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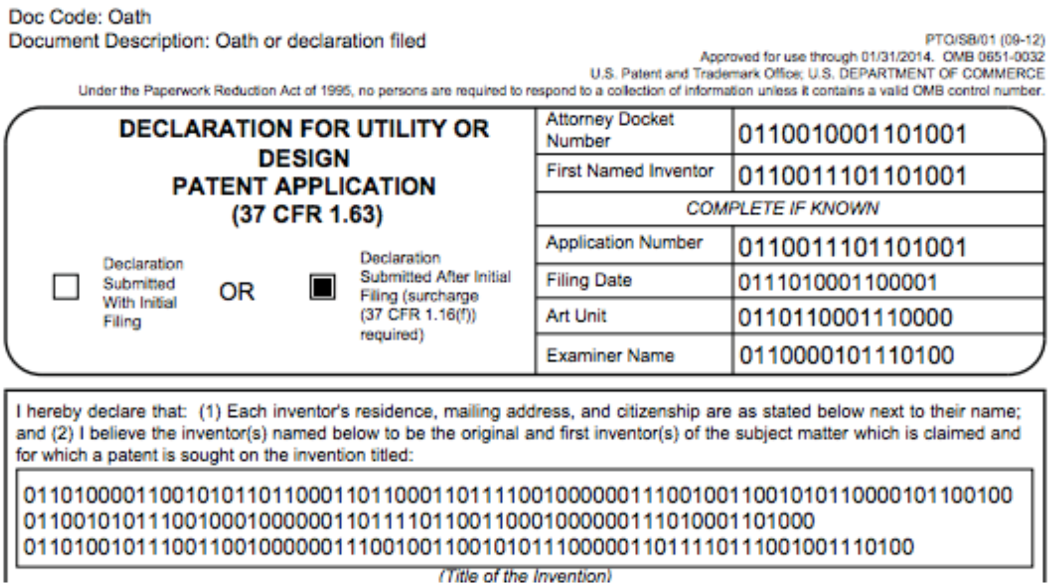

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I hereby declare that: (1) Each inventor's residence, mailing address, and citizenship are as stated below next to their name; and (2) I believe the inventor(s) named below to be the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought on the invention titled:

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The impact of digitalization on intellectual property strategy

An exploratory study of Nordic engineering firms

Master's Thesis in the Master's Programme
MANAGEMENT AND ECONOMICS OF INNOVATION

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CHALMERS UNIVERSITY OF TECHNOLOGY
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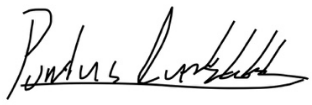

Abstract

An increasingly large share of firms in various industries have in the recent decade embedded digital technology in their products, processes and business models. Firms have therefore broadened their technology bases. As firms in different industries are moving into the same technology area, new issues of how intellectual property (IP) should be managed arise. Previous research has not aligned the areas of digitalization, technology strategy, and IP management. This study therefore attempts to clarify how digitalization affects firms' technology strategies and in turn firms' IP strategies. To investigate how firms work with these issues, interviews were conducted with 23 IP managers in 18 large technology-intensive Nordic firms. The empirical findings from these interviews reveal that as firms add digital technology with multiple external approaches for technology acquisition, they move into complex innovation ecosystems with multiple new types of actors. Furthermore, appropriability regimes for digital technology generally require multiple forms of protection, e.g. protection of an invention with both copyright, secrecy, and patent protection of complementary technologies. Additionally, embedding digital technology in products makes freedom to operate more difficult to achieve due to increased complexity in the surrounding patent landscapes. The empirical findings also reveal that data is to be considered an important, valuable asset. These findings suggest that appropriability needs to be expanded from a single-firm perspective to an innovation ecosystem perspective, and that multiple complementary assets and protective forms need to be managed in a strategic and holistic way.

Key words: *Appropriability Regime, Digitalization, Innovation Ecosystem, Intellectual Property Management, Intellectual Property Strategy, Open Innovation*

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1 Introduction

1.1 Background

Recent years of technological development has been characterized by an increased importance of digital technology. Connectivity and software is being added to physical products in a large number and variety of industries (Yoo et al. 2012; Pagani 2013). These include, but are not limited to, vehicles, tools, production equipment, and consumer products that thereby could be automated or made more efficient. Firms also to an increasing extent connect process equipment to computers so that operations and processes in general can be more efficient (Swanson 1994). This includes IT systems that can be used in purchasing and logistics to enhance material- and product flows. It also includes databases and IT based business intelligence tools that can be used in administration and marketing to target relevant customers. Digital technology may also enable new ways of selling physical products and add services to them (Bharadway et al. 2013), for example subscription services for on-demand use of cars and bikes. All the above examples can be seen as a part of what often is called digitalization[1], which in more general terms can be seen as the increasing embeddedness of digital technology in physical products, processes and business models. This affects firms that traditionally have not developed digital technology, but rather have focused on physical products or services of different kinds. These firms might need to make digital technology a part of their business (Fitzgerald et al. 2014).

A parallel trend can be seen in what here is referred to as the technology strategies of firms, i.e. how firms acquire and exploit technology. To a decreasing extent firms appear to rely on internal research and development (R&D) for technology acquisition and internal manufacturing and sales for technology exploitation (Granstrand et al. 1992; Chesbrough & Brunswicker 2014). Instead, firms now also partake in R&D collaborations, engage customers in creating ideas for new for technologies and products, and license in patents for acquiring new technology. Similarly, firms sell or license out patents and spin-off new firms for exploiting the technology in the firm. Together, this makes up what is often referred to as open innovation (Chesbrough 2006). By engaging in open innovation activities, firms have better chances to incorporate new ideas and bring in the right competence and resources (Chesbrough 2003) to

[1] Sometimes interchangeably used with "digitization". Here digitalization is used to not only capture the mere shift in information formats, but also the shift towards an increased utilization of different technologies that incorporate digital information formats.

improve their innovative performance (Chesbrough & Crowther 2006; Parida et al. 2012) and thereby improve their growth (Chesbrough & Crowther 2006).

In order for firms to firms to exploit the value of their technology, i.e. earn profits, a key question is how well they can protect it from being imitated by competitors (Teece 1986; Granstrand 1999). Perhaps the most important method to do this is through patenting. Other intellectual property (IPs) or intellectual property rights (IPRs), e.g. copyright and design rights, may also play an important role. How these protection-forms are to be managed in general, and how IPRs are to be managed in specific is commonly referred to as intellectual property management (Granstrand 1999). Recent research has emphasized that IP management should be strategic and aligned with business strategy, as well as take multiple different protection forms into consideration (Reitzig 2004; Al-Aali & Teece 2013). Further opportunities for protecting a product from being imitated may also come from secrecy, technical complexity and different means of technical protections such as encryptions (Teece 1986). These protective measures together make up the appropriability regime which plays a key role in profiting from technology and innovation (ibid.).

1.2 Purpose

When firms develop and exploit technology internally, the opportunities for exclusive protection from imitation are large (Teece 1986). This naturally follows the fact that all technology is held internally and could potentially be patented without concern for co-developing parties of the technology. As firms increasingly rely on open innovation approaches, knowledge and technology often need to be shared across actors (Bogers 2011; Chesbrough 2006). Firms may then rely on technology developed and owned by others (Granstrand et al. 1992; Chesbrough 2003; Chesbrough & Appleyard 2007). This makes protecting innovations from imitation more complex due to risks of knowledge leakage and risks of technology suppliers licensing or selling their technology to competitors (Hagedoorn & Zobel 2015; Manzini & Lazzarotti 2016). As physical products become increasingly digitalized, new technological areas are brought together, e.g. mechanical and digital, material and digital, etc. Firms that have previously focused largely on one technological area now may have to focus on two. This, could make open innovation even more relevant for firms. Together, it could be said that digitalization appears to put new demands on firms' ability to acquire, protect and manage technology. A key component of this is the IP management in firms. The purpose of this study is therefore to investigate how digital technology and digitalization affect the management and strategy of intellectual property.

Technology strategy, open innovation and IP management are relatively well explored areas whereas digitalization is not. The research presented in this report is relevant for three reasons. First, digitalization has been given large attention in business media and by consulting firms in recent years as it appears to affect many different aspects of firm strategy.[2] Second, while digitalization is a popular concept among practitioners, it has not been defined at firm level in an academic setting. In other words, research on how digitalization affect firm strategy in general, and technology strategy and IP management in specific, is largely a new area for research. Third, innovation and IP are important drivers of growth and welfare both at macro- and micro-level (Granstrand 2018), and are perhaps affected by digitalization.

The research is presented in this thesis as follows. The first section above has outlined the background and the relevance of this research. The second section will describe relevant theory and studies conducted in the areas of technology strategy, open innovation, and IP management. The third section is focused on methodology, outlining how this study was carried out, why certain methodological choices were made, and what could be said about the quality of this research based on methodological considerations. The fourth section presents the empirical findings from the gathered data. The fifth section contains the analysis of the empirical findings by contrasting it with existing theory. Finally, the sixth section discusses what potential conclusions could be drawn from this study, and what implications those conclusions have for researchers and managers, as well as suggestions for further research.

[2] Some noteworthy examples from the consulting world are McKinsey Digital, Accenture Digital, and Deloitte Digital. In these cases, large existing consulting firms have set up specific specialist departments for their projects focused on digitalization.

2 Theoretical framework

2.1 Technology strategy

Technology can be defined as "a body of knowledge about techniques and technical relationships" (Granstrand 1999, pp. 418). A firm typically has a set of technologies, together making up the technology base of the firm (Granstrand et al. 1992) which forms a subset of a firm's total resources (Wernerfelt 1984). This technology base can be monetized through different means of exploitation, e.g. implementing the technology in products manufactured and sold by the focal firm. Firms may expand the technology base through means of multiple different and complementary technology acquisition approaches. These approaches vary in their degree of integration with the internal organization of the firm, ranging from internal R&D (fully internal acquisition) and manufacturing and selling products (fully internal exploitation) to buying technology in the form of patents or contract R&D (largely external acquisition) and licensing out technology (largely external exploitation) (Granstrand et al. 1992), as shown in Figure 1. A firm may choose to diversify its technology base by expanding into new technological areas, i.e. through technology diversification (Granstrand et al. 1992; Granstrand 2018). Technology diversification thereby renders the focal firm a multi-technology corporation (MTC), as defined in Granstrand (1998). With a diversified set of technologies, business diversifications are enabled through e.g. new products, new services, or new markets. Technology diversification can thereby enable business diversification and thus improve firm growth (Granstrand & Oskarsson 1994).[3]

[3] It is here important to note that business and product diversification has been criticized in the recent two decades, especially from financial economists pointing out risks of decreased shareholder value, see e.g. Martin & Sayrak (2003), Martynova, & Renneboog (2008) and Grant (2016).

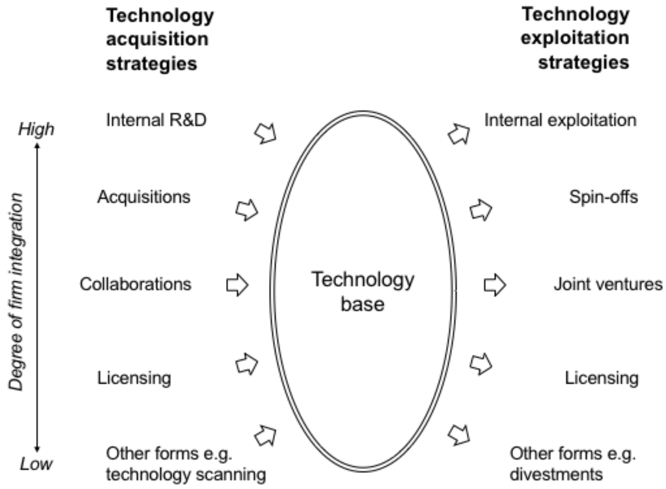

Figure 1. Technology acquisition and exploitation strategies with different integration with focal firm (adapted from Granstrand (1999))

One important reason to diversify the technology base in a firm is to achieve complementarities between different technologies. More specifically, "[t]echnological complementarity occurs when the value of an innovation depends on altering the nature of one or more existing technologies and/or on creating new ones" (Teece 2016, pp. 15), through which additional value can be created. In cases of products or innovations drawing on multiple technologies or inventions (i.e. multi-invention contexts), external sources of technology are often needed (Teece 2016). Technology diversification may thus also help firm growth in firms with an increasingly narrow business focus (Gambardella & Torrisi 1998), through technological complementarity in the current products on their existing markets.

Technology also play a key role for profitability in firms. In particular, the commercialization of new technology (i.e. an invention turned into an innovation) could become a considerable source of profit. To profit from an innovation, firms need either a strong appropriability regime or the ownership of complementary assets, or preferably both (Teece 1986). The appropriability regime then refers to how easy imitation is for potential competitors and depends on the strength of any given legal protection (e.g. patents, trade secrets, etc.) and "the inherit replicability of the technology" (Teece 2006, pp. 1134). Ownership of complementary assets refers to e.g. manufacturing facilities and capabilities and complementary technology assets (e.g. software programs to hardware products), and is as important as appropriability regime for profiting from innovation (Teece 1986).

2.1.1 Protection of technology in open innovation

Chesbrough (2003) introduced the concept of open innovation which since has been defined from opposing perspectives. Openness can, for example, be understood as the amount and number of processes partners are engaged in throughout the innovation process (see Lazzarotti & Manzini 2009). It can also be understood as the extent firms use external technology acquisition and exploitation (see e.g. Lichtenthaler 2008; Gassman & Enkel 2004; Holgersson & Granstrand 2017). In common for both these views is that firms may pursue more or less open innovation, i.e. there are different degrees of openness. We can here use the earlier introduced framework of technology acquisition and exploitation to define open innovation in this context: open innovation is innovation created through not only internal acquisition and exploitation strategies, but also external acquisition and exploitation strategies. These external acquisition and exploitation strategies might for example be joint development of new products and patent in-/out-licensing. This definition is also well aligned with how open innovation is defined in Bogers et al. (2018), extending earlier works such as Chesbrough (2003) and Chesbrough (2006).

Firms today largely utilize various open innovation strategies, especially for technology acquisition, and this phenomenon is relatively well understood (Bogers et al. 2018). It has been noted that the acquisition of technology through external means is an increasingly important strategy (see e.g. Granstrand et al. 1992; Chesbrough & Brunswicker 2014). Inbound open innovation is primarily pursued to gather new ideas (Chesbrough 2003) for enhanced innovation performance (Chesbrough & Crowther 2006; Parida et al. 2012) in turn generating growth potential for firms (Chesbrough & Crowther 2006). However, this does not mean that internal R&D for technology acquisition in absolute terms is of less importance, as using open approaches to technology acquisition generally is complementary rather than a substitute to internal R&D (Lichtenthaler 2008; Kurokawa 1997; Veugelers & Cassiman 1999). For a firm to make use of new technologies and technological areas, internal R&D capabilities are needed to integrate and find uses for these new technologies. More generally it can also be said that those firms that engage in open innovation (both for acquisition and exploitation) to a large degree tend to have relatively high R&D expenditure (Lazzarotti & Manzini 2009), which further supports that open innovation is complementary to internal R&D (Cohen & Levinthal 1990; Lazzarotti & Manzini 2009). Thus, open innovation does not imply a lesser importance of internal innovative capabilities or resources.

As noted earlier, profiting from innovation may require various means to protect technology. In cases of open innovation where new technology is brought into a firm, much of the innovative capabilities and resources are external, i.e. not owned by the firm. This requires strategic considerations, such as weighing the benefits and costs of openness (Chesbrough & Appleyard 2007). In certain cases, e.g. open source software, innovators “cannot exert exclusive rights over the resultant innovation” (Chesbrough & Appleyard 2007, pp. 60). Although this might be beneficial in the sense that the technology base is expanded and potentially diversified, the protection of innovations might be limited. In other terms, IP ownership might be needed to profit from the innovation resulting from open innovation development efforts (Chesbrough & Appleyard, 2007; Granstrand & Holgersson 2014). Laursen & Salter (2014) explains this as the paradox of openness: “the creation of innovation often requires openness, but the commercialization of innovation requires protection” (pp. 867).

