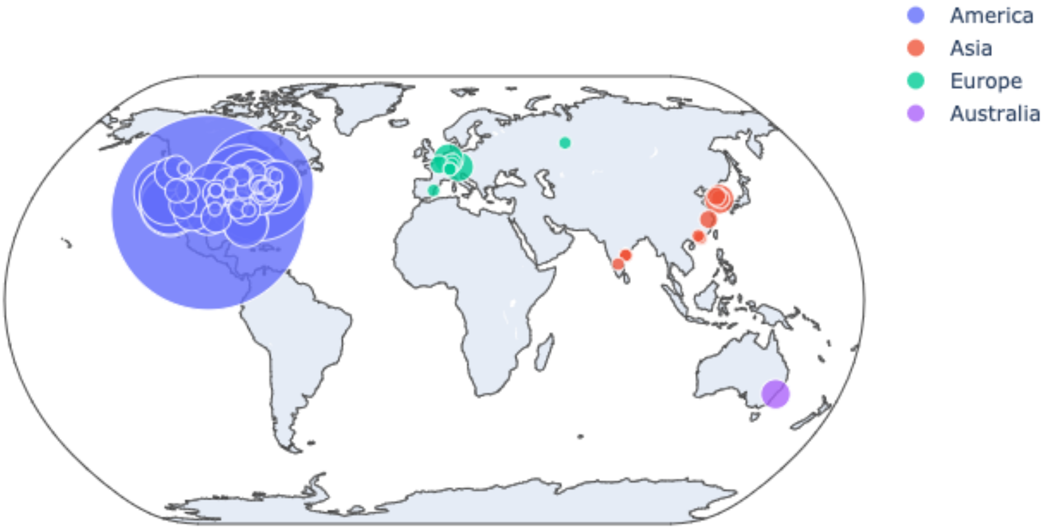


Source: Darts IP

Ultimate cause of concern could be risen over the geographical distribution of these proceedings as shown in Figure 16. As a matter of facts, they focus mainly in the US and Asia, probably due to the fact that the vast majority of NPEs are based in America and the legislative ground facilitate the thriving of such organizations. Recalling what already discussed in chapter 2 about the US legislation, it is worth mentioning that the system presents no time limits on the infringement actions filing; in contrast with the European legislation that set a nine-months-after-grant threshold (World Trade Organization, 1994). Comprehensively and according to what stated above about NPEs' business model, a part of these entities, called patent trolls, thrives on the monetization of old patents asserting them as valid in response to new upcoming patented technologies. These innovations may base their improved applicability on prior art that not always could be enforced, especially if widely acknowledged and by date obsolete.

On the other side, the litigation filed in Asia may be due to the high incidence of Toyota in this subsample as most of its patent may be registered in the Far East.

Figure 16: Geographical distribution of infringement proceedings filed for 4IR patents granted between 1990 and 2014



Source: Darts IP

4.5 Conclusions and research limits

Digital transformation in the automotive industry is forcing OEMs to face serious challenges, from the changes occurring to the knowledge base to the emergence of new players that in future may subvert the market equilibria. The research has verified that, while there is an active patenting approach towards new uprising technologies, litigation volumes still focus on core technologies at relatively low rates compared to the patenting activity. This result is supported by numerous data. Firstly, *transport*, *mechanical elements*, *engines, pumps, turbines* and *machine tools* are the most disputed Schmoch's fields and typically assigned to traditional automotive applications. However, an increasing volume of litigation around *environmental technology* and *electrical machinery, apparatus, energy* may suggest a progressive sensibilization on sustainability topics, as well as the wide usage of electrical components in the modern vehicles.

Second, the majority of filed patent suits are coming from suppliers. In this regard, it has been corroborated that litigations are not likely to occur within the same supply chain. This aspect may underline the efficient and robust vertical integration between OEMs and their suppliers. The two clusters in the dataset most likely do not only play nice in business, but also, they establish as interconnected network with OEMs at the apex acting as integrator of knowledge and components. On the other hand, the presence of external players in the industry does not seem to highly affect disputes' frequency. Yet, the ongoing convergence of different technologies in the product development process and the consequent surge of new opportunities in the market for new players does not seem to undermine OEMs and suppliers' networks, at least litigation-wise. It is worth of mention the fact that, historically, established player in the automotive industry have outperformed new players (Klepper, 2002). To date, OEMs have combined internal knowledge with increased outreach to suppliers for innovative products and process propositions. The key resides in creating valuable learning for core business while not being overly distracted by the demand of new businesses. The example of Daimler using multiple business models concurrently could be emblematic, since it manages car sharing service (car2go) via subsidiary. As it happens, they offer new technologies to customers while learning from customers preferences know-how to implement for marketing and engineering uses (Schulze, MacDuffie, & Täube, 2015).

In the final analysis, the research focuses on the impact of 4IR patented technologies on OEMs' litigated patent portfolios. Evidence shows that compared to an already limited amount of filed patent suits on 4IR technologies over the initial dataset, OEMs and suppliers' patents result almost unharmed. A twofold conclusion could be drawn. Either OEMs do not consider high-tech patents as a real threat to their IPRs; or they wisely choose not to start any type of legal action that potentially could lead to repartees before the court against companies that are used to deal with endless patent wars, as it happens in the ICT industry with Samsung for example. Therefore, the focus of the analysis has been moved on the companies that, holding 4IR patents, sue OEMs and their supplies. As appeared also when dealing with the initial dataset, it becomes evident a strong presence of NPEs that enforce their patent acquired in the IP market against operating companies. As far as global distribution is concerned, the majority of these proceedings are based in the US, probably driven by the American legislation structure and the presence of well-known plaintiff-friendly courts and rural jurors (Robinson, 2017).

All in all, patents have several limitations when it comes to assess innovation and inventive efforts. On one hand they could reflect innovative endeavours, on the other they could be also fruit of appropriability strategies (Teece, 2018b). Companies are likely to exploit patents for a series of reasons that range from rising entry barriers to enhance their bargaining power with business partners. In addition, the majority of patented technologies are not implemented as they may serve as defensive strategy against competitor or to restrict their inventive efforts.

Ultimately, there are a number of limitations also concerning the use of these data to capture possible trends in the industry through patent suits. First of all, patents mirror only codified knowledge and not the tacit one. Thus, the success of a firm comes tricky to assess only taking into account patent and litigation activities, without considering also other critical aspects, for instance, the brand power and the long-established business relationships. Moreover, the risk to receive wrongly assigned patents as litigated, stated the querying of different databases, might have happened.

As well as, a truncation problem affecting the analysed data may have been responsible for the quick drop of litigation volumes after 2016. The dataset, as it has been shaped, takes into consideration only patents granted in a fixed period that goes from 1990 to 2014, while patent suits data cover a different range (2006-Q1 2020). Thus, it may be legit to expect that after a certain date the patents data start to omit more and more information giving a partial perception of what happened in the last years of the time interval.

