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Spreading green IoT tech through mechanisms of sharing intellectual property

Master's thesis in Entrepreneurship and Business Design

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SUMMARY

If IoT tech is spread and utilized on a broad scale in manufacturing, it has the capacity to heavily reduce energy consumption. Through the reduction of energy consumption, the Global e-Sustainability Initiative (GeSI) and Accenture (2015) estimates that IoT tech can reduce the global greenhouse gas emissions by 4.4 % in 2030. In this setting, IoT tech should be classified as green technology, according to the UN´s definition from (1992). Green technologies, such as green IoT is often proprietary to the innovator through patents. A patent is a negative right, preventing others from practicing the patented invention (Morrison, 2020). In this way, the patent system promotes innovation, since it rewards innovators investment with commercial possibilities through patents (Kitch, 1977). Standard essential patents (SEPs) are patents for technologies deemed to be essential for the functionality of other technologies within the technological field. These are common in the IoT and ICT industry and effectively made accessible through licensing terms which are Fair, Reasonable and Non-discriminatory (FRAND) (Blind, Gauch, & Hawkins, 2010). In IoT all technological elements are not deemed to be standard essential. Hence, all the technologies are not effectively made accessible and spread through FRAND (Trappey, Trappey, Govindarajan, Chuang, & Sun, 2017). To enable IoT to make its environmental benefits in manufacturing, this thesis aimed to answer the question of how companies that have a solution to make manufacturing more sustainable through IoT can create effective intellectual property sharing initiatives to allow their technology to be utilized on a broader scale.

To answer the question, past green tech sharing initiatives were investigated through a literature review. Opinions on spreading green tech and green IoT manufacturing technology in particular were also generated and analyzed from intellectual property professionals through semi-structured interviews. The results suggest that to reach broad spread and usage of the computational layer of IoT, through sharing mechanisms of intellectual property rights, there must be mutual benefit, with low risks of economic backlashes for the patent holder of the technology, the licensor, and the user of the technology, the licensee. Furthermore, ambiguities around the technologies value, licensing terms, successfulness of technology transfer and the technology scope must be dealt with through an effective sharing mechanism of IoT patents.

A semi-open patent strategy, with standardized licensing terms, a cost reduction percentage-based payment model, inclusion of know-how and with technology implementation is suggested by the results to be the most suitable mechanism to generate value for the licensee and licensor while also mitigating risks concerning mentioned ambiguities. Thus, spreading green IoT and allowing it to generate value and environmental benefits.

This study can be used by companies in possession of green tech solutions characterized by software to enable a broad usage of their patents, thus generating value environmental benefits.

Keywords: green tech, patent sharing initiative, spreading technology, technology diffusion, technology transfer, green IoT

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Terminology

CSR	Corporate Social Responsibility
EcoPC	Eco-Patent Commons
ICT	Information and Communication Technology
IoT	Internet Of Things
IP	Intellectual Property
IPRs	Intellectual Property Rights
IPS	Intellectual Property Strategies
SEP	Standard Essential Patent
WIPO	World Intellectual Property Organization

1. Introduction

This chapter will provide the background to the study, the aim and research questions as well as delimitations of the study.

1.1. Background

Global climate change presents one of the most pressing environmental problems today. Rise of global temperatures, degraded air and water quality, accumulation of waste in the oceans, and more. The effects of climate change are not news to anyone today, but with harmful greenhouse gases continuing to rise there is an immediate threat to the planet. To lower the emitted gases into our atmosphere, societies need to use the planets' resources in a more sustainable way. New technologies can be one part of the solution. Not technologies that generate even more growth and more greenhouse gases, but technologies that can be used over time without the risk of further damaging the earth. Technologies aimed to do this can be called green technologies. The UN claims that green technologies "protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual waste in a more acceptable manner than the technologies for which they were substitutes" (United Nations, 1992).

Cellular devices, Internet of Things (IoT), and other primary means of communication are the foundation of modern society. The ICT-sector is what makes modern society possible. The networks that our connected devices depend upon are constantly being developed with the increased demand of connectivity. Innovation within the sector significantly contributes to the growth of productivity and economic development (Organization for Economic Co-operation and Development, OECD, 2004), hence it is a globally important sector. For example, mobile broadband is an enabler of sustainable development, economic growth, and reduced carbon emissions (Ericsson, 2020).

IoT solutions can bring financial benefits to several different fields, such as manufacturing operations to increase efficiency. More efficient manufacturing is one way that IoT solutions can provide significant environmental benefits. The Global e-Sustainability Initiative (GeSI) and Accenture (2015) estimates ICT, with IoT included, can reduce the global GHG emission by 20% by 2030. The enablement of smart manufacturing through IoT can make up 22% of the total emission reduction, while also saving billion liters of water. With IoT's environmental benefits, it would be classified as green technology.

If innovations are novel, have inventive height, have not been disclosed, and qualifies for patent eligibility, the inventor can claim the right to the technology through a patent. The patent system exists to promote innovation by granting the inventor the sole right to utilize the patented invention for commercial purposes. Thus, rewarding the innovator for her innovation and gives her the financial means to further innovate and drive technological advancement (Kitch, 1977).

In the field of green technology there have been a variety of proposals to increase innovation and broad usage of technology (Contreras, Hall, & Helmers, 2019). Although patents give the owner the right to exclude others from using the inventions, an increasing number of companies across different industries have started or joined different patent sharing initiatives for green tech. Depending on the structure of the initiatives, companies voluntarily limit their ability to seek compensation or exclusivity. Examples of green tech patent sharing initiatives are pledge initiatives such as Eco-Patent Commons, Low-Carbon Patent pledge and Tesla's patent pledge (HPE, Facebook, & Microsoft, 2021; Tesla, 2021). There are also initiatives with more control over the accessibility to the patents, such as WIPO Green and GreenXchange (Roya & O´Brien, 2012). Since IoT can be defined as green tech, the principles of past green tech sharing initiatives may be beneficial for the spread and broad usage of patents covering aspects of IoT solutions in manufacturing. With effective sharing mechanisms for patent rights regarding IoT solutions, the technology can reach its full value creation potential and generate both environmental and financial value.

ICT industries are highly dependent upon standards (Blind, Gauch, & Hawkins, 2010). Standards are a means of maintaining quality, provide information and interoperability among working systems. A4 papers, plugs, switches, etc., are types of standards, and they give consumers the freedom to choose or change supplier without impacting the existing system. Furthermore, standards drive economic interpenetration amongst actors, simplifies product development and levels the playing field for actors engaging in the technology (Prakash & Raju, 2021). Standards in the ICT industry includes both hardware and software. The information formatting standards are however the most prominent. It concerns programming languages, operating systems, communication protocols, etc., which enables interoperability between devices. Thus, enabling cellular communication, IoT, etc. (3GPP, 2021).

Technologies which are deemed as standards are also eligible for patenting if they fulfill the previously mentioned criteria. Patents that are necessary to implement a standard are declared as standard essential patents (SEPs). Innovators and businesses who have SEPs have a market leadership-role. Since products and solutions within the technological field of a SEP will build on the SEP protected technology, it raises the value of the SEP. Both because it has been deemed by standardization organizations to be the best technology for society, but also because other technologies within the technological field will have to build on the SEP protected technology to enable interoperability with other products and services (Pohlmann, Neuhäusler, & Knut, 2016). Such standards are for example related to 3G, 4G and the emerging 5G (3GPP, 2021).