Some researchers argue that openness of innovation should be seen as the level of knowledge being shared openly and publicly, and in turn suggest that IPRs hinder and limit innovative openness (see e.g. von Hippel & von Krogh 2006; West 2006; Pénin 2012). Conversely, another group of scholars view openness of innovation as the share of innovations that come from non-internal acquisition and exploitation strategies (see e.g. Graham & Mowery 2005; Chesbrough 2006; Pisano & Teece 2007; Bader 2008). This implies that different means to protect knowledge are key for open innovation to occur and that the paradox of openness needs to be dealt with. Thus, IPRs incentivize firms to do open innovation, and should consequently increase innovative openness if sufficiently strong. Recent studies into the field has uncovered evidence that IPRs in fact facilitates rather than hinders open innovation. Henttonen et al. (2016, pp. 154) found that “the need for a strong appropriability regime [including IPRs] increases as the number of partners increases” in R&D collaborations. Hagedoorn & Zobel (2015) found that IPRs in general, especially patents and trade secrets, are seen as the most important instruments to protect the innovative capabilities from leaking to their partners. Perhaps most importantly, Holgersson & Granstrand (2017) found that the incentive to patent increases as firms do more open innovation.

In cases where technology has been acquired from an external actor (e.g. licensing in patents) there might be limitations to the degree and context in which it can be exploited (Lichtenthaler 2008; Granstrand & Holgersson 2014). An alternative approach to get access to technology and avoid exploitation limitations is then collaborations to complement lacking or missing competencies in a firm (Lazzarotti & Manzini 2009), as that allows for potential application-specific technology to be owned by the focal firm. Collaborations are therefore especially relevant in cases of multi-invention products (Manzini & Lazzarotti 2016). However, in these collaborations, issues of IP ownership are prominent (ibid.; Bogers 2011; Granstrand & Holgersson 2014). Further, the knowledge of firms, including technology, needs to be protected as it otherwise spills over to collaborators (Cassiman & Veugelers 2002; Heiman & Nickerson 2004). Simply applying secrecy in open innovation collaborations is also difficult due to the nature of the knowledge sharing (Manzini & Lazzarotti 2016). Other protective mechanisms might be needed for the protection of trade secrets, especially protection through contractual forms (Bader 2008; Hagedoorn & Zobel 2015). The problem of knowledge and IPR allocation in collaborations is particularly prominent where partners have large overlaps, in terms of technology areas, with the focal firm's IPR portfolio (Hagedoorn & Zobel 2015).

As firms engage in open innovation activities in general, and collaborations in specific, an increasingly complex value chain emerges in which multiple partners have interest and require knowledge transfer (Hagedoorn & Zobel 2015). This requires management of the innovation networks and which partners that are included in them (Lazzarotti & Manzini 2009). More open innovation oriented approaches require new approaches to strategy to acknowledge the implications of more complex forms of innovation processes in innovation ecosystems and innovation networks (Chesbrough & Appleyard 2007). For these complex settings, IPR allocation dictated by contracts are effective means of protecting firms from knowledge spill-overs to competitors (Arora & Merges 2004; Hagedoorn & Zobel 2015; Teece 2016). Due to the complexity of the networks, standardized contracts are generally insufficient for these type of collaborations (Hagedoorn & Zobel 2015), which gives contracts an increasingly important role in open innovation.

2.1.2 Emergence of network forms

Recently, digital technology has moved beyond the traditional infocom technology (ICT) infrastructure applications into new areas and industries, leading to new fields of technology such as Internet of Things (IoT)[4], and increased importance of other technological fields such

[4] IoT comprise of vast networks of devices, where data and control can be provided through means of added sensors and processors for computing (i.e. "smartness") (Teece 2016). This enables for interactions and integration between devices etc., if so common standards for communication are used (ibid.).

as sensors and data[5] (Bogers et al. 2018). For this, software and hardware, or more generally digital technology and physical technology, are combined (ibid.). With this combined digital and physical technology, more information can also be turned digital (Teece 2016). These changes in products and information format largely make up what is understood as digitalization. When digital and physical technology are combined, knowledge from completely different bodies of knowledge are combined, i.e. making it a multi-invention context (Somaya et al. 2007). Digitalization thus causes innovation processes to become more distributed as it requires heterogeneous technologies and heterogeneous actors to be integrated (Yoo et al. 2012). Due to this, firms move into complicated networks with competitors, customers, and suppliers in different types of alliances and partnerships (Bharadwaj et al. 2013).

Recent decades have brought increasingly fragmented networks of firms, i.e. shifting firms away from vertical integration (Bitran et al. 2007; Pagani 2013). This can at least partly be contributed to the increased importance of digital technology and digital strategies (Pagani 2013). Beyond that, the merge of wireless and internet technologies into converging industries have caused the emergence of innovation ecosystems (Teece 2016; Granstrand & Holgersson 2018). As networks become increasingly complex and interrelated, the lines between different industries typically appear blurred (Granstrand et al. 1992; Granstrand & Holgersson 2018), which here largely can be said to be the result of digitalization (Yoo et al. 2010). To arrange for these complex innovation ecosystems, more complicated organizational arrangements, license deals and collaborations are required (Yoo et al. 2012). Holgersson et al. (2018) argues that innovation ecosystems changes appropriability regimes and further suggests that the IP management needs to acknowledge changes that might be brought within the innovation ecosystems. Teece (2016) more generally argues that digitalization appears to bring a weaker appropriability regime: “Appropriability regimes for many digital businesses are often quite weak. Business models cannot rely heavily on intellectual property (IP) to capture value because IP is generally not self-enforcing; of instances of patent infringement and trade secret misappropriation must be identified and negotiated or litigated, often at great expense” (pp. 4). We can thus see that profiting from innovation in general and IP management in specific, need to be seen in a larger context as a result of digitalization.

[5] Sensors can be added to products to generate data e.g. on the status of the product or its surroundings. These added digital sensors has thereby blurred the line between value created through manufacturing and value created through services (Teece 2016).

2.2 Intellectual property management and strategy

2.2.1 IP and forms of IPR

Intellectual property is defined by the World Intellectual Property Organization (WIPO) as "creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commerce" (WIPO, I, pp. 2). As such, IP is a collective term to just about any valuable idea. While similar to knowledge, an important distinction is that knowledge does not directly imply ownership while "property" implies so for IP. For the protection of these properties, IP rights (IPRs) can be allocated by governments and institutions, providing ownership rights by law. There are arguably four prominent forms of IPRs: patents, copyright, trademarks, design rights (Hall 1992), and in addition less prominent forms such as database rights. In addition, trade secrets could also be seen as an IPR (Lemley 2008). These have different areas of use and the legal frameworks governing them differ from one another. Table 1 provides a short summary to these rights.

	Patent	**Copyright**	**Trademark**	**Design right**	**Trade secret**
Protection of	Technical function	Literary and artistic work	Words and symbols	Shape and appearance	Information or knowledge in general
Scope of right	Exclude others from using	Exclude other from copying form of presentation	Exclude others from using symbol	Exclude others from using design	Protection from theft
Requirements	Novel, non-obvious, industrially applicable	Original character, creative effort	Distinctiveness	Novelty, originality	Reasonable measures taken to keep secret
Duration	20 years	70 years after death of creator	N/A	>10 years (varies nationally)	N/A
Application	Apply at patent office	Automatic	Register at trademark office	Register	N/A

Table 1. IPRs and their key characteristics

Patents are represented in form of a document conveying technical information about an invention, and grant holders an exclusive right of what is disclosed (WIPO, II). Essentially, the holder has the right to exclude others from using or making use of what the patent covers. It should not be confused with the right to sell or manufacture. Patents protect technical functions of products and processes. There are three requirements for patentability: novelty, non-obviousness, and industrial applicability (WIPO, III). They are defined as follows:

1. Novelty - the invention has to contain some element that is unknown to the technical domain.
2. Non-obviousness - the invention must contain an improvement that is not obvious to practitioners in the area. This criterion is referred to as inventive-step in EPO, but generally corresponds to same logic (Barton 2003).
3. Industrial applicability - some usefulness is required, i.e. the invention cannot be a purely theoretical insight.

The emergence of software-based products and how to patent these is a debated issue (WIPO, IV). US patent law allows for patenting of software, and the share of software patents has been growing since the mid 1970s (Hunt & Bessen 2004). Resulting from changes in patent law in the US, software patents have become an increasingly prevalent phenomenon. As there are no official classifications of software inventions, definitions may vary. Hunt & Bessen (2004) proposes a simple definition where the terms “software”, “computer”, or “program” are present in the patent specification, whereas various terms are excluded, one example being “semiconductor”. The suitability of protecting software through patents has been criticized, however. The time and cost of getting a patent granted might not be worth it for the short life cycles software applications usually display (Menell 1989).

Copyright is another common IPR, distinct in that it allows to exclude others from copying the form of a literary and artistic work. As such, copyright allows for protection of computer programs, technical drawings, and databases, among other things (WIPO, V). However, copyright merely protects the representation of the work itself, and not its technical function (Swinson 1991). Copyright has been deemed appropriate to protect application (source) code, i.e. code that allows a program to perform its function, due to its low grant requirements (Menell 1989).

Trademarks are another IPR-form that protects symbols used to differentiate between goods and services (WIPO, VI). These include distinct words, images, numbers. Thus, trademarks cannot directly protect technology, and are traditionally seen in a legal or marketing context (Cohen 1986).

Design rights are closely related to patents in that they allow for protection of technology. Rather than protecting the technical function, however, design rights protect the shape and appearance of an invention (WIPO, VII). Similar to patents, it offers an exclusive right to the inventor, to exclude others from applying the disclosed design.

Trade secrets can be defined as information that has commercial value to the point the firm possessing the information will, especially as it is kept secret from external parties (Friedman et al. 1991). The requirements for trade secret protection is much lower than for the previously mentioned IPRs. Rather than the criteria of novelty, non-obviousness and industrial applicability, trade secrets require there to be no disclosed information regarding the matter and that the owner of the trade secret has taken measures to keep the information hidden (Erkal 2004). When these criteria are met, the trade secrets are typically protected as trade secret rights, i.e. giving legal protection from theft.

Database rights are as such only present in the EU (and in the UK). There, database rights protect "a collection of independent works, data or other materials arranged in a systematic or methodical way and individually accessible by electronic or other means" and are valid for 15 years without any need for application (EU DIRECTIVE 96/9/EC). Copyright also enables certain protection of databases in certain legislations (e.g. the EU and the US). However, copyright can only be allocated in the EU and the US "by reason of the selection or arrangement of their contents, constitute[-ing] the author's own intellectual creation" (EU DIRECTIVE 96/9/EC), i.e. an originators original and creative structuring of the data. It is thus by and large only possible to protect non-original databases in the EU. It should here also be mentioned that it is not the data itself that is protected, but rather the way it is structured and organized.

2.2.2 The value of IPRs

As technology becomes an increasingly important resource for firms, so does the importance of intangible assets (Granstrand 1999), which have been described as a key driver for firms to achieve competitive advantage (Teece 1998). The means by which a firm can control and protect intangible assets are therefore critical for appropriating value from innovation (Teece 1998; Pisano 2006) and securing freedom to operate (FTO) (Holgersson & Wallin 2017). Other scholars, such as Harrison & Sullivan (2000) describes the strategic importance of IP in terms of a defensive and offensive role, which is similar to the framework of appropriability and FTO. The offensive role, which encompasses revenue generation, cardinally through direct sales or income through license royalties, is by and large analogous to the appropriability-dimension. The defensive role, focusing on protecting products, achieving freedom to design, and avoiding litigation, could be seen as analogous to the freedom-to-operate-dimension. Another valuable aspect of IPRs is that of standards. Thus, the rest of this section will focus on explaining the value of IP through the subsets of the appropriation and FTO factors, as well as standards.

Appropriation refers to the capturing of value (profits) from investments in innovative activities (Teece 1986). It has often been described as how large of a share of the total profits a firm retains when investing and partaking in innovative activity (ibid.). Levin et al. (1987) argues that appropriation can be described by two dimensions. First, through the use of patents and other IPRs to protect technology. If a firm easily can protect technology through strong legal rights, it will end up with a larger share of the profits yielded by innovating. Second, a combination of factors such as secrecy, lead times, and learning curves. These factors can be bundled together due to strong correlation (ibid.). Teece (1986) describes the value of IP being related to the ease of which products or processes can be imitated. If imitation is easy, competitive success is rather determined by the ownership of complementary assets. The interplay of IP and the nature of technology constructs appropriability regimes - a set of factors which combined with complementary assets enable (or disable) innovators from reaping profits from their innovations (ibid.) Appropriability regime strength, in particular strength of patent protection, significantly affect firm performance in general, and the returns from R&D investments specifically (Ceccagnoli 2009).

Thus far, the theory on appropriability has focused on the imitability of a core technology. In innovation ecosystems, where there is significant complexity of actors and technologies, this perspective can be seen as insufficient. Holgersson et al. (2018) therefore propose an expanded perspective wherein focal appropriability regime interplays with the surrounding complementary and substitute appropriability regimes. Additionally, it is argued that having patents on a focal technology that is only weakly differentiated may be less valuable than having patents on complementary technology that is more differentiated (ibid.). Another way to understand different, interacting fields of technology, protected by patents, in an innovation ecosystem is through the concept of IP modularity. If each relevant area of technology is seen as a module with corresponding patents, preferably held by one actor, different modules of IP could be pieced together for a product that relies on multiple modules (Henkel et al 2013). Henkel et al. (2013) argues that IP modularity may allow for value creation in decentralized innovation ecosystems through reduced IP conflicts within modules of technology. To illustrate, one can think of two separate technologies in vehicles: transmission systems and brakes. In a modular system there should be some sort of bundled ownership of the associated IPRs for each of the two technologies. This way, IP licensing agreements are easy to motivate and IP conflicts can be avoided within each module.

FTO is an IP-related issue pertaining to the ability of a firm to sell a product or service without infringing on IPRs held by others (Grindley & Teece 1997). For technology-based products, patents are often at the core of the issue. In theory, however, as patents give the holder the right to exclude, being granted a patent is not the same as having FTO (Holgersson & Wallin, 2017). Having patents can be useful to secure FTO, nevertheless, as patents prevent others from filing the same patents later on (ibid.). Having a control position in regards to technology through patents is therefore helpful to protect one's FTO in practice.

Standard setting can be another way to gain a competitive advantage, and thus generate value from IP (Reitzig 2004). A standard refers to a solution that multiple producers make in a similar way for the benefit of consumers (Friedman 1993). For example, a certain file format may be standardized in order to allow for compatibility between operating systems. By gaining a significant share of patents within a technology standard, a firm can extract royalties from their IPRs. The benefit of contributing to a standard is not all that clear, however. It has been shown, albeit on small sample levels, that patent intensive companies tend to have little incentives of joining standards as their strong positions allow them to function without needing them (Blind & Thumm 2004).

2.2.3 Strategic management of IP

The attention and the sophistication to which IP assets are managed has seen an increase since the early 1990s (Harrison & Sullivan 2000). As IP is of increased value to firms, it is argued that organizations must manage the area through a top-level strategic approach (Reitzig 2004). Integration of IP management can then be seen as a combination of the co-management of all forms of IP rights (patents, trade secrets, copyright, trademark) and the alignment of the IP strategy with the business design and overarching strategy for a firm (Al-Aali & Teece, 2013). Reitzig (2004) argues that combining patents and trademarks are useful for firms to sustain a competitive advantage and in order to extract the strategic value of IPRs. Management must then shift away from the "shadowy existence in patent and legal departments" (ibid, pp. 35). Often, there is strategic weight to IP-related decisions, why firms should not delegate these tasks only to specialists. Rather, it is proposed that business executives, lawyers, and engineers should interact in a continuous manner in order to make the most out of the firm's IP (Fisher III & Oberholzer-Gee 2013).