Conclusions

The automotive industry is on its way towards digitalisation. As proved by previous studies, the amount of granted patents around new technologies is exponentially growing (Moretti, Perri, Silvestri, & Zirpoli, 2021).

Nonetheless, interconnect digital components in vehicles requires a deep understanding and numerous capabilities. For incumbent carmakers, whose core competencies notably focus on mechanical engineering, this new technological trajectory may represent a significant challenge to face. To counterbalance the absence or the insufficient competencies around new technologies, incumbents resort to an external source of knowledge (Hildebrandt, Hanelt, Firk, & Kolbe, 2015). Besides, the emergence of 4IR technologies has emphasised the need for an open innovation model that considers different players providing for the variety of components to implement in vehicles.

The purpose of such a dissertation has been to investigate the behaviour of OEMs' IP portfolios in this period of digital transformation. Besides, it has been examined how OEMs deal with a landscape full of uprising opportunities for players not traditionally related to the automotive world.

After introducing the needed theoretical frameworks to understand the analysed dynamics better, the elaborate could be divided into three sections. Primarily, the discussion has been focused on the legal landscape around patents and the enforcement of their rights to pursue market strategies. Second, it has been analysed the impact of 4IR technologies on the automotive value chain and the advent of new entities in patents' trade. With recent trends, incumbents are combining knowledge coming from previously unrelated industries to keep the pace of progress and safeguard their market share (Piccinini, Hanelt, Gregory, & Kolbe, 2015). Since forming new capabilities in-house may not be the best approach to deal with digital transformation, new strategic alliances are taking shape, connecting them to partners that traditionally operate outside the industry.

The last section of the paper focuses on the empirical analysis of the retrieved dataset. The available data allow performing a study that could partially monitor the emergence of the 4IR trend and the evolution of the patent suits dynamics in the sector from the early nineties. It turned out that according to the extant literature, the litigation rate in the industry has been relatively low (Robinson, 2017). In such a context where OEMs act as system integrators or the connector between multiple suppliers providing different components and the customers, strong business relationships among vertically integrated companies may result fundamental. However, lately, the litigation volumes could have increased accordingly to an overall increment in the patent applications. In the investigated dataset, most OEMs' patent disputes are located in Europe and come from established suppliers outside the OEM's supply chain or NPEs. The disputed patents mainly concern traditional technologies, such as mechanical engineering, although the increment of environmental technologies' lawsuits may reflect an increased sensibility towards environmentally sustainable projects.

The second purpose of this research points at the patents suits involving 4IR technologies. Such a topic has recently gained relevance stated the exponential growth of patent applications filed by OEMs (Moretti, Perri, Silvestri, & Zirpoli, 2021). Nonetheless, the 4IR technologies belonging to OEMs patent portfolios are paltry. At this point, a different approach has been utilised, moving the focus from the threatened to the threatening patents through the investigation of the firms enforcing their IP rights against OEMs in infringement actions. A significant portion of the plaintiffs has been classified as NPEs, or entities that ground their business model on monetising acquired patents, potentially threatening alleged infringers of patent litigation. These same disputes are located mainly in the US, where they base their businesses and where slightly looser legislation facilitates their proliferation.

On the whole, the research brought pieces of evidence on the litigation landscape in the automotive industry. Compared to the exponential volume of granted patents, lawsuits are still a tiny number. However, the interval analysed presents a steep increase in the number of filed disputes by year, possibly favoured by the convergence of unrelated technologies in the industry. OEMs that traditionally do not seem prone to litigation are adapting to the change to keep the sector's leadership. At the same time, suppliers' market position may be threatened by potential new entrants, holders of specialised knowledge. Alongside, the rising of NPEs could put in danger a smooth transition towards digital and a gradual adaptation to change. Considering the premises, lead incumbents as OEMs are likely to assist the digitalisation of the sector exploiting their privileged market position of system integrators and building a solid relationship with new partners. Besides, the future establishment of standards could favour the decrease of excessive uncertainty around the latest technological investments and help settle market dynamics.

Nevertheless, one last argumentation should be brought to the attention. All the above-mentioned possible changes could be strongly affected by the evolution of the patent legislation and the proliferation of NPEs, as the European Union is planning to reinforce the area of competence of the UPC. Also, an increased public sensitisation towards specific topics closely related to the automotive product development process.

Bibliography

Abernathy, W., & Clark, K. (1985, February). Innovation: Mapping the winds of creative destruction. *Research Policy, 14*(1), p. 3-22.

Abernathy, W., & Utterback, J. (1975). A Dynamic Model of Process and Product Innovation. *The International Journal of Management Science*.

Abernathy, W., & Utterback, J. (1978). Patterns of Industrial Innovation. *Technology Review*.

Abernathy, W., Klein, B., Dopico, J., & Utterback, J. (1982). *A proposal for policy oriented research on the automobile industry.* Cambridge, MA: MIT Center for Policy Alternatives.

Aboulnasr, K., Narasimhan, O., Blair, E., & Chandy, R. (2008). Competitive Response to Radical Product Innovations. *Journal of Marketing American Marketing Association*, 94-110.

Adhikari, B. (2011). Innovation: Tools to Create Competitive Advantage for Business. *SSRN Electronic Journal*.

Afuah, A., & Utterback, J. (1996). Responding to Structural Industry Changes: A Technological Evolution Perspective. *IIASA Working Paper*, 1-32.

Agarwal, R., Ganco, M., & Ziedonis, R. (2009). Reputations for toughness in patent enforcement: Implications for knowledge spillovers via inventor mobility. *Strategic Management Journal, 30*(13), 1349-1374.

Agostini, L., & Caviggioli, F. (2015). R&D collaboration in the automotive innovation environment. *Management Decision*.

Akerlof, G. (1978). The market for "lemons": Quality uncertainty and the market mechanism. In *Uncertainty in economics* (p. 235-251). Academic Press.

Alcácer, J., & Zhao, M. (2012). Local R&D strategies and multilocation firms: The role of internal linkages. *Management Science, 58*(4), 734-753.

Allen, R. (1983). Collective inventions. *Journal of Economic Behavior and Organization, 3*, 1-24.

Allmag. (2020). *Lean Production*. Tratto da Il Muleano del cambiamento: http://www.ilmuleanodelcambiamento.it/lean-production/lean-production/

Almeida, P., & Phene, A. (2004). Subsidiaries and knowledge creation: the influence of the MNC and host country on innovation. *Strategic Management, 25*, 847-864.

Arias, F. (2019, February 6). *Fuzzy String Matching in Python*. Tratto da datacamp.com: https://www.datacamp.com/community/tutorials/fuzzy-string-python

Arora, A. (1997). Patents, licensing, and market structure in the chemical industry. *Research Policy*, 391-403.

Arora, A., Fosfuri, A., & Gambardella, A. (2001). *Markets for Technology.* Cambridge, MA: MIT Press.