In the ICT industry standards are often set through the interplay between several patents from different firms. For instance, standards relating to Wi-Fi and Universal Mobile Telecommunications Service (3G) functions through multiple SEPs, held by different firms. To enable the usage of standards in industry and society, firms with the best technologies agree to either cross-license these essential technology patents, formulate a standard, or to license a standardized technology package, consisting of multiple SEPs, under FRAND (Fair, Reasonable and Non-discriminative) terms (Prakash & Raju, 2021). FRAND entails reasonable pricing, and that the technology is accessible for all who wish to use the technology. Through FRAND, the best technologies are available for a reasonable price and consumers can easily access the technologies. Also, the innovators that are developing the state-of-the-art technologies get compensated for their innovation and maintain the incentives to innovate. Thus, driving technological advancement for society to benefit from (Prakash & Raju, 2021; Hill 1992).

Far from all technologies are however deemed to be standard essential, thus not declared as SEPs and effectively shared and profited from through FRAND (Baron & Pohlmann, 2018). Many technologies in the IoT are enabled by SEPs but the functions themselves, which utilizes SEPs to function, are not recognized as standard essential (Trappey, Trappey, Govindarajan, Chuang, & Sun, 2017). Trappey et al. (2017) explains the structure of IoT as having four different layers: Application, Computation, Transmission and Perception. The perception layer includes the sensors that collect data for IoT to process and the actuators that creates an action. The transmission layer enables communication between devices. The communication protocols and technologies are standardized and often protected as SEPs and shared through FRAND licensing terms. The computation layer consists of software, algorithms, hardware, and cloud computing. There, data is processed, and decisions are made. Finally, the application layer enables the IoT system to communicate with the consumer by creating a window between the network and user.

The technology innovation in the transmission and computation layers are highly characterized by software. Software itself is not patentable. However, software patents can be granted for inventions which use technical means, solves a technical problem, or brings a technical effect/advantage, and if the solution is non-obvious (Heckeler, 2019). As mentioned, the transmission layer often constitutes of technologies classified and protected as standard essential patents (3GPP, 2021). However, that does not apply to the same extent for the technologies in the computation layer. Still the patented technology plays an important role in the enablement of IoT applications (Trappey et al., 2017). Therefore, inventions relating to the computational layer of IoT applications is the focus of this study.

This thesis aims to investigate effective sharing mechanisms for patents in order to propose such a sharing mechanism for green IoT. Hence forth, the computational layer of manufacturing-IoT will be the chosen area for green IoT.

1.2. Aim and research questions

This study will generate an understanding of how sustainability enabling IoT in manufacturing can be spread and broadly utilized. The objective is to provide insights into how other industries have managed the spread and usage of green technologies on a broad scale, and ultimately provide a practical and effective IP strategy for spreading sustainability enabling IoT in manufacturing.

The main research question is:

- How can companies, that have a solution to make manufacturing more sustainable through green IoT manufacturing technology, create effective intellectual property sharing initiatives to allow their technology to be utilized on a broader scale?

To answer this question the following sub-research questions will be addressed:

- What can be learnt from initiatives sharing green tech?

- Based partly on insights from these initiatives, what do intellectual property decision makers prefer for sharing green tech in general and for green IoT manufacturing technology, in particular?

1.3. Delimitations

This study will not focus on spreading green IoT manufacturing technology towards developing countries. The reason is that developing countries seldom have a functioning IP system.

Spreading and enabling usage of technology can be studied from multiple perspectives, e.g., both an inward and outward perspective. This study will mainly focus on the outward perspectives of technology transfer and not on the receiving companies' absorptive capacity.

IP strategies generally include many organizational aspects, such as how businesses should protect their innovation, how the protection and usage of intellectual property rights is integrated in the overall business strategy, etc. This thesis will only investigate the aspect of how green IoT technology developing businesses should utilize their intellectual property to enable broad spread and usage of green IoT manufacturing technology.

2. Theoretical framework

This chapter explains the fundamentals of IP and how patent sharing initiatives emerged. Furthermore, the chapter includes several patent strategies and frameworks for how different factors affect the willingness to share patents.

2.1. Background to green tech patent sharing initiatives

Several well-known economists have requested for policies to encourage both public and private investment in technologies that are aimed to mitigate climate change (Hall & Helmers, 2013). In the field of green technologies, several initiatives aimed to increase innovation and spread technologies have been made, sometimes involving adjustments to the patent system. There have been governmental strategies to increase the number of green tech patents in society by e.g., “fast tracking” green patent applications, to encourage the investment that the private sector puts into green tech. There have also been initiatives to decrease the patent strength of green tech, by e.g., compulsory licensing from governments (Contreras, Hall, & Helmers, 2019).

One of the most widely available policies that is designed to encourage private R&D investment in majority of the world is the intellectual property (IP) system (Hall & Helmers, 2013). This study focuses on the private sector approach for spreading green technologies: patent sharing initiatives. Patent sharing initiatives take shape in different forms, e.g., patent commons. Patent commons greatly differ from other mechanisms that are used in the ICT-industry, such as cross-licensing agreements and patent pools (Contreras, Hall, & Helmers, 2019). For example, in cross-licensing agreements, access to patents is only granted to companies with participating patents. Patent pools can often be accessed for a fee for outside companies wanting to take a license and the purpose is mainly to reduce transaction costs, avoid duplication, mitigate patent hold-up, etc. (Maggiono, Marin, Charry Morales, Orlando, & Guegan, 2020). In the case of patent commons, the commons typically benefit all parties, regardless of contribution to the commons, and normally without a formal contract or payment (Contreras, Hall, & Helmers, 2019). Patents that are pledged to a patent commons can be done with several companies or as a sole company, for several reasons. The aim can be to set a new technology platform, or setting product interoperability through common technical standards, and philanthropic or corporate social responsibility (CSR) goals. Philanthropic goals are a major distinguishing factor between common patent pools and patent commons. Patent commons for green tech are founded to provide a place where green innovations can be easily shared, to accelerate and facilitate implementation to protect the environment, while also preferably leading to additional innovation that builds on the technology. Patent pledges have been made several times during the last decade, for example in the open-source community (IBM, Red Hat, Google) where no legal assertion would be made for hundreds of their pledged patents, for electric vehicles (Tesla, Toyota), hydrogen cell vehicles (Toyota), amongst others (Vimalnath, Tietze, Prifti, & Akriti, 2020).

Patent pledges are relatively open, considering that any actor that wants to use the pledged technology can do so if the terms of the pledge are followed. Patent sharing initiatives that allow the green tech patent owner to have more control over the usage of the spread technology are licensing initiatives. Licensing can take different forms, and more collaborative mechanisms are green tech sharing platforms where companies post their green tech patents. When companies have posted their green tech patent on a platform, it shows that the technology is available for license (Vimalnath, Tietze, Prifti, & Akriti, 2020).