Al-Aali & Teece (2013) argues that integrated IP management is required for firms today, pointing out six factors to why that is: (1) there are more patents per product and more patent holders; (2) innovation sources are increasingly scattered e.g. as a result of the development in East Asia; (3) the emergence of IP dependent business models due to the internet; (4) an expansion of what is patentable; (5) the emergence of standards and platforms; and (6) an expansion of the IP market. Consequently, the number of dimensions to be acknowledged by the IP management have increased. Firstly, firms need to understand how to use different IPRs in tandem with one another. Second, there is a need for emphasis on the increased importance of open innovation (ibid.; see also above). Third, new commercialization routes are made possible due to development of markets for technology (Arora et al. 2001). The decision of simply manufacturing a product or licensing a technology should now be contemplated (Al-Aali & Teece 2013). Somaya et al. (2011) argues that IP management should not only be integrated with corporate strategy and other business-related decisions; it should also be done in the early stages of the product development. Being proactive, rather than waiting until litigation problems arise, should be seen as integral to the business (ibid.). This alignment between the business organization, and patent/IP strategies, is, however, lacking among most firms (ibid.).

There are many approaches for protecting technology. Firms can gain protection through combined use of forms of IPRs, where certain elements of a product or technology may have different protection mechanisms. Thus, firms need to make strategic choices regarding their IP management in order to achieve optimal protection (Al-Aali & Teece 2013; Reitzig 2004; Somaya et al. 2011). A disadvantage of patent protection is that it requires the inventor to disclose the technology, making it available to the public (Scotchmer 1991). However, without IP protection, competing firms may imitate important technologies through reverse-engineering and re-inventing. Without disclosure, these imitations can even be patented (ibid.). Thus, firms are presented with the dilemma: should they patent and by extension allow their competitive advantage to be known, or should they simply keep the technology secret? The relationship between having intellectual property rights and keeping inventions secret is a crucial trade-off in how IP should be managed (Anton & Yao 2004). Since filing for a patent requires disclosure of information, the threat of imitation is looming as long as IPRs provide only limited protection (ibid.). Thus, for weak appropriability regimes, as described by Teece (1986), the IPR decision making for the protection of an invention has to account for the increased risk of imitation.

In attempts to uncover the choice between patenting and maintaining secrecy, it has been shown patents to be more desirable for inventions already on the market, whereas trade secrets are important for inventions that have not yet been commercialized (Czarnitzki et al. 2007). Similar conclusions are drawn by Erkel (2004), who argues that patents and trade secrets behave complementary in early stages of the innovation process, and as substitutes in later stages. In short, trade secrets can be used instead of patents, but in certain cases they can also be used side-by-side. Patents take the role of providing exclusivity to an innovation, whereas secrecy can protect collateral know-how (Ottoz & Cugno 2016). Patents, while important, are in most industries not the dominant mechanism for appropriating returns of innovation (Cohen et al. 2000). Rather, firms are found to protect profit through a number of methods combined with patents, some of these being secrecy, market lead time and complementary assets such as manufacturing or marketing (ibid.). Further, there is reason to also consider so called strategic publishing, i.e. publishing to avoid competitors getting exclusive rights over certain technologies (Holgersson & Wallin 2017). Thus, the dichotomous view of secrecy and patenting should rather be seen as a trichotomous (ibid.).

2.2.4 Generic patent strategies

Theory on patent strategy tends to draw upon research from various academic fields, such as economics, law, and management, and as such is a fragmented field of study (Somaya 2012). In an attempt to review and unify previous research, Somaya (2012) proposed a framework with three domains to which patent strategy research can be mapped to, see Table 2. The rights domain pertains to the acquisition and filing strategies of firms, as well as how patent rights are retained. Simply put, it regards what the firm chooses to patent, and how it chooses to maintain these patents. The licensing domain involves firm's strategies on how patented technology is shared in various contexts. The enforcement domain refers to the strategic choices firm's make surrounding legal action in regards to their patent rights. This can include strategies to handle infringements or imitators. Mapped onto these dimensions are three proposed generic patent strategies: proprietary, defensive, leveraging, explained more in detail below.

	Proprietary	Defensive	Leveraging
Rights	Acquire and maintain robust rights to technologies	Acquire large portfolios to avoid being held up by patents of others	Acquire some patent coverage on significant technologies others use
Licensing	None, unless required to access complementary assets	Cross-licenses and patent pools	To gain rents
Litigation	Systematic effort to detect and prosecute infringers	Settlements to avoid holdup	Injunction threats

Table 2. Generic patent strategies and their characteristics (adapted from Somaya (2012))

The main incentive to use a proprietary patent strategy is to ensure the firm's market advantage. By having patents, firms will seek prevention from imitation (Somaya 2012). Thus, firm's will aspire for "watertight" patent protection, having access to strong patents that are unquestionable from a legal point of view. Firms pursuing this strategy will rarely license out their technology, but it may be required in some cases. For instance, Teece (1986) notes that firms wanting to gain a better position in regards to complementary assets, may want to grant an exclusive license to a firm which controls these assets. Infringing actors are dealt with through aggressive enforcement (Somaya 2012).

The defensive strategy aims to ensure a firm is not put at a disadvantage in the marketplace due to being stopped by external actors' patents. Often this strategy is used in industries where technology moves fast (Hall & Ziedonis 2001). Hall & Ziedonis (2001) notes that despite that technology moves fast where firms tend to rely more non-patent mechanisms to appropriate value from their inventions (i.e. complementary assets), the same firms also patent for defensive strategic reasons. This is often done by building up large patent portfolios. Having large patent portfolios may then help firms to overcome holdup issues caused by other patent holders, as well as to gain negotiating power to access new technologies (ibid.). In terms of what patents to acquire, firms pursuing a defensive patent strategy typically attempt to build a large portfolio to minimize risks of not having a patent covering a possible invention in a product (Somaya 2012). It is also possible to simply publish inventions, to disallow others from patenting in later stages (Guellec et al. 2012; Holgersson & Wallin 2017). Cross-licensing can be useful in a defensive patent strategy as it amplifies the size the patent portfolio and prevents patent holdups issues (Somaya 2012). Contrary to the proprietary strategy, where firms will go to full-lengths when pursuing infringers, defensive strategy implies less aggression. Consistent with the logic of minimizing patent holdup, firms will aim for settlements (ibid.)

The leveraging patenting strategy differs from the above two in that it is not especially concerned with protection of innovations (proprietary) or FTO (defensive). Rather, patents are here seen as ways to gain additional economic rent. Licensing is for this purpose very much the core to this strategy. In order to have a license to offer, firms pursuing this strategy need to acquire patents in technologies used a great deal by others (Somaya 2012). There is no need for these firms to have a bulletproof protection as far as technology areas are concerned, it is instead merely about having something to bargain with. As such, the threat of litigation is of primary focus for the enforcement of these firms' patents. Firms who weigh the cost of a potential litigation process as too high will simply pay royalty fees or license-in to avoid risks of higher costs (ibid.). The "patent troll", which has gained attention during recent years could be seen as an actor deploying this type of strategy (Reitzig et al. 2007). Holgersson et al. (2018) further showed that the IP strategies of firms in an industry might converge over time, i.e. that firms shift towards similar patenting strategies. This shift should perhaps also be expected to be towards more aggressive approaches for IP enforcement, as in the case in Holgersson et al. (2018).

3 Research design

3.1 Methodology

This study is centered around two bodies of theory that are relatively well-explored and well-connected, namely technology strategy and IP management (see further "Theoretical framework"). Recent contextual changes in the marketplace has also brought change that may reveal underlying mechanisms and a better understanding of these two research areas. These contextual changes revolve primarily around digitalization, as defined above. Digitalization is, despite its massive attention in media and business journals in recent years, still relatively unexplored in the academic research setting. Earlier studies on digitalization have focused on policy factors and telecommunications (see e.g. Corrocher & Ordanini 2002; Billon et al. 2010). Additionally, the firms studied in the innovation management field have mostly been companies operating in the telecommunications industry, while only a few recent studies in the research area has brought digitalization in as a relevant contextual factor (see e.g. Teece 2016; Yoo et al. 2012). This study intends to bring these two bodies of theory together in the context of digitalization. Thus, this study focused on the intersection of these three fields, where technology strategy, IP management and digitalization overlaps.

The purpose of the study as presented above is to be seen either as executed in a nascent or intermediate body of prior research, as it brings together theoretical bodies that are researched to varying degree (as explained in Edmondson & McManus 2007). Edmondson & McManus (2007) suggests that for this type of research, either a completely qualitative study or a hybrid study (qualitative and quantitative) is suitable. This study was done with the intent to explore and uncover not yet known relations between phenomena. As hybrid research designs typically require some a priori relations to be understood (Easterby-Smith et al. 2015), this approach was not seen as relevant here. Further, Shah & Corley (2006) argues that uncovering relations that "allows for future theory testing" are most effectively achieved with qualitative approaches (pp. 1822). A more open and qualitative approach was therefore deemed most suitable for this study.

This study by and large attempts to answer how digitalization impacts firms' IP strategies and if so, why. Yin (2013) argues that case studies are the preferred method when: "(1) the main research questions are "how" or "why" questions; /.../ and (3) the focus of the study is a contemporary (as opposed to entirely historical) phenomenon" (pp. 2). The goal of this study is to uncover "how"- and "why"-relations occurring as a result of the contemporary phenomenon digitalization. Thus, a case study approach was considered suitable for this study.

However, what actually constitutes a case study is somewhat unclear. Drawing upon cases for a study is not so much a methodological choice, but rather a choice of what is to be studied (Stake 2000). For this study, a number of firms were studied since strategy is a firm-level question.

Jick (1979) argues that multiple methods for data collection are preferred in case studies to enable comparison between the data gathered from the different data sources for reliability. Data in case studies can be collected through interviews, reports and documents, externally accessible firm data, and public statistics (e.g. patent data). In the IP setting, these types of data only exist to a very limited extent as IP strategy by its nature typically is kept secret. Documents and reports are thus limited. While there is an abundance of information one can acquire from patent data, it was excluded in accordance with Eisenhardt's (1989) rationale of marginal return from research. Therefore, interviews were chosen as the only source of data in this study.

The eventual goal of this research is to add new insights to existing theory as well as to add new elements of theory to existing bodies of theory. Yin (2013) argues that multi-case studies provide a better foundation for theory building than single-case studies. Thus, multiple cases, or units of analysis in terms of firms, were included. Eisenhardt (1989) suggests that at most 10 cases should be used for theory building. However, we believe 10 cases would not provide enough breadth for the study as it intends to look at firms in different industries having varying degree of digitalization, and firms having different IP strategies to uncover broad changes in IP strategy. Yin (2013) suggests that 30 cases or more typically provide for a sufficiently broad set of data. However, this type of approach could risk a lack of in-depth insight due to time constraints, e.g. as time scarcity would only allow for simple analysis approaches. As such, a sample size of 15-20 firms was deemed appropriate for this study. This sample size arguably mitigates issues brought with both a smaller sample size (maximum 10 cases) and a larger sample size (minimum 30 cases).

3.2 Data collection

3.2.1 Sampling

The data gathering strategy used in this study can be defined as judgement sampling, as explained by Marshall (1996). Several elaborate considerations and selection criteria were used for the selection of firms. The first set of considerations regarded the firms' IP strategy. In order to consciously work with IP strategy, an arbitrary assumption was made that relatively large patent portfolios are needed. This consideration was not intended to be strict, and no definite minimum number of patents was set. Rather, the number of patents of a firm was put arbitrarily in relative relation to firm size in terms of employees and revenue. This selection criterion thus generated firms that are relatively technology intensive.

The second consideration regarded the firm's degree of digitalization in order to align the purpose of the study with the sample firms. For this, firms had to (1) utilize non-digital technology to a large extent, and (2) to an increasing degree utilize digital technology in their products, processes, and business models. These considerations meant that pure digital companies such as software firms were not included. For remaining firms this was checked for by searches for different indicators of digitalization, such as notes on digital initiatives in year-end reports, products marketed as digital in the product portfolio, and patents on digital technology.

The above selection criteria revealed some general industry patterns. Specifically, three industries have been doing business in a non-digital environment, with relatively large patent portfolios, and are now moving into a more digital environment. These are the medical technology industry, the industrial equipment industry, and the consumer durables industry. As such, the focus shifted towards finding firms within these industries. Two additional selection criteria were therefore utilized to narrow down the sample consistently. (1) To avoid geographical differences in market characteristics and legal system, the firms in the sample needed to have its headquarters in the Nordics. (2) To enable easier access to managers and contact information as well as company information, the firms in the sample also needed to be publicly traded on one of the Nordic exchanges.

For each firm, one to three persons per firm were interviewed. To get a good idea of how each firm was working with their IP strategy, primarily people with strategic (i.e. managerial) positions were included. To gain access to managers working with IP management or IP strategy within these companies, searches on LinkedIn and Google were made using search terms such as "[company name] patent manager" and "[company name] IP manager". Patent and/or IP managers from these firms were then contacted, first through email, then through phone. In total 23 managers in 18 firms were eventually interviewed. Of these firms, 10 were Swedish, 4 were Finnish, 2 were Danish, 1 was Norwegian, and 1 was Icelandic. Of the included firms, 11 were from the industrial equipment industry, 2 were from the medical technology industry, and 5 were from the consumer durables industry. No firms had less than 500 MEUR in yearly revenue 2017. The number of cases included (18) was hence within the planned sample size of 15-20 firms as discussed above.

3.2.2 Interview design and procedure

In order to explore the topic and potential new phenomena, relations and motives for certain strategies and so on, a high degree of openness during the interviews was deemed necessary. To enable rich and varied data from interviews, structured interviews are not suitable (Easterby-Smith et al. 2015) and were therefore not used. As the data gathered in the interviews was intended to be compared between cases, certain common topics were needed. To ensure certain comparability across interviews, unstructured interviews are not suitable (ibid.) and were therefore not used. Consequently, semi-structured interviews with open ended questions were used for the data collection. The interviews centered around a number of questions designed before the first interview. Certain alterations were also made to the interview questions during the first 5 interviews.

The interview questions were to some extent based on existing theory, drawing especially on Granstrand et al. (1992). All interview data was treated anonymously, and hence no detailed account of firms or interviewees can be given in this thesis. In most of the interviews, interviewees tended to elaborate on issues they and the firms they represented had given more attention, which occasionally lead to even a majority of the time spent on follow-up questions outside the questionnaire. This is largely in line with that Edmonson & McManus (2007) describes as beneficial for nascent research, noting that "openness to input from the field helps ensure that researchers identify and investigate key variables over the course of the study" (pp. 1162). However, as a rough guideline the interviews were divided into four, non-uniform segments: (1) introduction, (2) degree of digitalization, (3) technology strategy, and (4) IP strategy. The questions were not asked in any strict order during the interviews, but typically followed a somewhat chronological order as per the template (see "Appendix").

The first segment consisted of an introduction to the interviewee's educational background, career, current role and designated responsibilities at the focal firm. The second segment was an attempt to get an understanding of how the firm was affected and worked with digitalization. This included, for example, how much digital technology had been implemented into the products presently sold, and why these solutions had been developed. Discussions on the interviewee's role and the firm's digitalization enabled for relevant follow-up questions at later stages in the interviews. Typically, less than a fourth of the interview time was spent on the first two segments. The third segment aimed to inquire in how technology was acquired and exploited by the firm, largely following the framework laid out in Granstrand et al. (1992). Many of the interviewees brought up differences between digital and non-digital technology. Where this was not the case, this was brought up by the interviewers. Finally, the fourth segment revolved more directly around how digitalization had changed or would change IP strategy.

The interviews were between 1 and 2 hours long. Most of the interviews were held face-to-face, but five were conducted via phone or video conference call. For detailed information regarding time and format for each interview, see Table 3. Note here that the interviewee position specified does not correspond to the interviewees actual title, but rather a more generally applicable position description based on the initial discussions in the interviews. This was done in order to not spoil the anonymity of the interviewees. All but one interview were recorded. During this interview, notes were taken by the interviewers. All recorded interviews were transcribed word-by-word for further analysis.