Assurant. (2018, February 14). *C.A.S.E. The Acronym Taking Over the Auto Industry*. Tratto da Assurant.com: https://www.assurant.com/newsroom-detail/Features/2018/February/c.a.s.e.-the-acronym-taking-over-the-auto-industry

Baidu. (2020, December 16). *Building a self-driving car that people can trust*. Tratto il giorno February 11, 2021 da technologyreview.com: https://www.technologyreview.com/2020/12/16/1014672/building-a-self-driving-car-that-people-can-trust/

Baker, S., & Mezzetti, C. (2005, April). Disclosure as a Strategy in the Patent Race. *The Journal of Law & Economics, 48*(1), 173-194.

Bannon, A. (2008). Copyright Infringement, 'Free-Riding' and the Lifeworld. *LSE Law, Society and Economy Working Papers 17*.

Bartodziej, C. (2017). The concept industry 4.0. In *The concept Industry 4.0* (p. 27-50). Weisbaden: Springer Gabler.

Baudry, M. (2014). Valuation and rating methods for patents and patent portfolios. In T. Madiès, D. Guellec, & J. Prager, *Patent Markets in the Global Knowledge Economy: Theory, Empirics and Public Policy Implications* (p. 95-124). Cambridge: Cambridge University Press.

Bensaou, M. (1999). Portfolios of Buyer-Supplier Relationship. *Sloan Management Review, 40*(4), 35-44.

Besen, S., & Farrell, J. (1994). Choosing how to compete: Strategies and tactics in standardization. *Journal of Economic Perspectives, 8*, 117-131.

Beukel, K., & Zhao, M. (2018). IP litigation is local, but those who litigate are global. *Journal of International Business Policy*, 53-70.

Biagioli, M. (2019). Weighing Intellectual Property: Can we balance the social costs and benefits of patenting? *History of Science, 57*(1), 140-163.

Bose, A., & Iannou, P. (2003). Analysis of Traffic Flow with Mixed Manual and Semiautomated Vehicles. *IEEE Transactions on Intelligent Transportation Systems*, 173-218.

Branstetter, L., Fisman, R., & Foley, C. (2006). Do stronger intellectual property rights increase international technology transfer? Empirical evidence from US firm-level panel data. *Quaterly Journal of Economics, 121*(1), 321-349.

Bresnahan, T., & Gambardella, A. (1998). The division of inventive labor and the extent of the market economic growth. In E. Helpman, *General-purpose technologies and economic growth.* Cambridge, MA: The MIT Press.

Bresnahan, T., & Trajtenberg, M. (1995). General Purpose technologies: 'engines of growth?'. *J. Econom., 65*(1), 83-108.

Bricco, P. (2017, January 15). *Industry 4.0, per l'Italia la sfida è investire.* Tratto da Il SOle 24 Ore: https://www.ilsole24ore.com/art/industry-40-l-italia-sfida-e-investire-AD0VYAZC

Brusoni, S., Prencipe, A., & Pavitt, K. (2001). Knowledge Specialization, Organizational Coupling, and the Boundaries of the Firm: Why Do Firms Know More Than They Make? *Administrative Science Quaterly, 46*(4), 597.

Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies.* New York: WW Norton & Company.

Buermeyer, S. (2005). Patent Strategies and the Progress of Science and Useful Arts. *Term Paper 6.901 Inventions and Patents*, 1-12.

Bundesministerium der Justiz und für Vebraucherschutz. (2013, October 10). *Section 148 - Suspension in the event of preliminary proceedings - Code of Civil Procedure.* Tratto da gesetze-im-internet.de: https://www.gesetze-im-internet.de/englisch_zpo/englisch_zpo.html#p0606

Caillaud, F., & Ménière, Y. (2014). Strategic Intelligence on Patents. In T. Madiès, D. Guellec, & J. Prager, *Patent Markets in the Global Knowledge Economy: Theory, Empirics and Public Policy Implications* (p. 33-54). Cambridge: Cambridge University Press.

California Air Resourses Board. (2018). *Zero-Emission Vehicle Program*. Tratto da arb.ca.gov: https://ww2.arb.ca.gov/our-work/programs/zero-emission-vehicle-program/about

Cardoza, K., Basara, J., Cooper, L., & Conroy, R. (2006). The power of Intangible Asset: an analysis of the S&P500. *Les Nouvelles – The Journal of the licensing executives society*.

Carlaw, K., & Lipsey, R. (2002). Externalities, technological complementarities and sustained economic growth. *Research Policy, 31*(8-9), 1305-1315.

Carraz, R., Nakayama, I., & Harayama, Y. (2014). Openness, open innovation à la Chesbrough and intellectual property rights. In T. Madiès, D. Guellec, & J. Prager, *Patent Markets in the Global Knowledge Economy: Theory, Empirics and Public Policy Implications* (p. 209-234). Cambridge: Cambridge University Press.

Chesbrough, H. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology.* Boston, MA: Harvard Business School.

Chesbrough, H. (2006). *Open Business Models: How to Thrive in the New Innovation Landscape.* Boston, MA: Harvard Business School Press.

Chesbrough, H. (2012). Open innovation: Where we've been and where we're going. *Research-Technology Management, 55*(4), 20-27.

Chesbrough, H., & Borges, M. (2014). Explicating open innovation: Clarifying an emerging paradigm for understanding innovation. In H. Chesbrough, W. Vanhaverbeke, & J. West, *New frontiers in open innovation.* Oxford: Oxford University Press.

Chester, M., Fraser, A., Matute, J., Flower, C., & Pendyala, R. (2015). Parking Infrastructure: A constraint on or opportunity for urban redevelopment? A study of Los Angeles

County parking supply and growth. *Journal of the American Planning Association, 81*(4), 268-286.

Christensen, C. (1997). *The Innovator's Dilemma.* Boston, MA: Harvard Business School Press.

Clark, J., Piccolo, J., Stanton, B., & Tyson, K. (2000). *Patent Pools: A Solution to the Problem of Access in Biotechnology Patents?* Alexandria, VA: US Patent and Trademark Office.

Clark, K. (1989). Project Scope and Project Performance: The Effect on Parts Strategy and Supplier Involvement in Product Development. *Management Science, 35*, 1247-1263.

Clark, K., & Fujimoto, T. (1991). *Product Development Performance: Stretegy, Organization and Management in the World Auto Industry.* Boston: Harvard Business School Press.

Cohen, W., Nelson, R., & Walsh, J. (2000). *Protecting their intellectual assets: Appropriability conditions and why US manufacturing firms patent (or not).* Cambridge: National Bureau of Economic Research.

Colombo, M. (2003). Alliance Form: A Test of the Contractual and Competence Perspectives. *Strategic Management Journal, 24*(12), 1209-1229.