2.2. Intellectual property

As discussed by Petrusson (2004), for technology companies that are actively pursuing R&D activities, IP is one of the most important building blocks for value creation in a business setting. Intellectual property rights (IPRs) can be used not only to block competitors, but also to be used creatively to transform R&D into products, ventures, commercial transactions, and markets. This is true regardless of the company is producing physical goods or a so-called knowledge-based business that companies transition to in modern times. Today, in what we can call an intellectualized economy, knowledge-based businesses in sectors such as the ICT industry do not get their value from only producing physical goods. With production of physical goods being located in low-cost countries, one of the ways to extract financial value in other ways is through using IP. It is no longer considered very controversial to claim that wealth and growth are increasingly driven by investments in, and governance of, intellectual assets, capital, and properties. In the intellectualized economy we are present in, businesses must appreciate how scientific discovery, technological change, and innovation are crucial for creating and sustaining growth. Human resources in a company are therefore not only leveraged into physical products, but into virtual products and license offers. Not to say that the physical products and its material value chain is non existing but extracting value in the intellectualized economy entails being active both the material and an intellectual value chain (Petrusson, 2004).

IP is a judicial field which has a long history of defining technology and innovation. Patents are one of the means to capture IP. If an inventor develops a novel innovation and files patents for the innovation in one or several of the world´s patent offices, the owner has the sole right to exploit the patent in the countries in which the patent has been granted. To decide whether an invention is novel, the patent office's require thorough documentation over, for example, what the innovation looks like, how it operates, which components it utilizes, amongst other factors. The inventor is obliged to append this information with the patent application to describe and characterize the innovation (Kitch, 1977). In other words, the inventor needs to define the innovation to be able to patent it.

Other means of protecting IP is through trademarks, trade secrets and copyright. In short, a trademark can be any word, symbol, phrase, design, or a combination of these, that identifies your goods or services (Landes & Posner, 1987). A trade secret is an internal practice or process which is not generally known outside a company. It is often a product of internal R&D and gives companies a competitive advantage. In contrast to trademarks and patents, trade secrets are not gained through an application. Companies are legally entitled trade secrets if they have taken reasonable measures to conceal the information to the public. Furthermore, trade secrets must have intrinsic economic value and contain information. It can take the form of patterns, formulas, codes, programs etc. (Frankefield, 2021). Lastly, copyright protection can be received for a product which is deemed as original and requires substantial mental activity to create. This includes computer software, art, musical lyrics, graphic designs etc. Like trade secrets, copyright protection does not need an application. It is granted if the mentioned criteria are fulfilled and it limits others from copying and using the copyrighted material (Kenton, 2020).

Communicating intellectual phenomena into the construction of IPRs is a crucial part of innovation. For example, patent claims are, when drafted, communicative claims in relation to the patent examiner, which, if granted, will define the patented invention as well as the patent. The tool of communicating what is claimed in the patent is a communicative process between the inventors, patent attorneys and patent examiner, and it is used to transform human resources into a specific patented invention. Having claimed a patent, it can be used to construct commercial offers, license agreements, R&D agreements, and agreements on strategic alliances. How the patent is constructed will affect the business goals, if it is to create competitive advantage to e.g., deter imitation and slow technological substitution or to block technical advance of competitors, or how to establish license structures in relation to customers, provide access to the technologies of others through cross-licensing (Petrusson, 2004).

Governments and businesses have had many ideas for different initiatives to develop green tech solutions on a broad scale in recent years. Legal scholars and economics have studied a variety of innovation mechanisms, including patents, prices, grants, and tax credits, among others (Ebrahim, 2020). The reason IP, and especially patents, are of special interest in this study is that the patent system is constructed to incentivize innovation and foster spread and usage of technology (Kitch, 1977).

2.2.1. Digital/Software patents

As mentioned previously, IPRs can be protected through patents, trademarks, copyright, and trade secrets (Petrusson, 2004). Additionally, there are three different types of patents. Innovations can either be patented as design patents, which protect ornamental design, plant patents, which protect asexually reproducing plants, and utility patents, which protect the underlying embodiment of an idea in an invention (Rodau, 1985). Utility patents are the most common form of patent application. Technology progression forces patent structures to develop. Therefore, two subclasses of utility patents have occurred: business method patents and software patents, Business patents are directed towards specific methods for conducting business. These are relatively hard to obtain protection for because the distinguishing between a business method and an abstract idea of conducting business is generally difficult to do. The other subset of utility patents, software patents, are directed towards software and how it together with computer hardware carries out a task of technical task (Misterovich, 2017). Software, and the code it consists of, is generally protected through copyright or trade secrets. Copyright is however a relatively weak protection because it covers the actual structure of the code and not the function it provides. Hence, by rewriting the code, the same technical function could be achieved without violating copyright protection. The technical function of software can however be protected through utility software patents. In a patent, the software code enabling the technical function is not specified. Hence, by licensing a software utility patent, solely the right to the technical function is obtained, not necessarily the actual software code which enables the technical function (Kastenmeier, 2013).

2.3. Technology transfer

Technology transfer is the application of information (a technological innovation) into use (Gibson & Rogers, 1994). The process of technology transfer normally includes the movement of a technological innovation from an R&D company to a receiving organization.

When transferring technology, both the absorptive capacity of the licensee is important, as well as the desorptive capacity, which refers to a company's ability to outward transfer technology (Lichtenthaler & Lichtenthaler, 2010). In this study, the main aspect will be the desorptive capacity, which consists of two stages, *identification,* and *transfer*. Identification of technology transfer opportunities are often underestimated, but in this study the demand of green IoT in technology markets is argued to be high. The second stage regards the actual transfer of technological knowledge to facilitate an application at the recipient. Transferring technology does not mean that the company that transfers the technology is not using the technology in their own products. Therefore, the process of transferring technology successfully often needs active participation and support from the technology source to make sure that the application is successfully. In the agreements that are a part of the technology transfer, the terms often include support from the transferring company, and is an important part of the agreements. The ability for the transferring firms receive income from royalties of the technology transfer often relies on a successful transfer, application, and commercialization (Lichtenthaler & Lichtenthaler, 2010).

As argued by Rogers, Takegami and Yin (2001), technological innovation can be considered to be fully transferred when it is commercialized into a product that is being sold. There are different mechanisms that facilitate technology transfer, such as spin-offs, publications, meetings, cooperative R&D agreements, and licensing. International technology transfer normally takes place through trade, foreign direct investment, joint ventures with local partners, or technology licensing. In all cases, IP is important since foreign firms are risking that imitation by local firms can occur, and therefore reduce profits. (Rogers, Takegami, & Yin, 2001)

A company that transfers technology through licensing can both aim to establish an industry standard and achieve learning effects. Actively licensing technology can generate an industry standard, as explained in the 1.1. Licensing can also generate learning effects, for example licensing unused knowledge that can be licensed to other companies, and when the receiving firm have successfully implemented the technology, the firm with the technology can afterwards start to adopt the technology. Examples of learning effects are for example the swiss company Sulzer Rueti, that transferred technology to a Japanese competitor in the form of a joint venture, and the competitor invented 150 new ideas to improve the technology. The new inventions then improved Sulzer Rueti's new innovations (Lichtenthaler & Lichtenthaler, 2010). Another example is Air Products that licensed their unused knowledge, and later used it internally when identified that it was advantageously implemented by the receiving firms (Chesbrough & Garman, 2009). In summary, technology transfer can significantly improve both the receiving firms' operation, but also the licensing firm's financial performance, especially when the technology has been transferred and implemented.