Firm	Number of interviewees	Total length of interview(s)	Interview type	Interviewee position
I	1	2h	In person	IP Manager
II	2	1h	In person	IP Manager Patenting Manager
III	1	2h	In person	IP Manager
IV	2	3	In person	CTO IP Manager
V	1	1h	In person	IP Manager
VI	1	2h	In person	IP Manager
VII	2	2.5h	Telephone In person	IP Manager IP Manager
VIII	1	2h	In person	IP Manager
IX	1	1.5h	Telephone	IP Manager
X	1	1.5h	In person	IP Manager
XI	1	1.5h	In person	IP Manager
XII	1	1.5h	In person	IP Manager
XIII	3	1.5h	In person	IP Manager Patent Manager Patent Manager
XIV	1	2h	In person	IP Manager
XV	1	2h	In person	IP Manager
XVI	1	1h	Telephone	Patent Manager
XVII	1	1h	Telephone	IP Manager
XVIII	1	1.5h	Telephone	R&D Manager
18 firms	*23 interviewees*	*31.5h interviews*		

Table 3. Summary of interviews and interviewees

3.3 Data analysis

This study intends to explore new potential for theory building. For theory building, inductively searching for patterns in data rather than implying a framework and searching for the framework's constructs in the data is especially feasible (Martin & Turner 1986; Easterby-Smith et al 2015; Locke 2001; Glaser & Strauss 1967). Easterby-Smith et al. (2015) argues that coding methods is a particularly relevant analysis approach for this type of research because it enables the researchers to tackle empirical data in an open way. For the data analysis in this study, all transcribed interviews were therefore coded.

Coding refers to the process of systematically analyzing qualitative data by labeling it (Malterud 2012). Coding can then be done either by designing a number of codes in advance and then attributing these to the text (i.e. a priori codes), or progressively design codes based on the data contents. Coding is often done in two steps, where a number of first level codes are attributed to the text and then organized and clustered into sets of second level codes covering for example overarching themes of the first level codes (Saldaña 2015). For both these levels of code, multiple approaches can be used, e.g. letting codes describe the theme of a quote, summarizing the content of a quote, and so on.

Here, the transcribed interviews were coded into 63 first level codes (in NVivo), directly referring to excerpts of text in the transcribed interviews. Strictly speaking, no a priori codes were used. All codes were instead made by labeling the transcribed interview data. When applicable, codes were reused for multiple quotes. This is what Hsieh & Shannon (2005) refer to as 'conventional coding', which is particularly relevant in studies on phenomena with only limited exposure to prior research. A general guideline to the first level codes as they emerged was to let them stay in close resemblance of the original interview data, i.e. quotes.

15 second level codes were derived from the first level codes. This was done by listing all first level codes and then clustering them. The clustering was primarily done through discussions between the authors. Multiple different clusters were created and compared for further re-clustering. This approach enabled for tying together different pieces of data. Finally, these second level codes were organized in a higher level cluster, here referred to as themes. In parallel to this step, theory was examined and used to find relevant overarching topics and theory that could be tied to the data. First and second level coding were thus largely inductive in their nature, as no initial framework was forced on the data. Instead, relevant topics emerged from the collected data as it was analyzed. This was deemed important due to the purpose of

the study. Forcing data into a predefined framework would risk overlooking potentially novel findings. For the themes, however, theory and empirical data was compared for determining how the empirical findings were reflected in earlier literature. From this comparison, new theoretical insights emerged. The themes can thereby largely be said to have emerged in an abductive manner (as described in Dubois & Gadde 2002), i.e. by moving back and forth between literature and data.

3.4 Methodological evaluation

Qualitative research can be evaluated in four dimensions: (1) credibility, (2) transferability, (3) confirmability, and (4) dependability (Bryman & Bell 2015). Credibility refers to whether the findings of the research are deemed to be believable. Due to the nature of social science, more than one possible social reality may exist (Bryman & Bell 2015). Thus, to achieve credibility, comparing multiple sources of data is typically needed (ibid.). The empirical data was limited to interview data. Data triangulation, i.e. using multiple sources of data to ensure confidence in one's conclusions (Bogdan & Biklen 2006), was therefore not present in this study. This was largely due to time restrictions. Having more data sources per company could help ensure higher credibility of the empirical results. On a similar note, one interview per company was generally conducted. This was largely due to the fact that IP departments, even within large organizations, tends to be comprised by relatively few people. As such, finding people with the knowledge required to discuss the topic was challenging. That said, managers in other departments and with other backgrounds and areas of responsibility could have given valuable insight into alternative perspectives. Whether this would add meaningful data to this study is however unclear as the knowledge on IP management is likely to be limited. As interviews were held, the number of new perspectives collected eventually declined drastically, suggesting that the data became saturated. This also suggests that a sufficient number of perspectives were included. Two ways to yet improve credibility would be to include more firms or more interviewees per firm.

Bryman & Bell (2015) defines transferability as how well a study can be applied to other contexts. The sampling of firms is therefore a key discussion point for this study's transferability. As previously explained, the interviewed firms were large Nordic technology-intensive firms. With a sample of 18 firms, in fact a relatively large share of this type of firms were included.[6] Whether the study's findings can be transferred to a more global setting is hard to determine. It is difficult to neglect cultural and geographic characteristics of firms. However, all firms included in the study are by most measures large and global. There is little reason to believe the behavior of these firms in regards to IP and technology strategy should poorly represent large, global firms in general, at least within the researched industries.

Confirmability refers to objectivity of the researchers (Bryman & Bell 2015). When designing the interviews, the questions were written in an open manner, allowing the interviewees to freely elaborate on the topics. When conducting the interviews, the researchers were careful to not ask leading questions. The interviews recorded and transcribed (except in one case). This lead to data being represented in the words of the interviewees, which contributed to a larger degree of objectivity compared to, for instance, taking notes while speaking. Further, as all transcripts were coded, it can be made relatively clear how the researchers came to the conclusions they did.

Bryman & Bell (2015) describes dependability as the likelihood of the findings to appear, should the research be replicated. Naturally, as this is a qualitative study, arriving at the same conclusions may not necessarily be the case when replicating the research design. However, the entirety of this research has been described in detail. Therefore, it should be possible to validate the results by repeating the same process. The ambition of this method section is largely to provide other researchers an idea of how this research was executed and what decisions that lay behind the execution, to enable replicability.

[6] Depending on how "large", "Nordic" and "technology-intensive" is defined, the total number of firms that could be included may vary. However, as defined in the sample selection, few ways of counting would result in including any more than 50 firms in total.

4 Empirical findings

4.1 Firm digitalization

This section covers why firms digitalize ("Need for firm digitalization"), how value can be created through digitalization ("New ways to create value"), and how digitalization makes new actors relevant for the focal firms ("New for managing digital actors"). These topics are aligned with the second level codes showed in the parentheses above and are further presented in Table 4.

The firms of interest for this study have generally not worked with digital technology to a large extent historically. Rather, the firms have produced physical products with varying embeddedness of digital technology. However, in recent years, firms have for two reasons started using more digital technology (see "Actively digitalizing").[7] First, some firms do it because they see value potential:

> *Everyone wants to become more digital because it is an opportunity to increase your revenue margins.*

This can be understood through multiple new ways for firms to create value, see further below. Second, firms do it because their customers are requesting it:

> *In recent years we have identified that customers request [digital]. So we have to provide connectivity to our products.*

As customers are requesting digital technology, or rather solutions that are made possible through the use of digital technology, there appears to be a general market pull towards digitalization (see also "Market pull for digitalization"). Taken together, it could be said that firms that historically have not worked with digital technology see a need to start doing so. By adding digital technology to physical technology, the products can be made more intelligent and interconnected (see "Increasing connectivity of solutions" and "Increasingly intelligent products"). Digitalization also enables value creation through feeding data back into the product development. This allows firms to improve performance and/or the design of new products. Thus, value can be created by embedding digital technology in what were previously purely physical products.

[7] Note here that the quoted reference refers to a first level code (see section 3.3) which also is shown together with a clarifying example quote in Table 4 below. For this section, similar references will follow and can be found in the corresponding code table following each sub-section, if not else is noted. Also note that all text in italics in this section are quotes from the interviews.

Similarly, the sales and business models of the interviewed firms have not been based or centered around digital technology. However, some firms noted how aspects of their business models have changed, or have the potential to change, due to digitalization (see "Digitalized business model"). That includes, perhaps primarily, e-commerce:

> *Selling products differently, for example by doing it online, if that is what you would consider digitalization.*

One important way of gaining value from digitalization is thus new ways to sell products. Another important example of what changes in the way value is created is in what is sold, i.e. that services are an increasingly important part of the business models (see "Increasingly service-oriented business models"). The most commonly mentioned example of how this can be done is by utilizing digital services to sell services in the aftermarket:

> *Already today, in our business model, we have a direct sale of equipment, and also a large aftermarket. It is often a larger part of the revenue than the capital sales. There are opportunities to develop the aftermarket part through digital services. It could be predictive maintenance, knowing when something needs to be replaced. It could be improving logistics of parts. It could also be to consult our customers in how to best utilize the equipment, to maybe intervene if you notice there is unnecessary wear on the product.*

Thus, multiple different approaches for service sales are made relevant or possible by digitalization. Common for these services, as well as the above mentioned added online sales channels is that value can be created in what and how firm offerings are sold.

When firms increasingly embed digital technology into their products and sales channels to create value, a number of differences between digital and non-digital technology become clear. One important difference is the rapid development of digital technology. This also mean that short development cycles are enabled, i.e. that new generations can be released within short cycles (see "Speed of digital technology development"). This means that firms are faced with not only new technology, but also new characteristics of the product development. For many of the firms interviewed, this new speed makes digital technology unpredictable, and non-digital technology seemingly more constant.

> *It [non-digital technology] is easier to control and predict. Things are not changing so rapidly as in digital.*

As such, firms are required to acknowledge the difference of development speed and life cycles characteristic to digital technology. Some interviewees' see digitalization as bringing broader and more general changes to the characteristics and speed of technologies (see also "Speed of digitalization"):

> *Digitalization means that the world is developing faster than before. There are more technologies to manage than in the past. Even though we are a large company in the Nordics, we are medium range globally, and we cannot manage all the technologies.*

Thus, this perspective reflects digitalization being an environmental factor for market and technology change. In summary, these perspectives reflect speed being one important difference between digital and non-digital technology that causes certain reason for consideration, or even issues, for firms.

A second important aspect with digitalization brought up in the interviews is that new firms become relevant. An important consideration for firms attempting to implement more digital technology in their offering is therefore to identify and manage new, potentially relevant actors (see "Need for managing digital actors"). Three new types of relevant actors were brought up in the interviews. First, some interviewees mentioned non-practicing entities (NPEs) as a potential risk (see "Rise of NPEs"). Thus, some of the interviewed firms see mention the risk that NPEs will require licensing payments and potentially engage in patent infringement lawsuits.

Second, firms within the telecom industry were brought up:

> *We have a collaboration with [telecom company], and we have no idea what patent searches they are up to. No one really knows what they are going to do tomorrow. I don't think the IP for digital technology is much more difficult, but these firms have unclear revenue models… Then you are going to collaborate with them, without knowing what their intentions are, what their core will be in the future.*

Thus, for some interviewees, telecom firms are relevant. However, what motives these firms are driven by in the collaborations are somewhat unclear. Other interviewees viewed telecom actors largely as NPEs:

> *They [telecom companies] are not interested in cross-licensing; they are only interested in money!*

In this perspective, trying to collaborate with telecom actors through cross-licensing is not an option. This goes much in line with yet other interviewees that considered telecom actors as "more aggressive" in their patenting strategies, often aspiring to be part of standards in order to generate revenue:

> *The telecom industry might be different, [telecom company] are more aggressive and their goal is to be part of standard setting organizations in order to make money off others that implement their technology. The telecom world is about squeezing firms for royalty payments.*

According to these interviewees, the business model of these actor relies on selling patents that are not actually used by the company itself. However, some interviewees do not see this as a threat:

> *There are already a few wifi-patents that these players have. But I am not overly worried about them - their business model relies on commercializing patents. It is technology to be used by others, so the royalty is fair and reasonable, whatever that really means.*

Thus, telecom actors may be interested in licensing out patents, but that does not necessarily imply that the focal firms should be worried over litigation from infringements. Instead, fruitful licensing could become relevant for technology acquisition. In summary, telecom actors are becoming relevant for firms that digitalize as these firms appear to often have digital technology relevant for digitalizing firms that might need to be licensed in.

Third, large firms in the IT industry such as Apple, Amazon or Google were brought up. Some of the interviewees view these actors as potential future competitors (see "New competitors due to digitalization"). Digitalization thus brings in new potential competitors which requires the focal firms to reflect on their competitive position:

> *We cannot compete against Amazon at logistics. If they would enter our industry, it would pose a challenge. Previously, this threat didn't really exist, but if we are talking about digital solutions you have to be prepared for this type of competition.*

These large IT firms may thus become competitors in the future. However, they may also be potential partners in collaborations as they provide new ways to create value:

> *There is overlap where we could create value for each other, but there are different motives somehow. Amazon will not settle to only collaborate with [company].*

Thus, the motives of large IT firms are ambiguous. They could potentially be important partners, or important threats. Taken together, the above could more generally be summarized as new actors being brought into closer proximity of the core technology areas of the digitalizing firms. Further actors may be relevant, but NPEs, telecom firms, and large IT firms are probably the most relevant. For the latter two, the role and the motives these actors have are somewhat unclear, and ambiguous. They could either be important technology enablers or collaborating partners for the development and sales of new digital products. They could also be problematic if they demand large license royalties or engage in patent lawsuits for technology that is required for the focal firms to digitalize.

The aforementioned digital actors thus become increasingly relevant. Some interviewees argue that this requires them to reflect upon their own IP strategy, as changes might be needed (see "Managing digital actors IP strategy"). However, not all are certain that proactive measures are needed, as IP strategy arguably should be driven by business strategy:

> *We are convinced that from a business perspective we are heading there [becoming more digital]. That is why we adapt [IP strategy] now. We do it because of market pull, not because some new actor is forcing us to.*

Thus, as the markets are demanding more digitalization, adaptations to firms' IP strategy are made, but not necessarily because of the emergence of new digital actors. Some interviewees noted that adapting proactively is a poor business decision as it is costly and, for this specific firm, too far into the future:

> *Let us imagine they have patented some telecom solutions suited for our product. Then we will have to adapt. But it is nothing we do proactively, for example by already covering such solutions with patents. It could be done, but spending time and money on it is going too far.*

Thus, adapting IP strategy to the new digital actors should be seen in the light of costs and time horizon of the progress. However, as discussed above, digitalization appears to move forward rapidly. This implies that there might already soon be an increased need to adapt IP strategies. By and large, it could be said that firms only to a limited degree see a need for proactively adapting their IP strategy to acknowledge new actors in the digital technology area. For a summary of all codes in this theme, see Table 4 below.

2nd level	1st level	Example quote
Need for firm digitalization	Market pull for digitalization	There has been ongoing demand which we see is going to be increased, where the majority of products the customer wants access to information and data.
	Need for digital competence	*We're increasingly recruiting new people in house for digital transformation. So, having the kind of competence and understanding and knowledge in-house.*
	Actively digitalizing	*It is a very difficult issue to define what it means a digital company, but we are actively going to that direction.*
	Speed of digitalization	*Digitalization means also that world is developing even faster than before.*
	Speed of digital technology development	*The lifecycle of certain algorithms for example and software, is much shorter. The timeline to develop those are shorter.*
	Digital ecosystems and platforms	*If you have X suppliers, /.../ the customer don't want to many systems to work with. They will demand standardized solutions to access information from their suppliers, so that it looks similarly. So they can process it in their systems. Else it will be impossible to adapt all systems.*
New ways to create value	Digitalized business model	*We have like, e-commerce development and we combine our customer, let's say CRM systems managing the customer information developing the sales channels and also the communication with the customer.*
	Increasingly service-oriented business models	*Digitalization will change the world very much. To that direction that we are operating customers' products as services and not necessarily sell the products in the same way as components as before.*
Need for managing digital actors	Rise of NPEs	NPEs have not been relevant for [company] before, but I can see how that is one possible risk as well.
	Managing digital actors' IP strategy	*There will be more refined strategies that are a bit abstract at the moment. Where you start to balance it by having patents bordering to a digital actor's IP portfolio in order to gain bargaining power for cross-licenses. But that in itself costs money, so you have to consider the trade-off.*
	New competitors due to digitalization	*Software companies like Amazon and Google, without having any knowledge of our product, could potentially through machine learning applied on data from the product, start to gain a lot of information. For example, when it needs maintenance. They have no idea why, but it might not even be relevant.*

Table 4. 1st and 2nd level codes relating to "Firm digitalization"

4.2 External sourcing of digital technology

This section covers how firms collaborate to digitalize (“Collaboration for digitalization”), issues of what IP to own in general (“Issues in determining what IP to own”), and how IP is allocated in collaborations (“IP ownership in collaborations”). These topics are aligned with the second level codes showed in the parentheses above and are further presented in Table 5.