Commission of the European Communities. (2009). *Preparing for Our Future: Developing a Common Strategy for Key Enabling Technologies in the EU.* Tratto da https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52009DC0512&from=IT

Cooper, R. (2011). Perspective: The innovation dilemma: How to innovate when the market is mature. *Journal of Product Innovation Management, 28*(1), 2-27.

Cremers, K., Ernicke, M., Gaessler, F., Harhoff, D., Helmers, C., McDonagh, L., . . . Zeebroeck, N. (2017). Patent litigation in Europe. *European Journal Law Economics*, 1-44.

Cusumano, M., & Gawer, A. (2002). The element of platform leadership. *MIT Sloan Management Review 43 (3)*, 51-58.

Cusumano, M., & Nobeoka, K. (1992). Strategy, Structure and Performance in Product Development: Observations from the Auto Industry. *Research Policy, 21*(3), 265-293.

Cusumano, M., Yoffie, D., & Gawer, A. (2020, February 11). The Future of Platforms. *MIT Sloan Management Review, 61*(Spring 2020).

Dasgupta, P., & David, P. (1994). Toward a new economic science. *Research Policy, 23*(5), 487-521.

David, P. (1998). *Common agency contracting and the emergence of 'open science' institutions* (Vol. 88). American Economic Review.

David, P., & Greenstein, S. (1990). The economics of compatibility standards. *Economics of Innovation and New Tecnology, 1*, 3-41.

De Rassenfosse, G., Dernis, H., Guellec, D., Picci, L., & de la Potterie, B. (2013). The worldwide count of priority patents: A new indicator of inventive activity. *Research Policy, 42*(3), 720-737.

Despujol, B., & Stansbury, J. (2017). *The New, New Economy: Data and Experience.* Oliver Wyman.

Diamantis, P. (2014). Self-driving Cars Are Coming. *Forbes Magazine*.

Dosi, G. (1982). Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change. *Research Policy, 11*(3), 147-162.

Dudas, J., & Kline, D. (2013). *Patent Licensing: The Founding Fathers' Secret for Economic Success.* Ottawa: Conversant Intellectual Property Management Inc.

Eggers, J., & Park, K. (2018). Incumbent Adaptation to Technological Change: The Past, Present, and Future of Research on Heterogeneous Incumbent Response. *ANNALS, 12*, 357-389.

Energy efficiency and innovation. (2018, March 20). Tratto da ENP Newswire: https://advance.lexis.com/api/document?collection=news&id=urn:contentItem:5RX8-Y6R1-JD3Y-Y448-00000-00&context=1516831.

Enkel, E., Gassman, O., & Chesbrough, H. (2009). Open R&D and open innovation: Exploring the phenomenon. *R&D Management, 39*, 311-316.

Epo.org. (2016). *Article 138 - Revocation of European Patents - The European Patent Convention.* Tratto da Epo.org: https://www.epo.org/law-practice/legal-texts/html/epc/2016/e/ar138.html

Epo.org. (2016). *Article 52 - Patentable inventions - The European Patent Convention.* Tratto da https://www.epo.org/law-practice/legal-texts/html/epc/2016/e/ar52.html

Epo.org. (2016). *Article 54 - Novelty - The European Patent Convention.* Tratto da Epo.org: https://www.epo.org/law-practice/legal-texts/html/epc/2016/e/ar54.html

Epo.org. (2016). *Article 57 - Industrial application - The European Patent Convention.* Tratto da Epo.org: https://www.epo.org/law-practice/legal-texts/html/epc/2016/e/ar57.html

Epo.org. (2016). *Article 63 – Term of the European patent – The European Patent Convention.* Tratto da Epo.org: https://www.epo.org/law-practice/legal-texts/html/epc/2016/e/ar63.html

Epo.org. (2016). *Article 83 - Disclosure of the invention - The European Patent Convention.* Tratto da Epo.org: https://www.epo.org/law-practice/legal-texts/html/epc/2016/e/ar83.html

European Commission. (2012). *Creating a Financial Market for IPR in Europe.* Brussels: European Commission.

European Commission. (2019). *SME integration to Industry 4.0*. Tratto da europa.eu: https://s3platform.jrc.ec.europa.eu/sme-integration-to-industry

European Patent Office. (2017, December). *Patents and the Fourth Industrial Revolution: The inventions behind digital transformation.* Tratto da epo.org: http://documents.epo.org/projects/babylon/eponet.nsf/0/17FDB5538E87B4B9C12581EF0045762F/$File/fourth_industrial_revolution_2017__en.pdf

European Patent Office. (2017, July 27). *Patent families*. Tratto da epo.org: https://www.epo.org/searching-for-patents/helpful-resources/first-time-here/patent-families.html

European Patent Office. (2018, July). *EPO - IPscore*. Tratto da European Patent Office: https://www.epo.org/searching-for-patents/business/ipscore.html

European Patent Office. (2018). *Patent litigation: Manual and terminology.* Munich, Germany: European Patent Office.

Evans, P., & Gawer, A. (2016). *The Rise of the Platform Enterprise: A Global Survey.* New York: The Center for Global Enterprise.

Fabry, B., Ernst, H., Langholz, J., & Köster, M. (2006). Patent portfolio analysis as a useful tool for identifying R&D and business opportunities—an empirical application in the nutrition and health industry. *World Patent Information, 28*(3), 215-225.

Fenn, J., & Blosch, M. (2018). *Understanding Gartner's Hype Cycles.*

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

Fleming, L., & Sorenson, O. (2001). Technology as a complex adaptive system: evidence from patent data. *Research Policy, 30*(7), 1019-1039.

FlorCruz, M. (2015, May 5). *China Increases Subsidies On Energy-Efficient Vehicles, But Is It Enough To Alleviate Pollution?* Tratto il giorno February 7, 2021 da International Business Times: https://www.ibtimes.com/china-increases-subsidies-energy-efficient-vehicles-it-enough-alleviate-pollution-1929627

Fontana, F., & Caroli, M. (2003). *Economia e gestione delle imprese.* McGraw-Hill.

Foster, R. (1986). *Innovation: The attacker's advantage.* New York: Summit Books.

Frank, S. (2006a). Building an IP strategy. In *Intellectual Property for Managers and Investors: A Guide to Evaluating, Protecting and Exploiting IP* (p. 43-69). Cambridge: Cabridge University Press.

Frank, S. (2006b). Implementation. In *Intellectual Property for Managers and Investors: A Guide to Evaluating, Protecting and Exploiting IP* (p. 70-98). Cambridge: Cambridge University Press.

Frank, S. (2006c). Making the strategic choice. In *Intellectual Property for Managers and Investors: A guide to Evaluating, Protecting and exploiting IP* (p. 25-42). Cambridge: Cambridge University Press.

Frank, S. (2006d). Sketching the IP landscape. In *Intellectual Property for Managers and Investors: A Guide to Evaluating, Protecting, and Exploiting IP* (p. 1-24). Cambridge: Cambridge University Press.