2.4. Sharing intellectual property rights

The old traditional way of driving business, called Closed Innovation, had a philosophy of solely tending to your own operations and IP was used to make sure that other actors were locked out of using your IP. It was based on the idea that successful innovation requires control. To be successful companies would have to generate their own ideas, develop them, construct them, bring them to market; be self-reliant. This internally focused logic revolves around what Chesbrough (2003) calls: "The Virtuous Circle", seen in Figure 1.

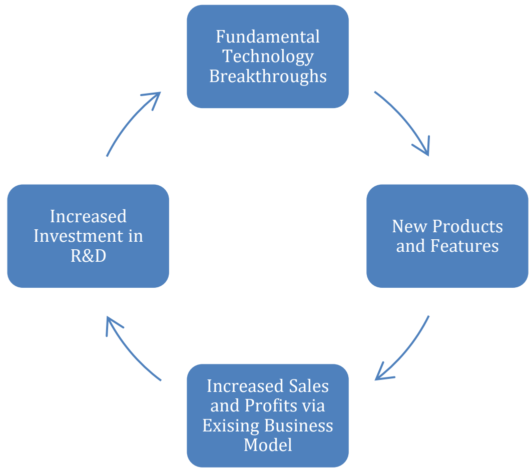

Figure 1, Adapted version of The Virtuous Circle by Chesbrough (2003)

Businesses would invest in their own R&D, make technological breakthroughs, use the breakthroughs to bring new products and services to market and generate more profit from those products and services. The generated profits would then be invested in internal R&D and the cycle would repeat itself. In the Virtuous Circle IP was used as a barrier, making sure that businesses´ self-reliant innovative silos would not be disturbed.

The paradigm shift into open innovation began when there was an increase of knowledgeable people who began to start their own companies with the financial backing of strong venture capitalists. Silo-like closed innovation structures could no longer guarantee they had the best products, and their innovative rate were often too slow to compete with other fast-growing actors. To solve this, businesses shift into the philosophy of open innovation, combining internal and external ideas to create value (Chesbrough, 2003). Under an open innovation paradigm, businesses can license technology which they do not find necessary for corporate performance. Furthermore, technology can be licensed in, to supplement products and services with technological features.

As a patent holder, Hill (1992) has established a framework for what factors to investigate before making the decision to license. He suggests that the choice when and when not to license should be influenced by the speed of imitation, first mover considerations and the transaction cost of licensing.

2.4.1. Speed of imitation

Hill (1992) argues that the speed of imitation depends on actual and potential rivals' incentive to imitate, barriers to imitate and rivals´ ability to imitate. The incentive to imitate is driven by the value the imitation could produce. This in turn is driven by cash flow intensity and competitive intensity. Deciding to imitate a process or a product entail switching costs. Operations most likely need to be reconfigured; new machines might be required to be acquired etc. Sticking to the old operations and/or processes might be more economically defensible instead of acquiring high switching costs and acquire products of more value and/or more cost-effective processes. Hence the incentive to imitate must make financial sense. (Hill, 1992)

Factors such as industry concentration, demand conditions, exit and entry barriers, and product characteristics affect the interpretation of competitive intensity (Porter, 1980). Hay and Morris

(1979) outline two different states of competitive environment; a benign and an intense environment. A benign competitive environment is one where demand is strong, the product is not a commodity, entry barriers are high and the industry concentration is high, meaning there are a few strong actors dominating the market. With a high demand, combined with the other factors, the benign environment does not have strong cost reducing incentives. Because of that the incentive to imitate cost reducing process innovations is low. Incentives are higher for product differentiation product innovations since it can attract a larger market share (Hill, 1992). There might however be short term incentives for process innovation imitation in a benign competitive environment. By lowering product manufacturing costs, equally functional products can be sold for a premium price, attracting a bigger market share. In the long term this would however, most likely, only set a new lower standard price for the product segment, leaving all competitors with lower product margins (Hay & Morris, 1991).

An intense environment is on the contrary characterized by low demand, the market is made up by several players, and the product is a commodity. Furthermore, in an intense competitive environment, exiting the market is expensive and fixed costs are high. Price wars, where actors are continuously lowering prices to pressure their competitors is common in intense competitive environments. This raises the incentives to imitate cost reducing process innovations. Imitation of product innovation can also be attracting in an intense competitive environment since it can distinguish a few players from the majority of product suppliers with more sought-after product features, allowing actors to avoid price wars to some extent (Hay & Morris, 1991).

The relation between the incentive to imitate and the status of competitive intensity is illustrated in Figure 2.

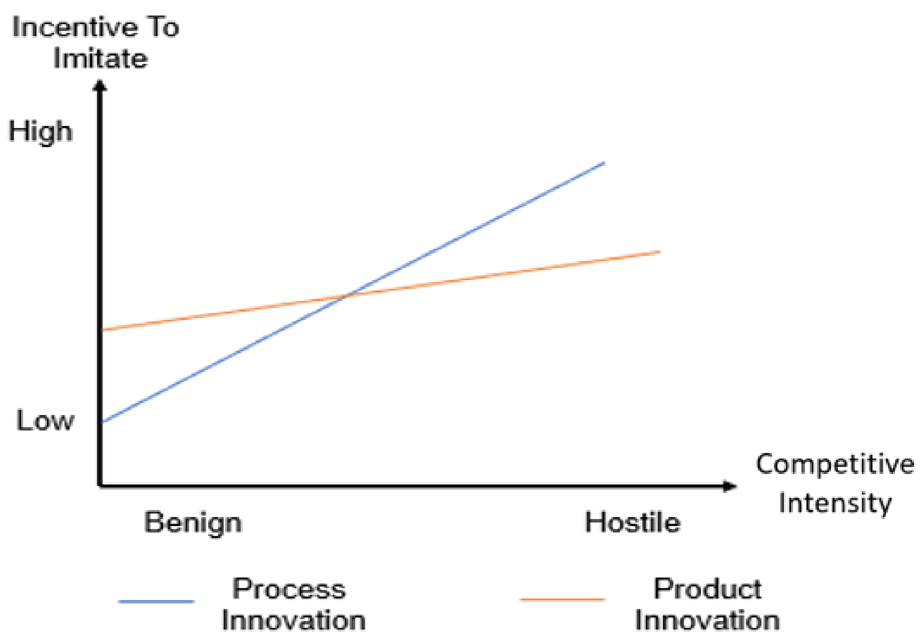

Figure 2, Relationship between the incentive to imitate and competitive intensity.

The incentive to imitate process innovation increases as the competitive environment shifts towards an intense environment. This is because when the environment becomes more intense, price competition occurs, and companies aim to lower their operation costs.

The relationship between Incentive to Imitate and Competitive Intensity not only highlights in what situations businesses should adapt other actors process and/or product innovations, but it also highlights when a patent holder of a certain product or process innovation has a favorable market for licensing (Hill, 1992). As price wars in an intense market emerges, the value of process innovation patents increases (Hay & Morris, 1991). With a clear value bringer in terms of reducing process-oriented cost, patent holder of process innovation has a favorable position to license to actors within their active industry and to other industries to generate revenue (Roya & O´Brien, 2012).