As seen above, digitalization can enable multiple ways to create value. Therefore, firms looking to digitalize need access to digital technology and/or digital technology competence. However, as most firms have historically operated in industries with limited amounts of digital technology, there is a lack of competence and experience working with digital technologies. At the same time, the development of digitalization and the development speed of digital technology moves quickly, as discussed above. This forces firms to, at least initially, rely to a larger extent than alternative approaches for acquiring technology than simply developing it with existing in-house capabilities and resources (see “Technology purchase for digitalization”). Rather, firms are forced to acquire technology by means of bringing it in from the market, either though acquiring firms with relevant competence and IPs, buying specific patents, in-licensing of patents (see “Changed role of licensing”), simply buying components, or by means of development collaborations (see “Partnership development for digitalization”). An interviewee explained the relationship between higher technology development speed and the use of external sources for technology development:

> *Looking into the past, we developed new technology gradually. Now it is going so fast. We are getting into areas outside of our current competency. If someone asks this in five years, the situation may be different. Then we might have built up a digital R&D department, whose sole task is to work with digital solutions. For now, we need to [externally] acquire the knowledge to a large degree.*

Due to the lack of competence within the specific field combined with fast moving technology development, firms are thus required to seek technology and competence from external sources (see also “Collaboration for digitalization”).

In certain cases, the relevant digital technology may have been developed in other industries. As discussed above, in some of the industries that rely largely on digital technology, e.g. the telecom industry, standards have been developed for generally applicable technologies. Differentiating through developing unique technology becomes more difficult in these cases. When firms are looking to implement digital technology in their products, there is a large advantage of technology standards. Technologies part of a standard are more easily accessed and can therefore be used to meet the market demand for added digital technologies. This could be seen for some of the interviewed firms, where standards were explicitly stated to be relevant for accessing certain digital technologies:

> *It is a well-developed technology, researched and developed in large standardization organizations. There, it is obvious and clear that we license in that technology. It is nothing we have come up with on our own. Instead, there we take and use a standard that is open, published. We acquire patent licenses on it.*

Thus, when utilizing communications technology, firms might be able to find their needed technology as part of a technology standard (see also "Digital standards issues"). The choice of which standards to comply with is largely a matter of what fits best with the need of firms' customers:

> *What will be important for our customers? Will it be telecommunications standards that support their needs best, or will that comes from datacommunications? We will have to adapt to our customer needs.*

This also implies a high importance in selecting between different standards when using digital technologies.

For some of the interviewed firms, added digital is of lesser importance, e.g. due to consumer conservativeness:

> *Digital is of course coming. /.../ [When] we go out ask the users they go "nah not really".*

Here, digitalization is not requested by the customers. In other cases it may however be a key differentiator as products more generally risk becoming commoditized (see "Added digital as differentiator"). An interviewee put it this way:

> *In a couple of years, we believe it will be impossible differentiating the physical product. Certainly, there are exceptions in some market segments, but in general this will be the case. / .../ What will differentiate us will be connectivity, not only being able to tell our customers when to replace the product, but also making this process automatic.*

This shows a polar opposite case to the above one. Not only will digitalization be of importance, the physical aspect of the product is largely seen as becoming a commodity in the future. In order to remain competitive, it is therefore considered necessary to automate processes to help the customers maximize the utility of the product, which is done through implementation of digital technology.

For some firms that have managed to develop internal digital competence, more collaborations between departments or divisions are needed (see "Internal collaborations for digitalization") to develop technology and create value from digital technology, e.g. collaboration between IT and R&D. For other firms, customers have required extended offerings to include digital technology, in turn to enable data generation and gathering which has led to increased partnerships with customers (see "Customer partnership for digitalization"). In these collaborations data is of key importance. However, since the data is of value for both customer and supplier, the ownership of data is important and needs to be configured (see "Ownership of data issues"). However, in many cases, the partnerships are more complex than simply supplier-customer as above (see "Complex partnerships for digitalization"). An interviewee explained how providing an integrated digital solution for a large customer may sometimes require collaboration between suppliers:

> *Our customer may demand our mechanical equipment being integrated to a control system of another firm. /.../ This would probably never have happened with purely mechanical products.*

Rather than developing and delivering a product to the customer, the focal firm first needs a collaboration in order to meet what is required. Thus, there is an increased complexity in developing and delivering products with embedded digital technology. Also, firms can partner with firms in digital technology to access digital competence (see "Partnership to access digital competence"), or engage in collaborative efforts with firms with digital expertise (see "Partnership development for digitalization"). These approaches appear to be relatively common for the interviewed firms.

In these types of collaborations, important issues of ownership of developed competence, know-how or IPs arises (see "IP ownership issues of results in collaborations"). For more tangible technology developed, this can be solved through core technology allocation:

> *Whatever we develop together, that is useful in our product, we have the [patent] rights and they're obligated to assign the rights to us. Then they get a license outside of our business areas.*

For this, contracts play an important role for ensuring the allocation of IP:

All collaborations started have a contract in place that states who owns what you may develop /.../ what would happen if IP is developed.

In cases of less tangible technology, secrecy might be needed from the partners, which in turn requires attention (see "Ensuring secrecy in partnerships"). Also for secrecy, contracts and agreements play an important role:

In order to ensure secrecy, agreements with collaborators are extremely important.

Thus, contracts appear to play an increasingly important role in the creation and allocation of technology and IP. This is because licenses, collaborations and partnerships are common approaches for digitalizing. For a summary of all codes in this theme, see Table 5 below.

2nd level	1st level	Example quote
Collaboration for digitalization	Complex partnerships for digitalization	*It may be a partnership where we have a customer, a, shall I say, sphere of suppliers where we supply one part, someone supplies the cloud service, someone supplies the telecom, someone supplies analytics tools. And we as perhaps a decision support based on the analysis supplied. It is getting different and becoming more complex to navigate.*
	Partnership development for digitalization	*We have other products as well that have current in them and some software in them, but those were developed with a partner, so they were sort of in control of all the digital software, imaging, stuff.*
	Partnership to access digital competence	*So there are a lot of electronic control systems in it. Those are developed by the external partner. Because we don't have those abilities in-house.*
	Customer partnership for digitalization	*Process data from different systems may be their competitive advantage or their business intelligence that they don't want to be handed to others. We need to have a partnership with the customer there.*
	Internal collaboration for digitalization	*Digitalization for [company] will force collaboration between the borders of the divisions.*
	Supplier partnership for digitalization	*For example, there is no need to invent IoT by yourself. There are hundreds of suppliers all over. You can select a partner and do it together.*
Issues in determining what IP to own	Ownership of digital technology issues	*IP due diligence is more complex when acquiring a digital company.*
	Changed role of licensing	*In my view that [licensing] will change. Since companies like us are looking into platforms, then you are into telecommunications. These are run by the large IT-companies. At that point you are looking to license technology. So, as the company moves into IT, or telecommunication-based systems, we will acquire IP more by licensing.*
	Digital standards issues	*Large firms like Google, Apple and Amazon are unwilling to accept old telecom standards, launching their own standard. Which standard will we comply with in our products?*
	Technology purchase for digitalization	*We will be forced to make more strategic decisions on what to develop in-house and what to outsource. In an early stage [of digitalizing] there is a desire to do it ourselves, but you quickly notice we lack resources. So you are forced into a position where you acquire technology externally.*
IP ownership in collaborations	IP ownership issues of results in collaborations	*In collaboration agreements, IP and ownership of results from projects are discussed. It is of large importance, and something we spend a lot of time on.*
	Contracts in collaborations	*[Company] has traditionally protected technology via patents. It is not possible to same extent developing digital, where we have more partnerships. We do want to own it, though, but it will be done through contractual methods rather than applying for x patents.*
	Ownership of data issues	*We have to let go of some data in order to get what we want. Potential partners might be reluctant to enter collaborations without getting any [data] from it.*
	Ensuring secrecy from partners	*In order to ensure secrecy, agreements with collaborators are extremely important. You also need confidentiality agreements with key persons, in order to prohibit them from bringing information with them when they quit.*

Table 5. 1st and 2nd level codes relating to "External sourcing of digital technology"

4.3 IP management of digital technology

This section covers why digitalization requires changes in the IP organization ("Digitalized IP organization") and how digitalization changes the strategic importance of IP management ("Strategic importance of IP organization"). These topics are aligned with the second level codes showed in the parentheses above and are further presented in Table 6.

As the interviewed firms digitalize, competence surrounding digital technology is needed (see "Need for digital competence"). Further, the increased share of digital technologies puts pressure on the IP organization. The studied firms display various levels of alignment of their internal IP competence with the new technological areas. For many of the interviewed firms, there is an expressed need to build internal IP competence in digital technology (see also "Need for digital IP competence"):

> *The digital aspect of the product is increasing, meaning we have to decide what to control. It might be relevant to control algorithms developed, which means we have to build IP competence in the area.*

In order to acquire internal IP competence, recruiting IP personnel from other, more digital industries is one approach (see "Digital background of IP manager"):

> *My background is from the telecom industry. When we recruit today, we always choose people with experience from the datacom or telecom industry. Not that we have a group of specialists only responsible for digital technology. But absolutely, when we recruit, that background is needed.*

This indicates that IP competence for digital technology is specific. In other words, there are different sets of competence needed compared to non-digital technology IP competence. Further, it points towards experience from digital industries as an important factor to facilitate this need for competence. Recruiting new IP employees with experience from digital industries can thus be seen as one approach to satisfy that need. An alternative approach is to build internal IP competence in digital technologies by educating the existing staff:

> *Me and a colleague attended to a class in London last week. On, you know, patenting on software. To get prepared for how to do the clearance and all of that.*

New staff might thus not need to be hired. Taken together, these firms see a need for internal IP competence in digital technology (see also "Internal digital IP competence"). A third approach for IP competence in digital technology is to utilize the expertise of externals such as patent agents or consultants:

In this respect we are leaning very much on external patent agents that we are using. Because we don't have big knowledge in this area regarding patents. We know a lot about chemistry and machinery and things like that, but these digital things and software patenting is a relatively new field for us.

This approach is typically aligned with IP operations that already largely draw on external competence.

To build IP competence internally, the effect of new, digital IP tools should be noted. These patent tools help reduce the complexity of the patent landscape as searching and organizing patents is made easier:

The search tools are also developing; it becomes easier to find what is out there even if what is out there is more complex.

Thus, the development of IP tools is a factor to be considered for building internal IP competence. All in all, digitalization can be said to demand new IP competence for firms, where the approaches to attaining such competence vary from relying on purely external patent agents, to educating existing personnel in the area.

The interviews also show that digitalization not only affects the competences needed within the IP management organization. Some of the interviewed firms have also explicitly changed their IP strategies to align with digitalization. This includes formulating new strategy documents (see "Formal IP strategy"). For most of the interviewed firms, however, this is only at an early stage, or at best, work in progress:

A strategy document for digital IP assets is in progress actually. We have been working with a consultancy firm on this, but it is kind of turbulent with these digital organizational changes. I hope it gets more stable. Hopefully the document will be approved by management this year.

There are thus needs to get management approval of the IP strategies that are coming to place. These strategies can contain a number of important adaptations or changes. For some of the interviewed firms, IP management have been distributed in the organization, either within the R&D organization, or in multiple divisions or similar. Digitalization conversely puts demands on a centralized IP management for these firms (see "Centralized IP management due to digitalization"). This lack of centralization, it should be noted, appear only limited to a few firms. For other firms, the changed IP strategy involves formalized goals or procedures:

We need to have some different process and guidelines, perhaps different strategies. We have to do something to manage the change to a digitalized world in a more controlled way.

While this may to some extent be more of operational questions, they are certainly shaped by the IP strategies pertained by the firms. Taking the above together, it could be said that digitalization for many firms appear to have an important impact on IP strategies (see "IP strategy affected by digitalization").

Many of the interviewees indicate that the strategic importance of the IP organization in itself remains largely unchanged in the face of digitalization. These firms typically patent the aspects that are seen as important differentiating factors. Other, non-core technologies are not managed actively, including digital technology. In some cases, this even involves not patenting digital technology. Digital technology is in this perspective just an additional technology area which is emerging and thus need no special attention:

I don't think we need a digital IP strategy at the moment. I believe in a business strategy. For us, a separate IP strategy for digitalization is just a burden. It has to be intertwined with the business strategy for a certain product.

This implies IP strategy being seen by and large as a subunit of business strategy. For many of the interviewed firms, there is also an explicit idea to see IP strategy as shaped by business strategy and business operations (see "Business oriented IP strategies"). In these firms, the IP organization has a more proactive role in facilitating innovation through IP intelligence (see "IP management for business support"), handle non-patent IPRs for a more holistic IP management (see "IP organization responsible for non-patent IPRs"), and educate other parts of the organization in IP management, which is often needed for e.g. patent enforcement (see "Need for IP awareness"). None of these last three functions of the IP department are, however, directly linked to digitalization. In short, IP has a strategic role for most of the interviewed firms, and digitalization enhances this for some of the firms. For a summary of all codes in this theme, see Table 6 below.

2nd level	1st level	Example quote
Digitalized IP organization	Internal digital IP competence	*We do have IP people with experience from the telecom industry. It explains how we view patenting digital technology as we do today.*
	Need for digital IP competence	*Yes, we need [digital IP specialists]. Last time we recruited, that was a parameter we looked at - finding a patent engineer who had experience with digital products. Someone who had worked with software or in the telecom industry. In regards to competency, we need to think like this.*
	Digital background of IP manager	*Then I went to [a telecom company] as a patent engineer. Spent almost 20 years there. Switched roles to IPR manager.*
	New digital IP tools	*In terms of digital, things are more easily available. You can download patent publications and do searches quickly.*
Strategic importance of IP organization	Centralized IP management due to digitalization	*Due to digitalization we have gotten to the point where it [IP organization] has to become more professional internally. Historically IP could be managed locally in the business units, there was no need for much expertise.*
	IP management for business support	*Sometimes we [IP dep't] enter projects and remark on the lack of innovative results. Usually there are two patent engineers conducting interviews with engineers in order to shake out inventions. It does not happen that often, but it happens.*
	Business oriented IP strategy	*We look at where our business is heading, we talk with the business people and how the business model is developing because that is what we want to protect. Well, not that you can patent a business model, but we want to protect central, differentiating aspects of it.*
	IP organization responsible for non-patent IP	*Since 2006 we started to expand this group, hiring yearly. We brought trademarks and other IP forms into this unit. We are a central organization that handles everything [related to IP] for the entire group.*
	Need for IP awareness	*To get people in sales trained to understand the underlying IP in our product is a key success factor. IP is a negative right, there is no police catching infringing parties. We have to enforce it ourselves, and the sales personnel is out in the front lines.*

Table 6. 1st and 2nd level codes relating to “IP management of digital technology”

4.4 IPRs for digital technology

This section covers how digital technology can be patented ("Digital technology is patentable"), how digital patents differ from non-digital patents ("Differences in patenting digital technology"), how the patent landscape of digital technologies adds complexity to IP management of firms ("Complex landscape for digital patents"), and how the role of IPR mechanisms for digital technology differ from non-digital technology ("Changed role of different IPR-forms"). These topics are aligned with the second level codes showed in the parentheses above and are further presented in Table 7.

The interviews reveal that there are some key differences in the view of IPRs for digital technology compared to non-digital technology. Patenting digital technology does differ from patenting non-digital technology, e.g. mechanical or material technology. From the interviews, four such differences were identified. First, certain digital technology cannot be patented, e.g. source code (see "Certain digital technology not patentable"). In a more general sense, however, digital technology can be patented. Some interviewees pointed out that by adding or connecting software or digital processes to some more physical or methodological process, it is possible to protect digital technology through the use of patents. As described by the interviewees, this can either be done through designing more method-oriented patent applications (see "Method patents for digital technology"), or by linking the digital technology directly into its usage in a physical solution (see "Patenting digital by linking to physical"). Beyond these approaches, certain types of digital technology may still be difficult to patent, such as system level inventions (see "Issues in patenting digital").