Frank, S. (2006e). Surviving IP disputes. In *Intellectual Property for Managers and Investors: A Guide to Evaluating, Protecting and Exploiting IP* (p. 99-113). Cambridge: Cambridge University Press.

Freeman, C. (1982). *The economics of industrial innovation.* Cambridge: MA: The MIT Press.

Freeman, C. (1992). *The Economics of Hope.* New York: Pinter Publishers.

Fusfed, A. (1970). *The technological progress function: A new technique for forecasting.* Technological Forecasting.

Galasso, A., Schankerman, M., & Serrano, C. (2013). Trading and enforcing patent rights. *The RAND Journal of Economics, 44*(2), 275-312.

Gambardella, A., Giuri, P., & Luzzi, A. (2007). The market for patents in Europe. *Research Policy, 36*, 1163-1183.

Gartner Inc. (2020). *Gartner Hype Cycle*. Tratto il giorno November 14, 2020 da gartner.com: https://www.gartner.com/en/research/methodologies/gartner-hype-cycle

Geradin, D., Layne-Farrar, A., & Padilla, A. (2011). Elves or Trolls? The role of non-practicing patent owners in the innovation economy. *Industrial Corporate Change*.

Germeraad, P. (2010). It is all in the game. *Intellectual Asset Management, 39*, 63-71.

Ghemawat, P. (2007). Managing differences: The central challenge of global strategy. *Harvard Business Review, 85*(3), 58-68.

Giannini, M. (2017, November 13). *L'implementazione di Industria 4.0; vantaggi e criticità*. Tratto da LM – Leadership & Management: https://www.leadershipmanagementmagazine.com/articoli/limplementazione-industria-4-0-vantaggi-criticita/

Grindley, P. (1995). *Standards, Strategy and Policy: Cases and Stories.* Oxford: Oxford University Press.

Grindley, P. (1995). *Standards, Strategy and Policy:Cases and Stories.* Oxford: Oxford University Press.

Grindley, P. (2018a). Patents. In T. D. Augier M., *The Palgrave Encyclopedia of Strategic Management.* London: Palgrave Macmillan.

Grindley, P. (2018b). Standards. In M. Augier, & D. Teece, *The Palgrave Encyclopedia of Strategic Management.* London: Palgrave Macmillan.

Grindley, P. (2018c). Licensing. In A. M., & T. D.J., *The Palgrave Encyclopedia of Strategic Management.* London: Palgrave Macmillan.

Grindley, P. (2018d). Cross-Licensing. In M. Augier, & D. Teece, *The Palgrave Encyclopedia of Strategic Management* (p. 380-382). London: Palgrave Macmillan.

Guellec, D., & Ménière, Y. (2014). Market for Patents: Actors, workings and recent trends. In T. Madiès, D. Guellec, & J. Prager, *Patent Markets in the Global Knowledge Economy: Theory, Empirics and Public Policy Implications* (p. 9-32). Cambridge: Cambridge University Press.

Haber, S., & Werfel, S. (2016). Patent trolls as financial intermediaries? Experimental evidence. *Economics Letters, 149*, 64-66.

Hagedoorn, J. (2003). Sharing Intellectual Property Rights: An Exploratory Study of Joint Patenting amongst Companies. *Industrial and Corporate Change, 12*, 1035-1050.

Hagiu, A., & Yoffie, D. (2013). The new patent intermediaries: platforms, defensive aggregators, and super-aggregators. *The Journal of Economic Perspectives, 27*(1), 45-65.

Hall, B., & Harhoff, D. (2011). Recent Research on the Economics of Patents. In *NBER Working Paper 17773.* Cambridge, MA: National Bureau of Economic Research.

Harayama, Y., & Carraz, R. (2012). Addressing global and social challenges and the role of university. In L. Weber, & J. Duderstadt, *Global Sustainability and the Responsabilities of Universities* (p. 119-130). London: Economica.

Hazlett, T., Teece, D., & Waverman, L. (2011). Walled garden rivalry: the creation of mobile network ecosystems. *George Mason University Law and Economics esearch Paper Series #11-50*.

Hedge, D., & Luo, H. (2018). Patent Publication and the Market for Ideas. *Management Science, 64*(2), 652-672.

Helmers, C. (2018). The economic analysis of patent litigation data. *Economic Research Working Paper, 48*.

Henderson, R., & Clark, K. (1990). Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. *Administrative Science Quarterly*, 9-30.

Hildebrandt, B., Hanelt, A., Firk, S., & Kolbe, L. (2015). *Entering the digital era: the impact of digital technology-related M&A on business model innovations of automobile OEMs.*

Hoppe, H., & Ozdenoren, O. (2005). Intermediation in innovation. *International Journal of Industrial Organization, 23*, 483-503.

Impakter. (2020, June 22). *Tenneco Inc.* Tratto da impakter.com: https://seller.impakter.com/tenneco-inc/

Industry 4.0: Transforming auto manufacturing landscape. (2018, May 25). Tratto da Automotive Products Finder: https://advance.lexis.com/api/document?collection=news&id=urn:contentItem:5SDB-8T01-F12F-F3BJ-00000-00&context=1516831.

Javorcik, B. (2004). The composition of foreign direct investment and protection of intellectual property rights: Evidence from transition economies. *European Economic Review, 48*(1), 39-62.

Joskow, P. (2012). Vertical Integration. *The Antitrust Bulletin, 57*(3), 545-586.

Jovanovic, B., & Rousseau, P. (2005). General purpose technologies. In P. Aghion, & S. Durlauf, *Handbook of Economic Growth, vol. 1* (p. 1181–1224). Amsterdam: Elsevier.

Kagermann, H., Wahlster, W., & Helbig, J. (2013). *Recommenadtions for implementing the strategic initiative INDUSTRIE 4.0.* Final Report of the Industrie 4.0.

Kantner, R. (2017, May). *New Intellectual Property Considerations and Risks for Autonomous Vehicles*. Tratto da Jones Day:

https://www.jonesday.com/en/insights/2017/05/new-intellectual-property-considerations-and-risks-for-autonomous-vehicles

Klepper, S. (2002). The capabilities of new firms an the evolution of the US automobile industry. *Industrial and Corporate Change, 11*(4), 645-666.

Kline, S., & Rosenberg, N. (2010). An overview of innovation. In N. Rosenberg, *Studies on science and the innovation process: Selected works of Nathan Rosenberg* (p. 173-203).

Kogut, B. (1988). Joint Ventures: Theoretical and Empirical Perspectives. *Strategic Management Journal, 9*, 319-332.

Krishnan, V., & Ulrich, K. (2001). Product Development Decisions: A Review of the Literature. *Management Science*, 1-21.

Kwon, S., & Drev, M. (2020). Defensive Patent Aggregators as Shields against Patent Assertion Entities? Theoretical and Empirical Analysis. *Technological Forecasting and Social Change*.