As mentioned, Hill (1992) also brings up the barriers to imitation as a factor for whether a patent holder should license or not. Patents are one of the most common barriers of imitation. It lawfully restricts others from utilizing an invention because only the patent holder has the sole right to exploit it (Kitch, 1977). Patents are however often easy to invent around (Mansfield, 1985). A more prominent barrier is connected to tacit knowledge. Even though an idea or blueprint is obtained, organizations must be able to turn it into a new product or process. Tacit knowledge is acquired through licensing of patents, where implementation assistance is offered. Hence, imitation becomes difficult if not the rights to the technology is lawfully transferred together with tacit implementation knowledge from the licensor (Vimalnath, Tietze, Eppinger, & Sternkopf, 2020b). Technological complexity and organizational complexity are hence the key barriers to imitation of product and process innovation. The more complex a product or process is, the more difficult it will be to replicate. Additionally, complementary knowledge required to make the product or process pose as strong barrier to imitation. Otherwise known as organizational complexity (Oster, 1990).

The final factor affecting rivals' speed of imitation is their ability to imitate. Hill (1992) finds rivals ability to imitate to depend on their general R&D skills and their access to complementary assets. R&D skills refers to rivals´ ability to reverse engineer innovation and develop a comparable product or function. Romeo (1977) argues it is a matter of rivals' spending on R&D. Even if an actor is not directly operating in the area of a new technology, higher spending in R&D correlates with the actor to be better able at understanding new technology and thereby be better at imitating it. Complementary assets are similar to organizational complexity but with more focus on actual material complementary assets and not knowledge. Organizations with, for instance the proper machinery will be more capable of imitating new innovations or processes (Hill, 1992).

2.4.2. First mover advantages

First mover advantages are possible in a market environment where there is a lack of capable competitors and/or in a situation where there are barriers of imitation. Businesses can facilitate a strong market position by being a pioneer in an industry and at the same time being the sole provider for a product or service. The longer imitators can be held at bay through barriers of imitation, the longer can the pioneer facilitate its position (Lieberman & Montgomery, 1988). In a situation as such Hill (1992) argues for the innovator to not license. By licensing the first mover advantages will quickly dilute and rivals will have the ability to match offerings and processes. According to Gallini (1984) it is not as black and white as it may appear. By not licensing Gallini highlights the possibility of rivals inventing around the technology; possibly developing better products and services. The primary inventor may be left with a technology which quickly becomes obsolete, thus losing potential licensing revenue. In this case, innovators should instead license their technology as quickly as possible to generate licensing income and to steer development and set a new standard. A standard where the licensor has both the knowledge and complementary assets to further innovate and profit.

To summarize, if rivals do have the incentive and capability to invent around and possibly improve technology, it may be beneficial for innovators to reap the benefits of licensing. However, if barriers to imitation are high and there are few capable competitors, it may be more beneficial to not license and instead facilitate a strong market position through first mover advantages (Hill, 1992).

2.4.3. Costs of licensing

Finally, in the decision whether to license technology or not, Hill (1992) raises the importance to account for transaction costs of licensing. To achieve licensing, it entails more than a transaction between a licensor and a licensee. For both parties, to reach an agreement, the parties often invest in negotiations, as well as monitoring and potentially enforcing the clauses of contracts which govern the transfer of technology. Additionally, the estimation of the value of a licensing deal can never be precise nor with full security. Hill (1992) identifies three areas of concern. First, as mentioned, the value licensed technology brings to a licensee is difficult to estimate. A licensor may charge an arguably low transaction or royalty fee, resulting in the licensor losing money she could otherwise had obtained with the right information.

From a licensee’s perspective there is the risk of overpaying for a technology license which may not generate any or sufficient value. The general idea of a bilateral licensing agreement is for the licensor to gain some sort of value from their licensed IP, often monetary means, and the licensee gains the right to technology which can improve the efficiency of one´s operations or increase the value of the licensees' products or services. There is however always a risk for a licensee that the licensed in IP will not provide the value it was meant to generate. The transaction cost of IP can occasionally be as high as to offset the value the IP was supposed to generate (Teece, 1988).

The second area of concern is that the licensee does not report e.g., the correct number of products being produced using the technology of the license. Leaving the licensor with less licensing revenue than what she was entitled to. The licensor could control this with monitoring activities but those will also cost in terms of working hours and potentially governing equipment (Teece, 1988).

Third and final, Hill (1992) raises the risk of second-order diffusion, where the license manages to diffuse the underlying knowhow of the licensed innovation. The licensee may in this case be able to further-innovate and supersede the licensed technology, setting a new standard for technological performance and thus making the primary licensed technology obsolete.

2.5. The decision framework for licensing

Hill’s (1992) framework plays out on the assumption that the innovating firm which faces the crossroads to license or not, has the complementary assets required profit from its innovation.

Having the appropriate complementary assets entails manufacturing, marketing, organizational and financial assets.

With the three distinct areas of speed to imitation, first mover advantages and costs of licensing, with respective sub-factors, Hill (1992) recommends the following scheme in Figure 3 to help guide innovative businesses in the decision to license or not.

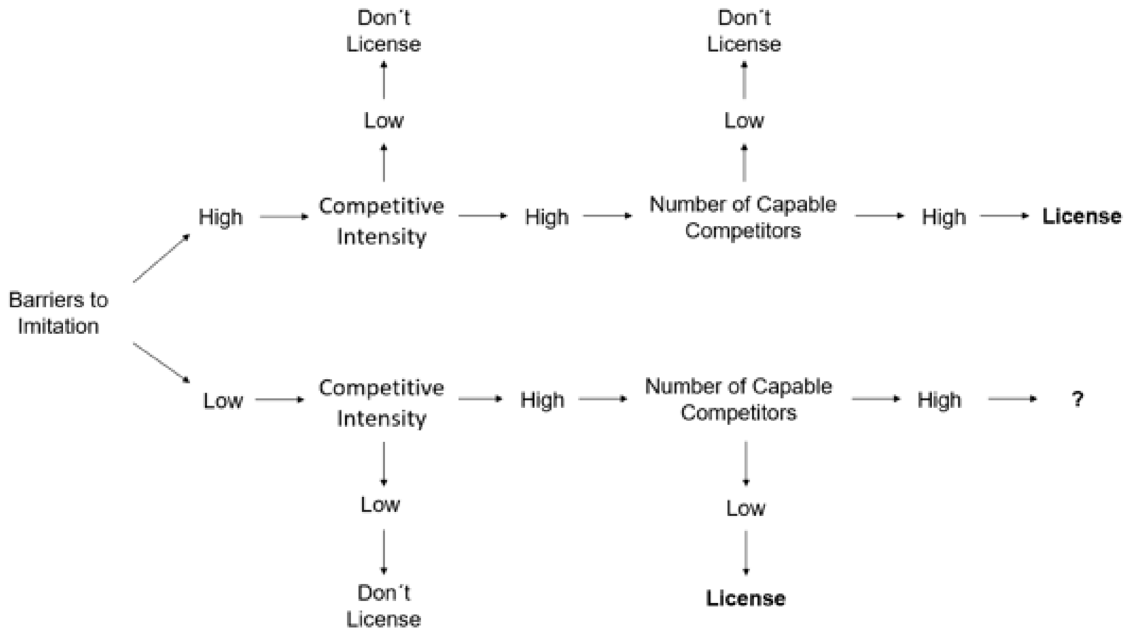

Figure 3, Decision framework for licensing or not (Hill, 1992)

High barriers to imitation lead on to the aspect of competitive intensity. If the competitive intensity is low, then an innovative firm should not license. Patents, tacit knowledge, etc., protects from direct imitation and with low competitive intensity, or benign market environment, the incentives for rivals to develop their own, possibly better products is low. These conditions pave the way for first mover advantages. If instead the market environment is intense, then further analysis of the number of capable competitors is required. With a low number of competitors, the ideal strategy is to not license. High barriers suggest that the technology is attracting to imitate, and with highly competitive intensity reducing costs by for instance imitating process innovation is desirable. The low number of capable competitors does however lower the threat of rivals being able to replicate and potentially improve an innovation. Thus, the innovating company does best at leveraging from first mover advantages. Considering the situation if there were a high number of capable competitors, then the risk increases for rivals to develop their own, potentially better technology. To not become obsolete, the innovating firm does best at licensing their technology (Hill, 1992). This will generate licensing revenue and the firm have a higher chance to make their technology the market standard, on which further innovation and licensing can be made (Vimalnath, Tietze, Eppinger, & Sternkopf, 2020b).