Second, the life cycle of patents on digital and non-digital technology differs (see "Life span of digital patents" and "Changed life cycle of patents"). As development of digital technology generally is considered to move at a faster pace than non-digital technology, new generations of digital technology are expected to more frequently replace old ones. This in turn makes the patent enforcement time shorter for digital technology:

> *The life cycle of certain algorithms for example and software is much shorter. The timeline to develop those are shorter. The timeline for enforcing your IP too.*

This can also be seen as a potential reason for assumingly shorter life spans of patents for digital technology:

If you look at the life span of many of our IP rights, they are probably on 13, 14, 15 years. Sometimes 20 years. With telecom, they start discussing dropping the patent after just three years.

Thus, it appears as some firms view both the life cycle of technology as well as the enforcement time and protection time of patents to be lower for digital technology than non-digital technology.

Third, the patenting propensity differs for some firms when it comes to digital technology versus non-digital technology (see "Changed patenting propensity due to digitalization"). Certain firms see their patenting propensity to decrease:

It [digitalization] will affect in that, yes, we will patent to a lesser degree.

One important argument for this decreased propensity to patent is the difficulties in patenting digital technology, as discussed above. Other firms do not see digitalization affecting patenting propensity at all:

Our likelihood to patent is the same. We patent if we think we have an invention and the timing is right. Digitalization hasn't changed that.

Among the interviewed firms, it can be noted that this was perhaps the most commonly recurring view. However, yet other firms saw their patenting propensity to be increased for digital technology:

I believe we are even more interested in patenting when it has to do with software. We are more likely to patent than if it is hardware.

One important reason for this increased patenting propensity is that there are simply so many other patents in the field:

With digital, it is just that the volume is so large.

In digital technology areas, there are thus typically a large amount of patents. For some firms this means an increased propensity to patent on digital technology compared to non-digital technology (see also "Increasing patenting due to digitalization"). All in all, there does not appear to be any dominating reason or consensus regarding whether patenting propensity should change due to digitalization or not as both arguments for increased and decreased patenting propensity exist.

Fourth, the complexity of the patent landscape increases. As mentioned above, firms need to manage new actors when developing digital technology. This includes changing their IP strategies, as for example telecom firms generally have a more aggressive approach to patent enforcement. Entering the digital technology field also means entering new patent fields. Again as mentioned above, the amount of patents on digital technology is generally seen as larger than in non-digital technological areas. That in itself plays a role in doing prior art searches when having developed technology:

> *It is easier to manage the mechanical side because there are fewer patents to look at.*

There are also more technical aspects that arguably make patent clearance more difficult to achieve in the digital field, e.g.:

> *It is much more concrete and straightforward with mechanical and hardware patent. It is more difficult to navigate the digital side.*

The issues brought up earlier on the patenting issues of digital technology are also reflected on the clearance side, since there might be reason to question validity to a larger degree on digital patents:

> *When you attempt to protect digital technology you enter the software world. And that is in the border line of patentability. Already there you have a difficulty. Are the patents even valid? Are they granted on the right circumstances? Can I patent this? There is a grey area here, patent for patent.*

By and large, doing IP clearance is therefore generally more difficult and resource demanding for digital technology than for non-digital technology (see also "Issues in IP clearance for digital technology"). Taken together with the increased number of patents of potential relevance, the patent landscape at large becomes more complex (see "Complex landscape for digital patents").

This increased complexity of the patent landscape translates into difficulties with doing FTO analyses for digital technology. It might even mean that while FTO is possible and economical for non-digital technology, it cannot be motivated or satisfactorily guaranteed for digital technology, i.e. requiring risk assessments rather than FTOs for new digital technology (see "IP clearance for mechanical vs risk management for digital"). At the same time, patent infringements on digital technology is generally considered harder to detect:

> *It is simple to see a physical product, but it is much more difficult to detect how a digital signal is sent from a mobile unit to a base unit. That is very hard.*

The difficulties with detecting and determining whether a competitor is infringing on a patent (see also "Issues detecting infringements for digital technology") again adds to an overall picture of an increased complexity in the patent landscape in the digital field. Consequently, a rise of conflicts over patent infringements is expected by some of the interviewees (see "Increase of IP conflicts").

Beyond the patenting of digital technology, other IPR-forms can be utilized for the protection of digital technology. As pointed out by some of the interviewees, software is generally protected by copyright on creation, which holds some protective value (see "Copyright for data and software protection"). At the same time, copyright comes with the limitation that it does not protect from imitation, as oppose to strict copying:

> *If we have a development project and I develop a concept for presenting something, how it should work, you can actually steal large parts. You don't need to copy it. You can just imitate it and make it similar to what I developed.*

Copyright thus clearly has limitations in terms of protection of software, but it is by some interviewees considered to be of larger value when it comes to data:

> *The thing with data is that you don't want to imitate it, you want to copy it. And there you have copyright, and therefore it is useful.*

Thus, copyright is considered to have some usefulness when the exact representation of data is of value, which is often the case for process data.

Additionally, secrecy can be used for the protection of technology. Many of the interviewees view the decision whether to patent or not also as a choice between patenting or protecting by secrecy. In the case of digital technology, it is sometimes also considered easier to protect through secrecy than for non-digital technology (see "Trade secrets for digital technology protection"). This since secrecy can be achieved for digital technology by means of blackboxing or encrypting software. Because of this, the decision whether to patent or protect through secrecy becomes more difficult (see "IPR form ambiguity for digital technology protection"). This also causes some of the interviewed firms to see increased usefulness of secrecy for protecting digital technology:

> *Keeping the results confidential as trade secrets is more common [for digital technology] than with traditional technologies.*

Thus, it seems as trade secrets is getting a more prominent role for the protection of digital technology. In a more general sense, non-patent protection forms appear to become increasingly important for protecting digital technology. For a summary of all codes in this theme, see Table 7 below.

2nd level code	1st level code	Example quote
Digital technology is patentable	Patenting digital by linking to physical	*It's said that you cannot apply for patents on pure software. We have never had any problem; we always connect it to the hardware in some way. It is implemented software, that you always connect to hardware.*
	Method patents for digital technology	*Method patents are, which steps do a machine perform? You may have done an IP [read: IT] invention. Through that you can protect the source code indirectly.*
Differences in patenting digital technology	Issues in patenting digital	*It is much more difficult to find that total solution and patent it from a system perspective.*
	Changed life cycle of patents	*The life cycle of certain algorithms for example and software, is much shorter.*
	Life span of digital patents	*The development is going so fast that you may think it isn't worth patenting. That your product will be outdated before the patent is granted.*
Complex landscape for digital patents	IP clearance for mechanical vs risk management for digital	*In the physical area, you can really have FTO. When it comes to digital, do not even bother. If a problem arises, solve it ad-hoc. Usually it is some royalty payment which you want to minimize.*
	Issues detecting infringements for digital technology	*I mean software, it is tricky in the sense that when you patent software, some of the solutions with the software patents is that you may not be able to identify if a competitor is using your software or not.*
	Issues in IP clearance for digital technology	*It is always more difficult to navigate in software. There is so much more... Mechanical and hardware patents are much more straightforward. It is more difficult to navigate the digital side, definitely.*
	Increase of IP conflicts	*There will be more court cases, because we are getting more competitors. /.../ Now we are getting a new series of products that are digital. There we will see more coming to us saying that we are infringing somewhere. Because we are also coming to a world with many actors we haven't seen before and that have a different culture around that. Take the telecom side. They are much more aggressive, patent-wise, in-between, than traditionally in our area.*
	Changed patenting geographical scope	*Say, Germany has developed a product for Germany and they haven't moved it outside of Germany because that wasn't needed. So, they only applied for patent in Germany. Now we have a digital world. /.../ we need to cover the whole, not all countries, but all the large countries. You need to see IP as the global asset it is.*
Changed role of different IPR-forms	Changed patenting propensity due to digitalization	*I think we are even more interested in patenting when it has to do with software. We are even more inclined to patent than if it is hardware.*
	Trademark of high importance	*The brand is our largest asset. That IP we want to protect. As much as possible!*
	Trade secrets for digital technology protection	*If we believe that it's an algorithm or let's say such a method or feature which is really difficult to dig-out and identify from the products, certainly we can consider just keep it secret.*
	Certain digital technology not patentable	*We cannot protect source code with patent rights.*
	Copyright for data and software protection	*Then software is basically copyrighted. There you protect your execution of the software, and the investment you have made to develop it.*
	IPR form ambiguity for digital technology protection	*When should we protect via patent? When should we rely on secrecy or technical control, or a combination of the two? We find it easier to determine this on the traditional side, is my view.*
	Increasing patenting due to digitalization	*We are affected in the sense in that we file more patent applications that we would otherwise do. If there would not be a computer implemented we would have less inventions, definitely.*
	Added digital as differentiator	*I think that is going to be a big change for us, not that we are going to become a software company, but software will be more relevant. It will be what differentiates us.*

Table 7. 1st and 2nd level codes relating to "IPRs for digital technology"

4.5 Importance of data

This section covers how data is created in the focal firms ("Creation of data"), how such data can create value ("Value generation from data"), and what issues data brings in terms of protection ("Issues in data protection"). These topics are aligned with the second level codes showed in the parentheses above and are further presented in Table 8.

One aspect of digitalization is the creation and utilization of data. Digitalized products often involve some sort of sensors that create data on the status of the products or its use (see "Sensors for product data"). Embedding sensors in products is often seen as an early step in digitizing. An interviewee explained:

> *Diagnosing information is also available but as I said, as long as we don't measure more, we don't get more information. /.../ We are still in very early in the journey. The amount of sensors implemented today is nothing if you compare it to what it will be in 20-30 years from now.*

Putting sensors on products enables for data to be generated. This data can then be sent between products or be collected in servers by adding connectivity to the products (see "Increasing connectivity of solutions"), i.e. collected. By further including processing power into either the products themselves, or to connected control units, products can be made more intelligent (see "Increasingly intelligent products"). Similar principles can also be applied in manufacturing to make manufacturing processes more efficient through digitalizing (see "Digital manufacturing"). On the business side of things, more connected, intelligent and data driven products in turn enables service-oriented business models (see "Increasingly service-oriented business models"). Common for all these is an important role of data as products and manufacturing is digitalized.

Thus, data plays an important role in the development of products, manufacturing and the enablement of service-oriented business models. Consequently, data can be seen as a valuable asset (see "Data as valuable asset"). For certain technology, data is needed to a high degree but often lacking:

> *Just look how important data is for machine learning, deep learning-systems. There you really… They say data is the new oil. To teach all neural networks, training data is extremely important. That is a big challenge for us, to access that data.*

As such, data can in itself be seen as a valuable asset or IP. Others, however, argue that data only has limited value compared to the actual methods or software that can analyze the data (see “Methods utilizing data as valuable asset” and “Complementary software for data analysis”). Both these perspectives do, however, require data to actually do analysis for e.g. developing intelligent products, improving service offerings through maintenance data, etc.

Protecting data can be difficult. As noted above, some interviewees view copyright as a mechanism to protect data. However, it can be difficult to know if data has been stolen or not, since it does not automatically show on a product what data was used to develop it. This is an important risk as cyber security becomes increasingly problematic in the protection of intangible assets (see “Difficulties with cyber security”). Thus, the interviewees often argued that data needs to be protected through software security, i.e. primarily by means of IT, rather than legally allocated rights as for the case of technology protected by patents (see “Data protection through software security”). This can also be seen as an important reason why many of the interviewees do not see data management as an IP management question (see “Data management not an IP management issue”), despite at the same time referring to data as an IP. For at least one of the interviewed firms, protection of data was instead managed through a specialized data manager (see “Specialized data protection manager”). For a summary of all codes in this theme, see Table 8.

2nd level	1st level	Example quote
Creation of data	Digital manufacturing	*We are running projects where we... particularly in production, where we are trying to see how we can improve efficiency through AI or machine learning.*
	Increasing connectivity of solutions	*They used to be standalone machines in the middle of nowhere, no one knew what they were doing, no connection. Now we embedded automation and a satellite connection. Then they came to the same network, not control wise, but sharing information.*
	Increasingly intelligent products	*One trend of course is that the products get smarter and smarter.*
	Sensors for product data	*There is a lot more sensors being put on, and you use those sensors to monitor performance.*
Value generation from data	Methods utilizing data as valuable asset	*To understand, what can we do with the data? That's kind of asset as such. And the other kind of bunch of assets is then to develop something, algorithms or optimization method that can utilize the data.*
	Data as valuable asset	*Well, we consider data as an asset and I think we have not actually defined it. It is intellectual property.*
	Complementary software for data analysis	*In our maintenance or our services we are providing for example online tools for our customers so that they can see, get data from work equipment how they are working.*
Issues in data protection	Specialized data protection manager	*We have a data protection specialist in-house at [company], who is only focusing on protecting data.*
	Data management not an IP management issue	*Data is handled by IT or engineering functions, with the security around that. The only connection to data we have, except data on portfolio things, is when we need it for [patent] protection.*
	Difficulties with cyber security	*Now you just need to go to the internet black market-sites to sell whatever you have stolen. So we need to protect the IP IT-wise, the networks and everything should be very secure so no one can steal our property because it is so easy to sell on the internet.*
	Data protection through software security	*It is about a source code or data set. It will be stored on a memory, or some type of inventory. The final question then is, what kind of lock do we have?*

Table 8. 1st and 2nd level codes relating to "Importance of data"

5 Analysis

5.1 The impact of digitalization on technology strategy

5.1.1 The value of digitalization for firms

Digitalization is a way to create value and potential profit for firms primarily engaged in non-digital technologies. The interviews revealed that this value creation can come from (1) changed business models in the form of e.g. new digital sales channels (for increased sales), (2) added digital technology into products making them smarter and more connected (for increased customer value), and (3) improved manufacturing automatization opportunities (for decreased costs). One way to understand the value enhancement from digital technology is through technological complementarity as defined in Teece (2016). For example, as digital technology in the form of sensors and processors are added to machines, this enables the machine to be run more efficiently through automatization, more reliably through component status information, and more effectively as it can be adjusted easily through software settings. Also, an important additional result of the added digital technology is the resultant data created, which will be discussed further below.

5.1.2 Technology base and technology acquisition strategies

As the firms acquire new digital technologies in addition to their existing technologies, they per definition become MTCs (see Granstrand 1999). As such, these different technologies have different characteristics. Many of the interviewees for example view mechanical technology as relatively stable, with long life cycles, while digital technology is unstable, with short life cycles. Further, most of the mechanical technology is seen as rather mature (as defined in Klepper 1996) and highly specialized, whereas the digital technology generally is less mature and specialized. This allows for more generally applicable digital technologies. Generally applicable technologies also cause standards to be relatively common for digital technology. For many of the interviewed firms, standards have not before been relevant. This should cause firms to reflect on the opportunities for adding technology to technology standards for further value generation from their digital technology (Reitzig 2004), or search for needed technologies in standards.

For most of the interviewed firms, digital technology has not been a part of the technology base up until recent years. In fact, for almost all of the interviewed firms, the acquisition of digital technologies started only in the most recent decade. As the firms decided to incorporate digital technology into their technology bases, this provides an interesting example of firms trying to diversify their technology base and what strategies they utilize to do so. In the interviews, most firms appear to largely depend on different means of external technology acquisitions. In more theoretical terms, this implies that firms increasingly get a lower degree of (vertical) integration (as explained in Powell 1990) for the development of digital technology. This high reliance on external technology acquisition strategies for acquiring digital technology implies an increased degree of openness, as defined in e.g. Holgersson & Granstrand (2017) and Bogers et al. (2018). This shows that firms rely to a large extent on external technology acquisition strategies in accordance with earlier research (see e.g. Granstrand et al. 1992, Chesbrough & Brunswicker 2014). By and large, this implies that digitalization specifically, and technology diversification generally, might be an important explanation for why firms engage in inbound open innovation approaches. It should also be noted that the same firms only see limited value and use of external technology exploitation strategies for digital technologies. This probably plays a role in the lesser understood and researched strategies for outbound open innovation (see Bogers et al. 2018). However, the opportunities for external technology exploitation strategies might also be underestimated, as these firms previously have navigated highly specialized fields, but now move into more generally applicable technologies where patent licensing-out could be more relevant than earlier for these firms.