Lamoreaux, N., & Sokoloff, K. (2002). Intermediaries in the US Market for Technology. *NBER Working Paper 9017*.

Lanjouw, J., & Schankerman, M. (2001). Characteristics of patent litigation: A window on competition. *Rand Journal of Economics*, 129-151.

Leiponen, A., & Byma, J. (2009). If you cannot block, you better run: Small firms, cooperative innovation, and appropriation strategies. *Research Policy*, 1478-1488.

Lemley, M. (2002). Intellectual property rights and standard-setting organizations. *California Law Review, 90*, 1889-1980.

Lessig, L. (2001). *The Future of Ideas.* New York: Vintage Books.

Linden, G., & Teece, D. (2016). System Integrators. In A. M., & D. Teece, *The Palgrave Encyclopedia of Strategic Management* (p. 1691-1693). London: Palgrave Macmillan.

Lorenz, R., Benninghaus, C., Friedli, T., & Netland, T. (2020). Digitalization of manufacturing: the role of external search. *International Journal of Operations & Production Management*.

Luman III, J., & Dodson, C. (2006). No longer a myth, the emergence of patent troll: stifling innovation, increasing litigation, and extorting billions. *Intellectual Property & Technology Law Journal, 18*(5), 12-16.

Lund, S., Manyika, J., Woetzel, J., Barriball, E., Krishnan, M., Alicke, K., . . . Hutzler, K. (2020). *Risk, resilience, and rebalancing in global value chains.* McKinsey Global Institute.

Macduffie, J. (2012). Modularity-as-Property, Modularization-as-Process, and 'Modularity'-as-Frame: Lessons from Product Architecture Initiatives in the Global Auto Industry. *Global Strategy Journal, 3*(1), 8-40.

Macduffie, J. (2013). Modularity-as-Property, Modularization-as-Process, and 'Modularity'-as-Frame: Lessons from Product Architecture Initiatives in the Global Auto Industry. *Global Strategy Journal, 3*(1), 8-40.

MacDuffie, J., & Fujimoto, T. (2010). Why dinosaurs will keep ruling the auto industry. *Harvard Business Review, 88*(6), 23-25.

Maci, L. (2020, December 16). *Che cos'è l'Industria 4.0 e perchè è importante saperla affrontare.* Tratto da EconomyUp: https://www.economyup.it/innovazione/cos-e-l-industria-40-e-perche-e-importante-saperla-affrontare/

Madhani, P. (2012). Intangible Assets: Value Drivers for Competitive Advantage. In G. G.N., & F. N., *Best Practices in Management Accounting* (p. 146-165). London: Palgrave Macmillan.

Matthews, H., & Brueggemann, R. (2015). *Innovation and Entrepreneurship: A Competency Framework.* New York: Routledge.

Maxton, G., & Wormald, J. (2004). *Time for a Model Change: Re-engineering the Global Automotive Industry.* Cambridge: Cambridge University Press.

McDonagh, L. (2014). *Exploring perspectives of the Unified Patent Court and Unitary Patent Within the Business and Legal Communities.* Newport: The Intellectual Property Office.

McElheny, V. (2010). *Drawing the Map of Life: Inside the Human Genome Project.* New York: Basic Books.

Meloso, D., Copic, J., & Bossaerts, P. (2009). Promoting intellectual discovery: patents versus markets. *Science*, p. 1335-1339.

Ménière, Y., Rudyk, I., & Valdés, J. (2017). *Patents and the Fourth Industrial Revolution: The inventions behind digital transformation.* EPO.

Merges, R., & Nelson, R. (1990). On the complex economics of patent scope. *Columbia Law Review, 90*(4), 839-916.

Meyer, M., & Utterback, J. (1993). The Product Family and the Dynamics of Core Capabilities. *Sloan Management Review*, 29-48.

Michel, J., & Bettels, B. (2001). Patent citation analysis. A closer look at the basic input data from patent search reports. *Scientometrics, 51*(1), 185-201.

Morck, R., & Yeung, B. (2001). *The Economic Determinants of Innovation.* Industry Canada Research Publications Program.

Moretti, A., Perri, A., Silvestri, D., & Zirpoli, F. (2021). *Traditional industries and the Fourth Industrial Revolution: new trends in the creation and protection of innovation in the global automotive industry.* Ca' Foscari University, Management, Venice.

Moss, S. (1981). Technology and Market Structure in the Analysis of Exchange. *Technology and Market Structure in the Analysis of Exchange, 2*(2), 106-121.

Murmann, J., & Frenken, K. (2006). Toward a systematic framework for research on dominant designs, technological innovations, and industrial change. *Research Policy*, 925-952.

Nightingale, & P. (2018). Innovation. In M. Augier, & D. Teece, *The Palgrave Encyclopedia of Strategic Management* (p. 734-738). London: Palgrave Macmillan.

Nishiguchi, T. (1994). *Strategic Industrial Sourcing.* New York: Oxford University Press.

Nonaka, I., Tomaya, R., & Konno, N. (2000, February 1). SECI, Ba and Leadership: A Unified Model of Dynamic Knowledge Creation. *Long Range Planning, 33*(1), 5-34.

Nuvolari, A. (2004). Collective invention during British Industrial Revolution: the case of the Cornish pumping engine. *Cambridge Journal of Economics, 28*, 347-363.

OECD. (2012). *Knowledge Networks and Markets in the Life Sciences.* Paris: OECD.

Oxley, J. (1997). Appropriability Hazards and Governance in Strategic Alliances: A Transaction Cost Approach. *The Journal of Law, Economics, and Organization, 13*(2), 387-409.

Paliotta, A., & Pannone, A. (2001). *Ict e "New economy". Orientamenti della letteratura e primi elementi per la costruzione di un percorso critico.* Isfol.

Pallini, D. (2008). *Brevetti e impresa.* IPSOA.

Panagopoulos, A. (2018). Closed vs Open Innovation. In M. Augier, & D. Teece, *The Palgrave Encyclopedia of Strategic Management* (p. 250-253). London: Macmillan Publishers.

Papst, D. (2013). NPEs and patent aggregators - new, complementary business models for modern IP markets. *Licensing Journal, 32*(10).

Pardi, T. (2019). Fourth industrial revolution concepts in the automotive sector: performativity, work and employement. *Journal of Industrial and Business Economics, 46*, 379-389.

Parr, R., & Smith, G. (2009). *Intellectual Property. Valuation, Exploitation, and Infringement damages. 2009 Cumulative supplement.* John Wiley & Sons, Inc.

Partington, O., & Calvo, P. (2017, June 16). *A Comparison of US and EPO Post Grant Practices.* Tratto da lexology.com: https://www.lexology.com/library/detail.aspx?g=bd361876-a09d-4e55-99f6-afa30dc9cabb

Patel, P., & Pavitt, K. (1991). Large firms in the production of the world's technology: an important case of "non-globalisation". *Journal of international business studies, 22*(1), 1-21.