In the lower path, where barriers to imitation is low, a low competitive intensity still indicates the innovating firm should not license. The low barriers to imitation indicate imitation will be made but a low competitive intensity highlights the incentive to imitation is low. Thus, imitation will take time. The innovating firm should use this time to facilitate a market position through first mover advantages. Licensing can then be more relevant when the market position is sufficiently strong to shift the market into being more intense. If the competitive intensity is high, then the number of capable competitors must be analyzed. With a low the number of capable competitors, licensing is to recommend. Low barriers for imitation and an intense market environment almost guarantees fast imitation. To not lose licensing revenue, the innovating firm might as well license. Ultimately if there is a high number of capable competitors then the indicators neither points to license nor not to license. If the firm chooses to license then it increases the risk of the capable competitors to understand the underlying knowhow, leading to them developing better technology which will make the innovating firm´s technology obsolete. If the firm does not license, the technology will likely be quickly imitated because of the low barriers and the capabilities of the competing firms (Hill, 1992).

2.6. Forces affecting IP strategies

Whether to license or not does not solely depend on the market situation of more or less capable competitors, if there is a highly competitive intensity, etc. The legal framework of IP and licensing primarily sets the terms for how business can be conducted and what boundaries there are for patenting, licensing, or locking out competition. Chesbrough (2006) has identified four forces which drive the evolution of patent protection. These are illustrated in Figure 4 below.

With the increase of technology complexity in multiple industries, the philosophy for how to conduct R&D and drive business is shifting from closed to open innovation. Competitive environments are becoming more knowledge-based, hence the rights to utilize technology together with tacit knowledge plays a bigger role for businesses. As transitions are happening the four forces outlines the rulebook (Chesbrough, 2006).

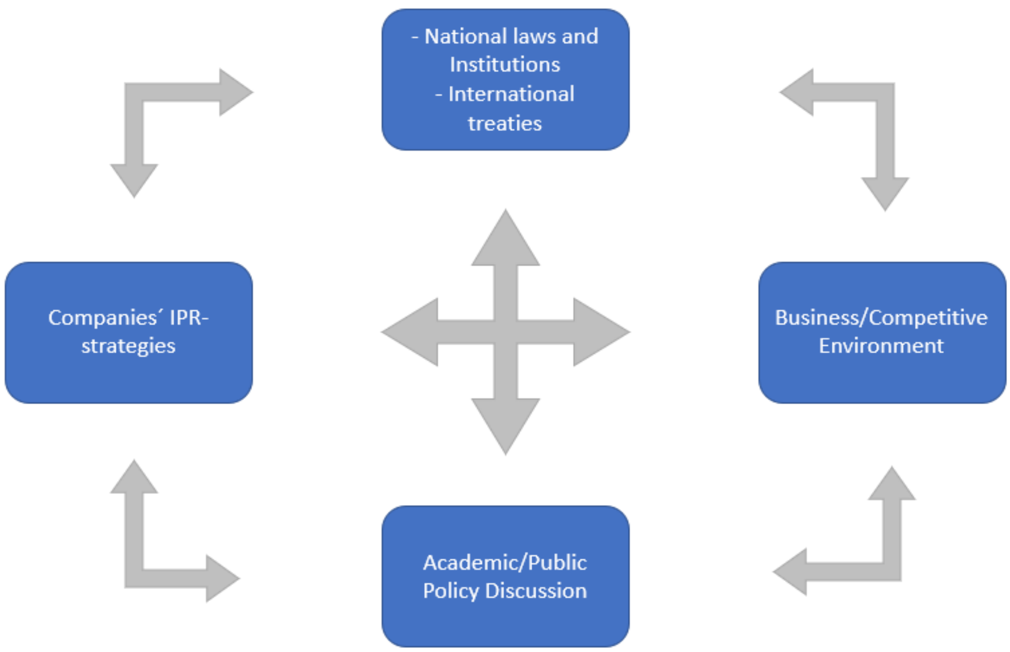

Figure 4, Forces driving the development of patent protection (Chesbrough, 2006)

2.6.1. Academic and public policy

Academic and public policy perspectives have long sought for effective structures for technology and knowledge diffusion and adaption. All this while still maintaining incentives for innovation. The incentives are often connected to how strongly businesses can protect their intellectual assets, thereto what can be protected through different means of IPRs. Stronger protection or barriers to imitation incentivizes for investments since then the protected technology carry more business potential through for example licensing or by giving the patent holder a competitive advantage. For the publics' interest there must be a balance between sufficient incentives to innovate, and accessibility to technology (Chesbrough, 2006). Figure 5 below shows the relationship between incentives to innovate and technology accessibility.

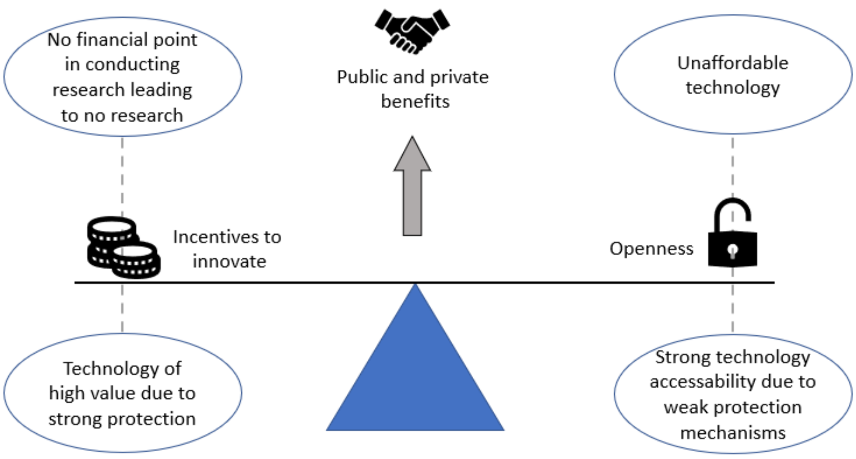

Figure 5, Relationship between incentives to innovate and technology accessibility (Chesbrough, 2006)

2.6.2. National laws and international treaties

Historically, laws and international treaties generally affect how business is conducted to a low extent. Businesses are not forced to operate in a certain way depending on how strongly patents can be protected. Legislation can however encourage businesses to adapt certain models. Harmonized national patent laws have however been seen as a great contributor to the trade and protection of IPRs, as business environments have become more globalized. The Paris Convention (1883), Patent Cooperation Treaty (PCT, 1970), and WTO governed Trade-related Aspects of Intellectual Property Rights agreement (TRIPS, 1995) are some of the agreements which have enabled the harmonized system Chesbrough (2006). argues for a low impact of these international treaties. The TRIPS agreement has however come up for discussion as the pandemic of Covid-19 emerged. The TRIPS agreement may have dire consequences for businesses´ dealings with IPRs through something called compulsory licensing (IAM, 2021). A more thorough explanation of the TRIPS agreement and compulsory licensing is presented in chapter 2.8.