5.1.3 IP issues in collaborations

Certain technology acquisition strategies appear to be more frequent and relevant than others. More specifically, the interviews reveal a large dependence on different means and types of collaboration for adding digital technology to their technology base. This high dependence on collaborations can be understood through the highly distributed technological areas needed to be combined (Yoo et al. 2012) before they can be further applied to the focal firms' respective need. Further, to acquire lacking competences or technologies where flexibility in the application is needed in the exploitation strategies, collaborations are highly relevant (Lazzarotti & Manzini 2009), particularly in multi-invention contexts (Manzini & Lazzarotti 2009) such as those brought by digitalization.

In these collaborations, however, issues of IP allocation are prominent. These include e.g. who gets patents on what, how secrecy can be ensured from partners, and what partners can do with the knowledge they acquired. In a two-firm collaboration, it is reasonable to assume that both parties want ownership of the IP created to ensure appropriability of the inventions they intend to commercialize (Teece 1986; Granstrand & Holgersson 2014). To ensure appropriability, openness in terms of developed knowledge need to be limited, as argued by Laursen & Salter (2014). Protective mechanisms beyond secrecy are needed, i.e. more complex contracts are required to dictate IP allocation (Arora & Merges 2004; Bader 2008; Hagedoorn & Zobel 2015). IPRs are thus an important facilitator for collaborations (Hagedoorn & Zobel 2015; Henttonen et al. 2016; Holgersson & Granstrand 2017). Conversely, collaboration requires certain openness between involved parties for there to be fruitful exchange of knowledge and capabilities. It could thus be said that firms need to balance their openness and appropriability from innovative outcomes in collaborations. These issues seem to be increasingly relevant as the interviewed firms engage in collaborations to a larger degree for developing digital technology than for non-digital technology.

5.1.4 New actors and increased complexity

As firms are implementing digital technology in their products, new actors appear to become relevant not only due to the collaborations initiated. For example, certain technology is owned by software firms (e.g. Google, Amazon, etc.), telecom firms (e.g. Ericsson, Nokia, Qualcomm, etc.), and NPEs, partly in the form of standard patents. Also, certain potential for collaborations between especially software firms and the interviewed firms is present. In both these cases, it is for now unclear what motives that primarily will drive these digital actors. In parallel to development collaborations as mentioned earlier, new actors emerge as potential competitors, suppliers, and so on. Firms therefore engage in more complex forms of collaborations across industries, competition and supply chains. Altogether, this makes up for a more complex innovation landscape meaning that firms move towards innovation ecosystems. These will in turn cause additional complexity, as each individual actor needs to acknowledge the strategies of other actors in these innovation ecosystems (Holgersson et al. 2018). In more general terms, new strategies are needed as firms enter more complex innovation ecosystems (Chesbrough & Appleyard 2007), especially in the IP management area (Holgersson et al. 2018).

For some of the interviewed firms there was an expressed need to adapt IP strategy to the more digital actors they are coming across. Such strategic changes discussed centered around the management of patenting strategies of NPEs and telecom companies, as these were generally seen as more aggressive. Holgersson et al. (2018) showed that the emergence of innovation ecosystems can bring together actors in an industry with different IP strategies. Firms with proprietary or defensive patenting strategies can come across firms with leveraging patenting strategies (as defined in Somaya 2012) as these innovation ecosystems emerge in an industry (Holgersson et al. 2018). This might cause firms to need to make drastic changes and adaptations by putting larger emphasis on complementary and substitute technologies and patents (ibid.). These types of adaptations to IP strategy might also be aggregated as innovation ecosystems has the potential to change appropriability regimes (Teece 2016). As firms from different industries then are brought together due to digitalization, as shown in this study, firms with different IP strategies and differing core technologies interact. For some of the digitalizing firms interviewed, the clash with new IP strategies and new appropriability regimes might also explain why new IP strategies are needed.

5.2 Protecting digital technology

5.2.1 Approaches to patenting

When a digital component is relevant to the technical function of a physical application or system, the interviewed firms could protect said digital technology by patenting. The usual way which this is done by the interviewed firms is by patenting the entire application or method, where typically also physical technology is present. Thus, the way which the interviewed firms protect digital technology through patents can be seen as indirect. If a new digital technology is integral to performing a process, this digital technology would be indirectly protected by a patent on the process. However, this comes with a significant downside. The digital technology is dependent on usage in the specific context of such a process, meaning that it be used by competitors in other applications. Software patents, while existent in the US, were often not considered feasible or relevant for the interviewed firms. This can perhaps be attributed to the firms being European. Still, all the firms interviewed operate globally and patenting software to protect commercialization in the US could theoretically be an option. Thus, the way which digital technology is patented among the interviewed firms suggests that the appropriability of digital inventions through IPR is weaker than that for mechanical technology. This further suggests that IP modularity (as explained in Henkel et al. 2013) might be problematic as strong appropriability regimes for digital technology is hard to achieve without a coupling the digital technology with non-digital technology.

To understand the profit capture within an innovation ecosystem, the dimensions of complementary and substitute appropriability regimes are necessary (Holgersson et al. 2018).

For most of the interviewed firms, digital technology can be seen as a complement to non-digital, e.g. mechanical and material, technology. Digital technology therefore typically corresponds to complementary appropriability regimes for the focal digitalizing firm, that are somewhat weaker than for non-digital technology (as also found in Teece 2016). The value of having strong appropriability regimes is also affected by the degree to which the technology can be differentiated (Holgersson et al. 2018). For some firms, the digital technology comes in the form of an add-on, e.g. added sensors that generate data or software systems that can process this data. This technology also need to be customized to create value from the physical product. Thus, for firms digitalizing, digital technology is an important complementary technology with a weak appropriability regime that can be strengthened if coupled with physical technology. Doing so could however limit the possibilities for cross-licensing and licensing out technologies to other industries.

5.2.2 Characteristics of patents on digital technology

The interviews point towards digital technology having a faster development rate, with frequent new generations of products thus making inventions obsolete quicker. Regardless of whether the technology is developed faster, the time it takes to apply for a patent and getting it granted is the same. In a fast moving technology field, waiting for a patent to be granted makes less sense. As digital technology is developed more quickly than non-digital technology, new digital products arrive to the market faster. This increased frequency of product launches or improvements presents a problem to whether digital technology should be patented or not. During the period which it takes to get a patent granted, a new technology or product may have replaced the original technology the same firm filed patent on. For the firms interviewed in this study, non-digital inventions are usually patented and the lifespans of these are long. This ties into a proprietary strategy logic, where patents are used to achieve robust protection of an innovation, and the patents are well maintained and often re-issued (Somaya 2012). A similar patenting strategy is by the interviewees considered seemingly less relevant as digital technology becomes increasingly important for firms, again, due to the fast-paced nature of digital technology. However, patents still do have merit in that they can prevent issues of patent holdups. Also, having a patent portfolio can be useful in preemptive purposes, e.g. to avoid injunctions and litigation at later stages (Hall & Ziedonis 2001).

The interviews provided various views on whether the firms' propensity of file for patent protection has increased, decreased, or remained constant due to digitalization. On an aggregate level, it is therefore hard to conclude any trend in specific. The most recurring view, however, was that the propensity to patent has remained unchanged. As such it seems that while the disadvantages of patenting (filing costs, effort, forced disclosure of invention) and the scope of protection is seen as the same for digital technology for a number of firms. Those who find their patenting propensity to have increased, argue on the basis of digital technology having dense patent landscapes. To an extent, this ties into a defensive patenting strategy, where firms seek to have a large enough number of patents in order to operate without the risk of patent holdups (Somaya 2012). In the cases of firms seeing a decreased propensity to patent, interviewees mentioned difficulty in patenting digital technology. This shows that although appropriability regimes might be weaker for digital technology, the use of patents for most firms is not seen as less important.

5.2.3 The patent landscape

As firms incorporate digital technology, the complexity of managing the surrounding patent landscape increases. Interviewees noted that the digital patent landscape is rather patent dense, i.e. that there are many patents on digital technologies. They also noted that patents for non-digital technologies, e.g. mechanical patents are often more straightforward to understand. This can be understood as digital patents from, by and large, non-competing or -substituting industries being relevant for firms in narrow industry settings. In other words, that digital technology and patents are more generally applicable than other technologies and patents. A proprietary strategy, i.e. having more or less watertight IP protection (Somaya 2012), is less feasible in this environment. Instead, defensive patenting strategies are typically more beneficial in this setting (ibid.), to prevent being held up by the vast amount of patents in the digital technology patent landscape.

While more or less all interviewed firms attempt to achieve full FTO for their strictly physical products, many of these view FTO differently for digital technology in their products. Rather than FTO, risk assessments are needed. This difference in the outlook on FTO can be explained by two factors. (1) In a non-digital setting, many firms deemed it possible to be quite sure on what relevant patents that existed in the technology area. In a digital setting, however, there are more patents and it becomes seemingly impossible to be aware of everything that exists in such domains. Thus, firms need to manage the higher risks surrounding this area. (2) Firms need patents sufficient to differentiate their product. As such, firms need to combine risk management with a strategic patent portfolio for key aspects of their product rather than achieving complete FTO. Also, as firms enter new technology areas with a large amount of patents, there is an increasing amount of relevant external firms. Again, this ties into the different patent strategies used in other industries, such as leveraging strategies commonly deployed by actors such as NPEs and telecom firms (Reitzig et al. 2007).

5.2.4 Non-patent forms of protection

Outside of patents, copyright and trade secrets were commonly brought up as methods to appropriate value from innovation. Copyright can indeed protect source code, but it only protects the representation (as in, it would prevent direct copying) of such code, allowing its protection to be bypassed easily by just writing the code differently while still retaining its technical functions. Further, many of the interviewees expressed a view of copyright as an important protective form for data. A common assumption among the interviewees was that copyright is automatically generated for data or datasets, which then provides protection from direct copying. However, it should here be noted that protection of data with copyright is limited, see further below.

Secrecy is by its nature often relevant for the protection of digital technology, such as software and algorithms. This, as source code could be "blackboxed" and encrypted, i.e. different means for keeping it hidden and inaccessible, which is generally not an available approach for protecting physical technology. At the same time, many of the interviewees perceive patents on digital technology as weaker than physical technology. As a consequence, many of the interviewees pointed out that the choice between patenting and maintaining secrecy therefore is more difficult for digital technology, as oppose to physical technology were patenting typically is default. However, trade secrets may just as well function as a complement to patents (Cohen et al. 2000; Erkal 2004), and using the combination of secrecy and patenting to achieve optimal protection is important, as only using secrecy might risk that competitors instead patent the focal firm's technology (Holgersson & Wallin 2017). Thus, an over-reliance on secrecy could inhibit firms' FTO. For example, secrecy could be used to protect increasing amounts of data linked to the digital elements of the product (or to a fully digital product), whereas patents still have merit in protecting important technical functions where secrecy is too hard to maintain (Cohen et al. 2000).

5.2.5 The IP management organization

For most of the interviewed firms, the IP organization was noted to have a strategic role in that it functioned less as a support function and instead was more intertwined with the overall business. Protection was often focused on differentiating aspects of firm's business models, and the IP department had responsibility of using combinations of IPRs to achieve that. This largely aligns with previous sentiments in literature, where the view is by and large that IP management should be integrated with the business strategies of firms (see Reitzig 2004; Al-Aali & Teece 2013; Somaya et al. 2011) and that the IP department should utilize a mix of IPRs in order to achieve optimal protection (Al-Aali & Teece 2013). Somaya at al. (2011) argues most firms have not aligned their IP- and business strategies. Whether this study can make the case against this is unclear. On one hand, most firms seem to have implemented a more "business"-esque way of viewing IP. On the other hand, this study has merely examined the case from the perspective of (mostly) IP managers. Consequently, the perspective of top managers is generally lacking. Also, even if the IP organization, or for that matter, the entire organization, views IP increasingly as an integral part of business strategy, there are no indications whether these strategies are sufficiently aligned.

Another important difference that digital technology brings, as revealed by the interviews, is the need for special IP competence in field. This perceived competence gap can be attributed to two factors: (1) as firms move into multi-invention contexts new competences are needed in the new technological fields; and (2) as digitalization brings weaker appropriability regimes (Teece 2016) and new actors, brought by the emergence of innovation ecosystems, new IP strategies are needed (Holgersson et al. 2018). Three approaches for acquiring IP competence for the digital technology field were found: (1) hiring people with a background in digital industries (primarily telecom); (2) educating current staff; and (3) relying to a larger extent on external expertise (e.g. IP consultants). Of these approaches, acquiring IP competence through hiring experts from digital industries may be most likely to bring the competence needed to manage the IP strategies of digital firms. This might, however, signal that the recruiting company is going into similar technology as the digital actors, and that there might be reason for the digital actors to monitor the recruiting company's products for infringements.

5.3 The role of data in IP management

5.3.1 The creation of data from digital technology

When digital technology is added on physical technology, it often happens in the form of digital sensors and/or processors being put on machines. Typically, sensors measure a physical parameter, e.g. the temperature of an engine, the pressure in a pipe, or the physical properties of a material. The sensors thereby create data on such parameters. This data can then be gathered in databases for later analysis, or analyzed in real-time (e.g. for software generated decision-making). For example, these data analyses can help tell managers how products or components are doing and if they need maintenance, how well the application of the products are working, etc. Data can thereby help give technical insight (e.g. data on product usage that might enable improvements in product design and functionality) as well as business insight (e.g. data on product usage that might inspire additional services to be offered). In more general terms, data can thus be said to create additional value from a product. Many of the interviewees also explicitly expressed a view of data having value, by stating that e.g. data is an asset, data can be used in negotiations, data can help build better products, data through analysis can reveal secrets to or from competitors, and so on. Worth noting here is also that raw data might need to be transformed into useful information (Borek et al. 2013). That might for example include simple transformations such as calculating the average temperature for an hours use of a product. This was also brought up by multiple interviewees, arguing that data in its raw form is "of no value".

5.3.2 The role of data in firms

We can then ask how well data fit the earlier presented definition of an IP from WIPO (I, pp. 2): "Intellectual property (IP) refers to creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commerce."[8] Clearly, inventions, artistic works, designs, symbols, names, and images appear to directly address IPRs such as patents, copyrights, design rights, and trademarks. However, this part of the definition does not cover data. Further, data is not so much "a creation of the mind" as it typically (here)

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[8] Many definitions of intellectual property exist, but most definitions typically point toward some creation of the human mind (see e.g. Granstrand 2018; Oxford Dictionary: Intellectual Property; Hughes 1998), and some sort of propertization of this creation (see e.g. Granstrand 2018, Hughes 1998). Some also argue that general information may be intellectual property. For example, Hughes (1998) argues that ""Gathered information" is another genre of intellectual property" (pp. 4), however, only if it can be seen as "a product of cognitive processes" (pp. 5).

is generated by installed sensors. By these means, data cannot and should not be considered an IP. However, data can be seen as “A useful or valuable thing” (Oxford Dictionary: Asset) and should thus be seen as an intangible asset.

In the business context, an asset is typically valuable in the sense that it can be owned or controlled and turned into economic value. Labelling data as intangible asset helps us understand it more broadly than earlier suggestions such as calling it a data asset or information asset (see e.g. Borek et al. 2013). One important question to ask then is if data can be propertized, i.e. creating a property (that can be held exclusive) from a resource (as defined in Granstrand 2018). That could perhaps incentivize trade in data and thus enable further diffusion of existing data in different applications. With data being an intangible asset, multiple important questions need to be answered on firm level. How should firms strategically manage their data? How should firms protect their data? How can data be valued? Which legal mechanisms should cover data? All these questions would however be relevant if data was considered as an IP as well. The distinction between data as an intangible asset, rather than an IP, thus should have no direct implications for a firm.