PatVal. (2005). *The Value of European Patents: Evidence from a Survey of European Invenstors.* Brussels: European Commission.

Penin, P., Hussler, C., & Burger-Helmchen, T. (2011). New shapes and new stakes: a portrait of open innovation as a promising phenomenon. *Journal of Innovation Economics, 3*, 11-29.

Pfeiffer, S. (2017). Industrie 4.0 in the making-discourse patterns and the rise of digital despotism. *New Digital Workplace: How New Technologies Revolutionise Work, 21*.

Piccinini, E., Hanelt, A., Gregory, R., & Kolbe, L. (2015). *Transforming industrial business: the impact of digital transformation on automotive organizations.*

Pisano, G., & Teece, D. (2007). How to capture value from innovation: Shaping intellectual property and industry architecture. *California management review, 50*(1), 278-296.

Pozzoli SpA v BDMO SA, EWCA Civ 588 (2007).

Probst, L., Lefebvre, V., Martinez-Diaz, C., N.U., B., PwC, Klitou, D., . . . CARSA. (2018). *Digital Transformation Scoreboard 2018: EU businesses go digital: Opportunities, outcomes and uptake.* Luxembourg: Publications Office of the European Union.

Raymond, E. (1999). *The Cathedral and the Bazar.*

Razgaitis, S. (2004). US/Canadian licensing in 2003: survey results. *Journal of Licensing Executive Society, 34*, 139-151.

Reitzig, M. (2003). What determines patent value?: Insights from the semiconductor industry. *Research Policy, 32*(1), 13-26.

Reitzig, M. (2004). Strategic Management of Intellectual Property. *Sloan Management Review*, 35-40.

Rietzig, M., & Puranam, P. (2009). Value Appropriation as an Organizational Capability: The Case of IP Protection Through Patents. *Strategic Management Journal, 30*(7), 765-789.

Rietzig, M., Henker, J., & Schneider, F. (2010). Collateral damage for R&D manufacturers: how patent sharks operate in markets for technology. *Industrial and Corporate Change, 19*, 947-967.

Robinson, B. (2017, April 26). *The future of high tech patent litigation in the auto industry*. Tratto da automotiveworld..com: https://www.automotiveworld.com/articles/future-high-tech-patent-litigation-auto-industry/

Rosenberg, N. (1976). Technological change in the machine tool industry. In N. Rosenberg, *Perspectives on technology* (p. 1840-1910). Cambridge, MA: Cambridge University Press.

Rothaermel, F. (2001). Incumbent's advantage through exploiting complementary assets via interfirm cooperation. *Strategic Management Journal*, 687-699.

Rothwell, R. (1992). *Successful industrial innovation: Critical factors for the 1990s* (Vol. 22). R&D Management.

Sanchez, R., & Mahoney, J. (1996). Modularity, Flexibility, and Knowledge Management in Product and Organizational Design. *Strategic Management Journal, 17*, 63-76.

Sanders, A., Subramanian, K., Redlich, T., & Wulfsberg, J. (2017). Industry 4.0 and lean management–synergy or contradiction? *FIP international conference on advances in production management systems* (p. 341-349). Cham: Springer.

Schmookler, J. (1962). *Economic sources of incentive activity* (Vol. 22). Journal of Economic History.

Schulze, A., MacDuffie, J., & Täube, F. (2015). Introduction: knowledge generation and innovation diffusion in the global automotive industry - change and stability during turbulent times. *Industrial and Corporate Change*, 1-9.

Schumpeter, J. (1934). *The theory of economic development: An inquiry into profits, capital, credit, interest and business firm.* Cambridge, MA: The Harvard University Press.

Schumpeter, J. (1942). *Capitalism, socialism and democracy.* New York: Harper and Brothers.

Shapiro, C. (2001). Navigating the patent thicket: cross licenses, patent pools, and standard-setting. In A. Jaffe, J. Lerner, & S. Stern, *Innovation Policy and the Economy* (Vol. 1, p. 119-150). Cambridge, MA: MIT Press.

Sharma, A. (2008, June 30). Tech Giants Join Together To Head Off Patent Suits. *The Wall Street Journal*.

Sherpa Technology Group. (2016). *Automotive Technology and IP Outlook.* Boston: 3LP.

Shladover, S., Su, D., & Lu, X. (2012). Impacts of Cooperative Adaptive Cruise Control on Freeway Traffic Flow. *Proceedings of the 91st Annual Meeting of the Transportation Research Board.* Washington, DC.

Simpson, T. (2004). Product platform design and customization: Status and promise. *Artificial Intelligence for Engineering Design, Analysis and Manufacturing, 18*(1), 3-20.

Sirkin, H., Zinser, M., & Rose, J. (2015). *The robotics revolution: The next great leap in manufacturing.* Boston Consulting Group Perspectives.

Sjödin, D., Parida, V., Leksell, M., & Petrovic, A. (2018). Smart Factory Implementation and Process Innovation. *Research-Technology Management, 61*(5), 22-31.

Society of Automotive Engineers International. (2018, November 12). *SAE International Releases Updated Visual Chart for Its "Levels of Driving Automation" Standard for Self-Driving Vehicles*. Tratto il giorno February 8, 2021 da sae.org: https://www.sae.org/news/press-room/2018/12/sae-international-releases-updated-visual-chart-for-its-%E2%80%9Clevels-of-driving-automation%E2%80%9D-standard-for-self-driving-vehicles

Somaya, D. (2012). Patent strategy and management: An integrative review and research agenda. *Journal of Management, 38*(4), 1084-1114.

Somaya, D., & McDaniel, C. (2012). Tribunal specialization and institutional targeting in patent enforcement. *Organization Science*, 869-887.

Spinello, R. (2009). *A Defense of Intellectual Property Rights.* Edward Elgar Publishing.

Srinivasan, R., Lilien, G., & Rangaswamy, A. (2006, April). The Emergence of Dominant Designs. *Journal of Marketing, 70*, 1-17.

T 0606/89 (September 18, 1990).

T 0632/02 (July 17, 2003).

T 0939/92 (September 12, 1995).

Takeishi, A. (2001). Knowledge Partitioning in the Interfirm Division of Labor: The Case of Automotive Product Development. *Organization Science, 13*(3), 321-338.

Teece, D. (1984). Economic analysis and trategic management. *California Management Review 26*, p. 87-110.

Teece, D. (1986). Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy. *Research Policy*, 285-305.

Teece, D. (2017). 5G Mobile: Disrupting the Automotive Sector. *Tusher Center for Intellectual Capital, U.C. Berkley*.

Teece, D. (2018). Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world. *Research Policy*, 1367-1387.

Teece, D. (2018a). Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world. *Research Policy*, 1367-1387.