2.6.3. Business- & competitive environment

The business and competitive environment is one of the forces which has influenced the development of patent protection the most. The ICT industry, with software, is overlapping into many other industries. It is embedded in products, operations, communication systems, etc. Its evolvance, complexity, and spill-over into other industries has shifted the old traditional industrial economy, with economies of scale, into the information economy where it is more knowledge-based (Chesbrough, 2006). As mentioned with the shift into a more knowledge-based economy, tacit knowledge, competence, and IP became more important to protect than tangible assets (Shapiro & Varian, 1999). Contracts and IPRs were thus adapted to protect these new highly valuable assets (Chesbrough, 2006).

2.6.4. Companies' IPR strategies

Finally, with new intangible assets being protected, for instance in the IoT industry, businesses are finding new ways for how to exploit their IPRs. This in turn influences the development for patent protection. It is not always in a company´s interest to assert rights in cases of infringement. Extensive usage of a certain technology area may be more prone to succeed if litigations based on imitating is not pursued. A new technology area may be set where the initial patent holder has great competence. The initial patent holder can then potentially gain more profits from further developing and either sell or license incremental innovations, instead of litigating as soon as infringement is discovered (Chesbrough, 2006).

2.7. Patent strategies

In this chapter Chesbrough's (2006) four distinct patent strategies with defensive, offensive, transactional, and open traits will be presented. Although the strategies have relative distinctive traits, they are not mutually exclusive and tend to overlap.

For a firm to use patented technologies, it can use an IP-strategy, which is a plan on how the firm develops, grows, leverages, and monetizes their IP. Intellectual property strategies (IPS) are defined as a set guidance processes and activities relating to how businesses should act in decisions in regard to exploration, generation/acquisition, enforcement, protection and re-occurring assessment of intellectual property rights (IPRs) to maximize value from organization´s assets. Assets such as, inventions symbols, technologies, products, artistic works, etc. IPR such as e.g., patents, trademarks, copyright are in turn meant to protect organization´s assets and enable organizations to reap the full value of their assets (Hernández-Chea, Vimalnath, Bocken, Tietze, & Eppinger, 2020).

2.7.1. Defensive patent strategies

Defensive patent strategies are most common for businesses who follow the philosophy of closed innovation. Patents are not reconned as one of the primary resources. Instead, it is a means of ensuring freedom to operate for the value-bringing manufacturing and selling processes to run smoothly. By acquiring patents on one´s products and processes, the business minimizes the risk of patent infringement, where the outcome can either be to cease operations or pay large settlement with the IP owner whose patents are being infringed (Chesbrough, 2006; Chesbrough, 2003).

Typically, defensive patent strategies entail manufacturing businesses building large patent portfolios. Although the possession of large portfolios does not guarantee exclusivity, it raises the assurance of businesses' products being proprietary (Chesbrough, 2006).

In a defensive-patent-strategy-setting a “cold war” state often facilitate where actors tend to infringe on one another but due to their respective infringements, none takes action to file lawsuits (Roya & O´Brien, 2012). This can be seen as a way of informal cross-licensing. Formal cross-licensing can however also take place where patents are used as “bargaining chips”, contrary to “weapons of mass destruction” (Chesbrough, 2006).

Another way of defensively sharing patents is through patent pools. A patent pool can be created if multiple patent owners agree upon to mutually license their patents to one another or to a third party. Patent pools have historically functioned as an effective tool for solving “patent thicket” problems (Lerner & Tirole, 2004). A “patent thicket” occurs when there are multiple patent owners, requiring potential licensees of a certain technology to license from multiple different licensors. Not only does the process of identifying all the patents needed, and the respective holders, take a lot of time, but the patent thicket also entail high risks of infringement since the overlapping structure of rights can be difficult to navigate (Shapiro, 2000). Although Kitch (1977) argues for the patents system´s function of promoting innovation by granting inventors the sole right to exploit the innovation, Shapiro (2000) is questioning whether the patent system promotes the creation of more advanced products and services. Situations where multiple licenses are needed from several patent holders becomes more common as technology advances. With the large number of licenses needed, there are more potential blocking patents which can hinder the development and thus suppress the production of new products and services. Patent pools aim to solve this by making relevant clusters of patents available for licensing. There are several patent pools in existence today. Many of them emerged from cooperative industry standards setting efforts. For example, patent pools for Bluetooth and DVD (Layne-Farrar & Lerner, 2011).

2.7.2. Offensive patent strategies

The usage of blocking users of technology in offensive patent strategies is similar to defensive patent strategies. Instead of solely using patents for defensive purposes and ensure freedom to operate, offensive patent strategies apply an additional dimension to the utilization of patents. With offensive strategies patents are also used to generate revenue streams through licensing (Chesbrough, 2006).

To effectuate the additional licensing dimension is however difficult. First, patents can often be invented around to achieve the same function (Chesbrough, 2006). In some industries only a few patents can protect the value of an innovation. This is typical for pharmaceutical industry where, for instance only a few patents can protect the compound of a medical drug. In other industries, such as the ICT industry, the functions of ICT have more room to be developed around. Hence, it becomes more difficult and requires more patents to protect innovation. The distinction between the ease and difficulty to protect knowledge and value is known as the “appropriability regime”, where the pharmaceutical industry operates in a strong appropriability regime, and the ICT industry has a weak appropriability regime (Teece, 1986).

Secondly, in relation to the appropriability regime of different industries, in order to license patents, the licensed patents must constitute a complete function or product. Licensors must hence acquire or internally develop innovation to patent which gives a licensee the complete “rights-package” to produce a product or enable a process. This is especially difficult in industries characterized by a weak appropriability regime. Although there are many ways to invent around technology patents, multiple functions are required, leading to either high risks of infringement, or that the licensee needs to license from several different patent holder to acquire a complete “rights-package” (Chesbrough, 2006).

Lastly, as a licensor, it can be troublesome to find licensors/buyers. To license or sell patents, actors must either use the patented technology or find the technology beneficial to use and hence buy or license the patent rights. Licensors must hence acquire patents which cover technologies which are or will be of interest to license (Richardson, 2004).

2.7.3. Transactional patent strategies

Transactional patent strategies are similar to offensive patent strategies but with the distinction of not using patents as a means of ensuring freedom to operate. Companies who engage in transactional patent strategies seldom have manufacturing operations. They solely rely on licensing or transactional revenue streams from patents. Patents are acquired through internal R&D and acquisition of patents. Acquiring patents is often very costly. Businesses who engage in transactional patent strategies hence often purchase patents from bankrupt firms. Patents are seen as company assets, just as furniture or machinery. Purchasing them from bankrupt businesses often entails premium pricing since bankrupt companies are in a desperate position to turn assets into money (Chesbrough, 2006).