5.3.3 The protection and management of data in firms

The above argument might be used to support a common misconception regarding data, that it cannot be protected through legal mechanisms. This might in turn cause firms to think of the protection of data as an IT issue, partitioned from the IP management (as also suggested by some of the interviewees). Here, however, it is important to note that there are in fact ways for firms to gain legal protection of their data through the protection of the databases the data is stored in. Databases can in fact be considered IP. The creation and design of a database is typically based on some intellectual effort by product engineers and programmers. This also motivates why firms in fact can gain certain IPRs for their databases. First, copyright protection over a database is given if it is original and structured in a creative way. For this, a firm could ensure originality of the databases, in which their valuable data is stored in, with the help of internal database experts that make sure that data is structured to meet these requirements. Second, the EU provides database rights as long as the database has required some investments. This should impact where firms decide to store its data. Third, trade secret rights protect data as long as it is kept from being disclosed to actors outside of the focal firm. As such, it is not a useful protection mechanism for sales and trade of data. It does, however, give certain protection towards cyber espionage and similar threats. Through the protection of data(-bases) with database rights, copyright and trade secret rights, more strategic protection of data can be made possible. This also means that the protection of data can be seen as a question for IP management.

For firms, there is value in handling different IPs (and other intangible assets) together (Reitzig 2004; Al-Aali & Teece 2013). In light of the above analysis, it should not be of any importance whether the intangible assets are “intellectual” in their nature or not, i.e. whether they are the result of creations of the mind or not. This is merely a question of semantics. By incorporating data management under the umbrella of what today typically is called IP management, potential synergies and complementarities could be expected. If all intangible assets were to be managed together, firms could potentially increase the total value of the intangible assets. For example, a firm from a mechanical industry may be able to approach a potential AI software partner with not only products to analyze and develop intelligence around, but also data to be used in the process, which in turn might help motivate additional IPR allocation towards the mechanical firm in negotiations or lower costs. It thus seems reasonable to say that data should be managed within the overall IP strategy, which then consequently rather should be called intangible asset management or intangible property strategy, again for semantical reasons.

6 Conclusions and implications

The empirical material gathered from the interviews in this study reveal a number of interesting perspectives that in the light of earlier research make out important key findings. These findings should also impact the existing bodies of theory in the field, as examined earlier in the Theoretical framework section. Further, these findings matter for decision makers at managerial level. The section below provides an overview of the findings the authors consider most relevant to theory, and their implications for managers. Finally, potentially interesting topics for further research are presented.

6.1 Major findings and theoretical implications

Perhaps the best way to understand why firms bring in digital technology to enhance the value of their products and business models is through technological complementarity. For firms without the digital competence, this however requires the acquisition of digital technology, which tends to be largely driven by external acquisition strategies, most importantly through different types of collaborations. This confirms the view found in earlier research that external technology acquisition strategies are increasingly important (see Chesbrough & Brunswicker 2014). This increased importance of open innovation approaches enhances problems of balancing openness and protection of knowledge and technology which thus makes appropriation more complex.

The increased amount and importance of external actors for the acquisition of digital technology also brings in actors from other industries with more aggressive IP strategies. The case presented in Holgersson et al. (2018) illustrates that when firms within an industry are faced with aggressive IP strategies, that might cause a convergence of IP strategy towards these more aggressive approaches. This study further suggests that as digitalization brings together firms from different industries with different attitudes towards IP strategy, a shift towards more aggressive IP strategies can be expected. Some of the studied firms also show important signs that more aggressive IP strategies are being introduced. This study also concurs with the view in Holgersson et al. (2018) that a firm-level analysis of profiting from innovation as presented in Teece (1986; 2006) has limitations in more complex settings where complementary (and substitute) technologies and corresponding appropriability regimes can be seen. Taken together, it can be said that IP strategy should be viewed to an increasing extent from an innovation ecosystem perspective rather than from single-firm perspective.

The appropriability regime for digitalized products and innovations become weaker as the protection strength of digital technology through patents is weaker. This has also been found in previous research (see Teece 2016). This study further found that firms patent digital technology primarily by putting it in specific contexts or applications, i.e. in the methods or functions it is used in. In regards to firms' perspectives on patenting digital technology, this study has also found that the speed of which digital technology is developed in adds an uncertainty element to whether it is worth patenting digital technology or not. Earlier research suggests that choices between patenting, maintaining secrecy or strategically disclosing inventions typically should lean in favor of patenting (see Holgersson & Wallin 2017). This study, however, suggests that these decisions are blurred by digitalization as protection of digital technology with patents is relatively weak.

Further, it is shown in this study that rather than achieving robust, wholesome protection, firms seem to primarily patent differentiating aspects of their products with digital technology. Following this, firms need to think largely in terms of risk management and strategic patenting, rather than being fully sure of their FTO. Patenting to gain watertight protection on innovative products (see proprietary patenting strategy as defined in Somaya 2012) has thus fallen out of favor for firms entering digital technology areas. Another generic patenting strategy, focused on achieving FTO seems more relevant for the interviewed firms. However, this study also shows that achieving FTO within the digital technology field is more difficult compared to, for instance, mechanical technology and other non-digital technology areas. As such, we argue that FTO-analyses may have to become more statistical and a matter of risk management. This claim can also be supported by the finding that patent landscape of digital technologies is seen as more complex than that for e.g. mechanical technologies. Despite this, no signs of an overall decreased propensity to patent can be seen or motivated among the interviewed firms. Following Teece (1986), this is somewhat paradoxical as a weakening of the appropriability regime should de-incentivize firms to patent to the same degree. One reason why patenting propensity appears to be as relevant is due to the seemingly higher risk of patent infringements involved in releasing a product with digital technology. Having patents that cover certain digital technology means that firms have "something to bring to the table". It could also be argued the rationale of appropriability regimes in large resonates with a proprietary patenting strategy, which again seems to have fallen out of favor. Appropriability regimes of core technology might then be of less importance, while the appropriability regime of complementary technologies might be of higher importance as these can be used in negotiations and for pre-emptive purposes.

In addition to patents, secrecy is feasible for certain digital technology. Taken together with copyright for certain software protection, IPR in general, and patents more specifically, still has an integral role to play for the appropriation of digital technology. However, this role must be more strategic and actively managed as multiple IPR forms are relevant for digital technology. Reitzig (2004) and Al-Aali & Teece (2011) have highlighted this importance before in a more general sense. This study, however, gives some concrete reasoning to why this is the case (see the Analysis section).

As firms digitalize, it typically includes the installment of sensors in products that generate data. This data can be transformed into valuable information in business decisions, used for automation of processes, improve maintenance of products, or enable added new service offerings. This together makes data an important and valuable asset. Data is however not an IP, as an IP requires some sort of (human) creation, while data (in the case of the firms in this study) typically is created by sensors. Regardless of this, data is an important intangible asset for firms. For some exploitation forms of data, e.g. collaborations or sales of data sets, protection mechanisms should play an important role, as it does for technology trade and open innovation (as shown in Henttonen et al. 2016, Hagedoorn & Zobel 2015, and Holgersson & Granstrand 2017). We therefore propose that databases should be seen as the key unit of analysis and management, as the structure (and contents) of a database can be protected through multiple IPR forms, such as database rights, copyright and trade secret rights. This further calls for an integrated management of data and databases together with other intangible assets for the strategic management of intangible assets at large in firms.

6.2 Managerial implications

While it can be noted that much of the above discussion primarily is relevant to theory, there are important lessons to be learned for managers, especially managers within the IP field.

First, when becoming increasingly digital, firms needs to take new actors into consideration for their strategies. This includes actors such as technology development collaborators, NPEs, and firms from the telecom and the IT industry. These actors may bring new and heavily patented technology areas, patents with more questionable validity, and more aggressive IP strategies.

This makes ensuring FTO for new products more difficult. Managers must therefore consider whether to proactively move into areas where there is potentially relevant IPR held by actors with more aggressive IP enforcement. There might thus be reason to reevaluate the current IP strategy and reconfigure it to the new IP landscape and the new actors.

Second, there might be a need to acquire new IP competence in firms to effectively manage digital technology. Multiple approaches for this was presented above. From a strategic point of view simply using external consultants (e.g. patent attorneys for protecting digital technology) might be problematic as this approach is likely to miss a strategic alignment with the new actors involved.

Finally, the management of data should be focused on database design and database protection through IPRs. That means that both IT and IP departments should be involved in the data management. Currently, IP managers often need to ensure that important inventions discovered in the R&D or product development department are patented. Similarly, the IP managers might need to ensure that important data is stored only in databases that are designed specifically for its use and thereby potentially give database or copyright protection. That would not only mean that the value of the data can be ensured. It might also increase the value of the data as the opportunities to use it for negotiation and trade purposes is made possible. This also implies that data management needs to considered in larger business model changes towards digitalization.

6.3 Suggestions for further research

This study has uncovered a number of relevant areas within the IP management field that could be studied further. Below follow brief discussions on four such potential areas for future research.

First, this study showed that data and its value is an important topic for research, with high relevance to managers in not only telecom and IT firms but for firms in many different industries. Multiple questions are yet to be answered: is there need for a data strategy in firms? How can firms value, protect and manage data? Which legal mechanisms should cover data?

Second, this study's empirical findings suggest an increased relevance of research on innovation ecosystems, and the allocation of IP within them. Complex forms of collaboration become increasingly important, and in these IP need to be managed. Holgersson et al. (2018)

marks an important first contribution to how IP strategy is shaped in innovation ecosystems. However, this study implies that this is an increasingly relevant topic that calls for further research.

Third, this study lacks sufficient data on how data actually is managed in firms, probably largely because data is not proactively managed in most of the interviewed firms. This, however, calls for more hands-on research for the development of theory and frameworks for data management in a business context, similar to that of how the management of patents has become increasingly a business issue.

Fourth, this study is limited to interview data. Further research is still needed to investigate the issue further by utilizing different methods and approaches. Patent data studies could be used for investigating how firms actually patent their digital technology. Perhaps patent data could also be used to investigate how IP is allocated in collaborations (some important restrictions are already worth noting here, as firms typically appear to avoid "shared patents"). Also longitudinal case studies could be utilized to increase the understanding of how IP strategy changes in relation to digitalization over time.

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Appendix: Interview question template

Background

1. Briefly tell us about your background.
2. Briefly tell us what you are working with here.

Digitalization

1. How digital do you think your company is?
2. Which functions are most digital?
3. How digital are your products and offerings?
    a) Could you provide an example of a digital innovation developed internally?
    b) How large is your share of products with digital elements?
    c) How is the share of digital technology in the firm changing?
    d) What types of digital technology are developed internally?
    e) How digital are your business models?
    f) Do you have dedicated digitalization experts?
4. Which trends do you see in regards to innovation and digitalization?
    a) What will be your most important product offerings in the future?
    b) How will your share of R&D dedicated to digital technology and non-digital technology change?

Technology strategies

1. What approaches does your company use for acquiring new technology?
2. Has digitalization affected which technology acquisition approaches your firm use?
3. What approaches does your company use for exploiting new technology?
4. Has digitalization affected which technology exploitation approaches your firm use?
5. Does digitalization make new firms or industries relevant?
    a) Have you come across new IP strategies?
    b) Have you had to adapt your IP strategy to other industries' IP strategies?
    c) Have you changed your work?
6. Which actors have been the most important in your technology strategy?
7. How has digitalization affected your collaborations?

IP-strategy

1. How do you view the link between technology and IP?
    a) What role does technology and IP have at your company?
    b) What are your primary reasons to patent?
2. How is your IP department positioned in the larger organization?
    a) Who has responsibility for trademark, copyright, design rights, trade secrets, and databases?
3. How has digitalization affected your IP strategy?
    a) Has it brought new challenges?
    b) Has it brought new opportunities?
    c) Has it changed how you collaborate internally?
    d) Has it changed how you collaborate with external actors?
    e) Should there be more change?
4. As a result of digitalization, has the types of IP or IPRs changed?
    a) Do you have more or less patents on digital innovations compared to other technology areas?
    b) How large share of your technology is patented today?
    c) Has the share of technology being patented changed in recent years?
    d) How has the geographical scope changed as a result of digitalization?
    e) Have you had to adjust your IP strategy because of new actors that have earlier not been relevant?
5. Do you expect more infringements and litigation cases as a result of digitalization?
    a) How easy or hard is it to navigate in prior art within digital technology?
    b) How easy or hard is it to identify if others are infringing?

Glossary

Appropriability: Factors external to a given firm determining the ability of capturing profits from an innovation (Teece 1986).

Appropriability regime: The possibility to protect knowledge and innovations from imitations.

Business model: The way in which a firm creates, delivers and captures value to its customers.

Copyright: An exclusive right preventing copying of artistic and creative work.

Data: Some sort of information that typically requires transformation to be made into understandable or useable information. A subset of data is *digital data* which then corresponds to data stored in the form of binary number series.

Database: Data collected and organized typically in some digital format, e.g. servers.

Database right (sui generis): A property right protecting databases. Unlike copyright, it does not require a creative arrangement, but some investment to have been made for the creation of the database in question.

Datacom: Refers to the industry in which firms are working with software.

Digital product: A product that contain a reasonable amount of digital technology.

Digital technology: Electronic technology that operate with digital signals, i.e. electronic signals that represent binary code series. Typically involves some sort of circuits arranged for computational processing power.

Digitalization: The increased embeddedness of digital technology in firms' products, processes, and business models.

Digitalize: Activities in firms for digitalization.

Freedom to operate (FTO): The ability to commercialize a product or process without infringing on IPRs held by others.

Information and communication technology (ICT): Technologies related to different forms of electronic communication. In this thesis strictly used for digital information and communication technology, e.g. internet technology, data communication, etc. Often called infocom technology.

Innovation: Novel applications of ideas. Could be technical, i.e. an invention (a novel technology of some kind) that has found some use or application. Could also be new approaches to applying ideas, e.g. new ways of selling a product (cf. business model innovation).

Innovation ecosystem: "A system of interconnected innovation actors, resources, activities, and institutions connected by organizational and market relations" that engage in innovative activities (Holgersson et al. 2018, pp. 303).

Intellectual property (IP): "Creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commerce" (WIPO, I, pp. 2).

Intellectual property management: The practice of managing IP and IPRs within an organization.

Intellectual property right (IPR): Legal property rights, functioning as a mechanism to protect some kinds of intellectual property, e.g. patents for technology, copyright for creative output, etc.

Invention: A novel technology in the form of a device, method, or process.

License: An official permit to do something. A patent license allows the licensee to execute activities otherwise protected by patent rights.

Multi-invention contexts: Products or product contexts where multiple inventions are involved. A multi-invention product thus contains a combination of multiple inventions.

Multi-technology corporation (MTC): A firm that has a technology base with multiple different technological areas.

Non-digital technology: All technology is not considered digital, cf. digital technology. In this thesis primarily relates to mechanical and material technology.

Non-practicing entity: A holder of a patent not intending to develop products or processes based on said patent.

Patent: A property right for inventions giving the right to exclude others from using the said invention, typically for 20 years at most.

Patent landscape: The relationships and coverage of patents and disclosed technology within an arbitrarily large field. In this thesis refers to the coverage of patents in a particular technological area.

Physical product: A product that is tangible and in itself contain no intangible parts, such as digital technology.

Physical technology: Technology that in applied form is tangible.

Propertize: The activity of creating a property (that can be held exclusive) from a resource.

R&D: Activities for developing new or improving existing technologies, products or services.

Resource: Tangible and intangible assets that are tied to a firm.

Royalty: A payment done by a licensee to the licensor for the right to use the particular asset in the focal license.

Technological complementarity: "Technological complementarity occurs when the value of an innovation depends on altering the nature of one or more existing technologies and/or on creating new ones" (Teece 2016, pp. 15).

Technology: "A body of knowledge about techniques and technical relationships" (Granstrand 1999, pp. 418).

Technology base: The set of technology held by a single firm.

Technology diversification: The activity of broadening the technology base of a firm by acquiring technologies in new technological areas.

Telecom: Refers to the industry in which firms are working with ICT.

Trade secret: Some sort of secret information held in a firm that has economic value and can be used for some economically beneficial activity.

Trademark: A recognizable mark that can be used to identify a product or service from other such.