Teece, D. (2018b). Profiting from Innovation. In M. Augier, & D. Teece, *The Palgrave Encyclopedia of Strategic Management* (p. 1353-1358). London: Palgrave Macmillan.

The New York Times. (2009, October 18). *Software Pirates in China Beat Microsoft to the Punch.* Tratto da nytimes.com: https://www.nytimes.com/2009/10/19/business/global/19iht-windows.html

Thomke, S., & Fujimoto, T. (1998). Shortening Product Development Time through 'Front-Loading' Problem-Solving. *CIRJE, Faculty of Economics, University of Tokyo, 11*.

Thumm, N., & Gabison, G. (2016). *Patent Assertion Entities in Europe.* Luxembourg: Publications Office of the European Union.

Tripsas, M. (1997). Unraveling the process of creative destruction: Complementry assets and incumbent survival in the typesetter industry. *Strategic Management Journal, 18*(1), 119-142.

Trombini, G., & Zirpoli, F. (2013). Innovation processes in the car industry: New challenges for management and research. In A. Stocchetti, G. Trombini, & F. Zirpoli, *Automotive in transition Challenges for strategy and policy* (p. 19-36). Venice: Edizioni Ca' Foscari.

Tushman, M., & Anderson, P. (1986). Technological Discontinuities and Organizational Environments. *Administrative Science Quarterly*, 439-465.

Unified Patent Court. (2015, October 27). *Unified Patent Court - Rules of procedure.* Tratto da unified-patent-court.org: https://www.unified-patent-court.org/news/unified-patent-court-rules-procedure

United States Patent and Trademark Office. (2019, December). *35 U.S.C. 120 – Benefit of earlier filing date in the United States – United States Patent and Trademark Office.*

Tratto da Uspto.gov: https://www.uspto.gov/web/offices/pac/mpep/mpep-9015-appx-l.html#d0e303023313

United States Patent and Trademark Office. (2019, October 31). *35 U.S.C. 102 Conditions for patentability; novelty - United States Patent and Trademark Office.* Tratto da Uspto.gov: https://www.uspto.gov/web/offices/pac/mpep/mpep-9015-appx-l.html#top

United States Patent and Trademark Office. (2020, December 28). *35 U.S.C. 112 – Specification – United States Patent and Trademark Office.* Tratto da Uspto.gov: https://www.uspto.gov/web/offices/pac/mpep/mpep-9015-appx-l.html#d0e302824912

Utterback, J. (1994). *Mastering the dynamics of innovation.* Boston: Harvard Business School Press.

Vanhaverbeke, W., & Cloodt, M. (2006). Open innovation in value networks. In H. Chesbrough, W. Vanhaverbeke, & J. West, *Open innovation: Researching a new paradigm.* Oxford: Oxford University Press.

Vatter, H. (1985). *The US Economy in World War II.* New York: Columbia University Press.

Venkatraman, N., El Sawy, O., Pavlou, P., & Bharadwaj, A. (2014, September 1). Theorizing Digital Business Innovation: Platforms and Capabilities in Ecosystems. *Fox School of Business Research Paper No. 15-080*.

Weckowska, D. (2015). Learning in university technology transfer offices: transactions-focused and relations-focused approaches to commercialization of academic research. *Technovation, 41-42*, 62-74.

West, J. (2018). Open Innovation. In M. Augier, & D. Teece, *The Palgrave Encyclopedia of Strategic Management* (p. 1157-1162). London: Palgrave Macmillan.

West, J., Salter, A., Vanhaverbeke, W., & Chesbrough, H. (2014). Open innovation: The next decade. *Research Policy, 43*, 805-811.

Weyer, S., Schmitt, M., Ohmer, M., & Gorecky, D. (2015). Towards Industry 4.0 - Standardization as the crucial challenge for highly modular, multi-vendor production systems. *IFAC Symposium on Information Control in Manufacturing (INCOM)* (p. 579-584). Ottawa: IFAC-PapersOnLine.

Wheelwright, S., & Clark, K. (1992). Creating Project Plans to Focus. *Harvard Business Review*, 1-14.

Windsurfing v Tabur Machine, RPC 59 CA (1985).

Winter, S. (2006). The logic of appropriability: From Schumpeter to Arrow to Teece. *Research Policy, 35*, 1100-1106.

World Intellectual Property Organization. (2005, September). *IP and Business: Launching a New Product: freedom to operate.* Tratto da wipo.int: https://www.wipo.int/wipo_magazine/en/2005/05/article_0006.html

World Intellectual Property Organization. (2008). *Concept of a Technology Classification for Country Comparisons.* Fraunhofer Institute for Systems and Innovation Research, Karlsruhe.

World Intellectual Property Organization. (2009). *Standards and Patents.* Tratto da wipo.int: https://www.wipo.int/patent-law/en/developments/standards.html

World Intellectual Property Organization. (2017). *Innovation and Intellectual Property*. Tratto da World Intellectual Property Organization: https://www.wipo.int/ip-outreach/en/ipday/2017/innovation_and_intellectual_property.html

World Intellectual Property Organization. (2020). *Competition and Patents*. Tratto da World Intellectual Property Organization: https://www.wipo.int/patent-law/en/developments/competition.html

World Intellectual Property Organization. (2020). *Opposition Systems.* Tratto da wipo.int: https://www.wipo.int/scp/en/revocation_mechanisms/opposition/index.html

World Intellectual Property Organization. (2020). *Patents*. Tratto da World Intellectual Property Organization: https://www.wipo.int/patents/en/

World Intellectual Property Organization. (2020). *What is Intellectual Property?* Tratto da World Intellectual Property Organization: https://www.wipo.int/publications/en/details.jsp?id=4528

World Trade Organization. (1994, April 15). *Article 62 TRIPS Agreement - Acquisition and maintenance of intellectual property rights and related inter-partes procedures.* Tratto da wto.org: https://www.wto.org/english/docs_e/legal_e/27-trips_06_e.htm

Wyman, O. (2017). *Automakers in the digital world.*

Yanagisawa, T., & Guellec, D. (2009). The Emerging Patent Marketplace. *OECD Science, Technology and Industry Working Papers, No. 2009/09*.

Zhang, Y., & Li, Y. (2020). Analysis of the Business Model of "Internet +" Intellectual Property Trading Platform. *Fourth Asian B&R Conference on International Business Cooperation (ISBCD 2019)* (p. 23-28). Advances in Economics, Business and Management Research.

Ziedonis, R. (2004). Don't fence me in: Fragmented markets for technology and the patent acquisition strategies of firms. *Management Science*, 804-820.

Zirpoli, F. (2010). *Organizzare l'innovazione - Strategie di esternalizzazione e processi di apprendimento in Fiat Auto.* Bologna: Il Mulino.

Zirpoli, F., & Becker, M. (2011). The Limits of Design and Engineering Outsourcing: Performance Integration and the Unfilled Promises of Modularity. *R&D Management, 41*(1), 21-43.