Effectuating transactional patent strategies face the same challenges as offensive patent strategies. By not having manufacturing processes in place, transactional patent strategies lack the “safety net” of using patents for freedom to operate and potentially generate revenues through manufacturing and selling products if no licensees are found. By not having manufacturing operations, transactional patent strategies do however come with the benefit of reduced risks of infringement. Bargaining chips of counterparts in a litigation loses its value and businesses with transactional patent strategies have a higher chance of generating revenues from assertions if the patents are legitimate (Chesbrough, 2006).

2.7.4. Open patent strategies

Instead of acquiring patents to block others from usage, open patent strategies have the idea of releasing patents to a “commons” and enable broad usage (Chesbrough, 2006). A patent commons is platform of patents which companies has pledged not to enforce if they were used by others (Hall & Helmers, 2013). By pledging patents to a commons tension is relived from patents which could otherwise be used assert litigations. Businesses can instead develop and practice their technologies without the fear of litigated for patent infringement (Chesbrough, 2006).

Open patent strategies can also generate value by luring businesses to embrace a certain technology. Once that has happened, the “pledger” can showcase complementary patents which have not been pledged. To receive the complementary features or traits the licensee must consequently license the technology and pay royalties. Revenue streams can also be obtained through services. The pledgor of technologies is likely the most knowledgeable in how the technology operates. If businesses would embrace technologies, open by pledged patents, and integrated the technology, making it an important function for business to proceed, breakdown might have dire consequences. The pledgor can then offer services to make the technology operational. Services which would not be provided for free. Pledgors can also directly provide services in terms of implementation of pledged technology patents (Chesbrough, 2006).

2.8. Compulsory licensing of green tech

Under the agreement on trade related aspects of intellectual property rights, TRIPS, all members of the World Trade Organization, WTO, must provide a minimum level of patent protection. The level of patent protection includes the right to exclude others from making, importing, or selling patented inventions as long as the patent is active (World Trade Organization, 1994). The TRIPS agreement does not use the exact term *compulsory licensing*; however, Article 31 clearly relates to compulsory licensing. Article 31 explains a negotiation requirement between the patent user and the patent owner that must be met before the patent can be used without authorization. This requirement can be skipped in the case of "national emergency, other circumstances of extreme urgency, and in cases of public non-commercial use" (Fair, 2010). This means that under such a case, a state can allow citizens to use the patented technology without having to notice the patent owner or receive authorization from the patent owner. The 2001 Doha Declaration on TRIPS encouraged states to actually use compulsory licensing, stating that "[e]ach Member has the right to grant compulsory licenses and the freedom to determine the grounds upon which [compulsory] licenses are granted" (World Trade Organization, 2001). With a compulsory license, a state can then produce the patented technology in the country, or import it, since compulsory licensing isn't limited to domestic use.

Compulsory licensing is rarely used, but there is a history of compulsory licenses being issued internationally. During the AIDS epidemic in 2005, Brazil approved a bill that allowed national manufacturers to produce generic versions of the patented drug. In 2007, Thailand also approved a compulsory license for an AIDS drug. Compulsory licenses have also been granted by Eritrea, Ghana, Guinea, Malaysia, Swaziland, and Zimbabwe, for example (Love, 2007). During the time of writing, the US is discussing to temporary allow compulsory licensing for corona vaccines (BBC, 2021). The Brazilian senate has passed a compulsory licensing bill, which also includes compulsory licensing of know-how (IAM, 2021).

The previous examples of compulsory licensing have been for pharmaceuticals. However, a case can be made that releasing pollution that damages the planet is a "national emergency". Every year, 150 000 people dies from the effects of climate change (World Health Organization, 2020). Compulsory licensing has only been issued for pharmaceuticals so far, although there is no limitation of the scope (Fair, 2010).

2.8.1. Negative aspects of compulsory licensing

There are of course serious drawbacks of using compulsory licensing. The negative aspects of using compulsory licensing for pharmaceutical patents is the decreased incentives to innovate for companies and would be the same for green tech (Fair, 2010). The economic backlash that nations receive after using compulsory licensing has been severe. When Thailand approved a compulsory license of the AIDS drug, the US put Thailand on its "priority watch list", a list then heightens the likelihood of trade sanctions against the country (Fair, 2010). The economic backlash can also come from the private sector, by removing their other patented products from that nations market, which happened in Thailand with the AIDS drug. The firm that was subject of compulsory licensing did not sell their newest products in Thailand afterwards, which does not violate any laws, because there is no obligation for companies to sell their patented technology. Another example is Egypt, that issued compulsory licensing for Viagra. Pfizer, the patent owner of Viagra, cancelled their plan to build a new production facility in Egypt and switched to another country. Even though Egypt has relatively educated population and cheap labor, foreign direct investment available to Egypt has been placed elsewhere (Bird, 2008).

The promise of a strong IPR protection is especially important for companies with green tech patents. It requires enormous amounts of capital to develop green tech, e.g., renewable energy. Without protection for the inventions, it will be harder to receive funding and subsidies because the incentives to innovate might be diminished or eliminated. Compulsory licensing can be attractive for spreading and enabling usage of technology on a short-term basis, but it will decrease long-term investment in more innovative technologies and will discourage of technology for which compulsory licensing has not been granted (Fair, 2010).

2.9. IP-strategies for green tech

How to utilize green tech IP is not a uniform set standard. The prospect of relying on patent incentives to adequately promote innovation in the environmental domain requires analysis of various approaches, mechanisms, and policy considerations (Ebrahim, 2020). A core step of developing an IP-strategy is defining the IP, but there are several more steps that needs to take place when forming an IP-strategy which aims to utilize a certain technology such as green ICT. A so-called dynamic property right means to have the right to give away, testament and borrow the property, or to sell, lease and enable extraction of financial values (Petrusson, 2004). A dynamic IP strategy involves continuous development of IP to control the flow of technology and to help or hinder competitors in the technological race, while a static IP strategy relies on existing positions. A dynamic approach which controls the flow of technology to a firm's advantage is claimed to be the optimal way to exploit IP (Pitkethly, 2001). For a firm to successfully achieve a dynamic IP strategy, the identification of the technology, and thereto the IP, is a key part of being able to implement and use an IP portfolio. IP-strategies that can be of interest when spreading or imposing a technological standard is the goal, such as a "free licensing" strategy or patent pools, patent commons, open licensing agreements and non-assertion pledges. Sharing rights through licensing or/and collaborative mechanisms promotes R&D and avoids duplication efforts, which is beneficial in terms of spreading and enabling broad usage of technology (Vimalnath, Tietze, Prifti, & Akriti, 2020).

2.10. Definitions in business and research

According to Merriam-Webster, one meaning of the word definition is "the action or the power of describing, explaining or making definite and clear", or "a statement expressing the essential nature of something" (Merriam-Webster, 2020). Based on these definitions it can be easily understood that definitions play a vital role in business communication. It helps businesses through a harmonized means of communication, making it possible to discuss needs, explain solutions and reach deals (Radović Marković & Aidin, 2018).

When discussing terminology, *the technical or special terms used in a business, art, science, or special subject*, research shows that the terminology we use affects attitudes, values, and behavior both at the organizational level and at the individual level (Baden & Harwood, 2013). There is a difference between the denotive (literal) meaning and connotative meaning, such as personal associations and secondary meanings. In the field of branding, connotative meaning is researched, and market tested extensively since it is well known how e.g., a new product name can have affective and behavioral implications. However, for terms used to promote sustainability, like *carbon footprint,* the connotative meanings are not researched. Futerra

(2007) conducted focus groups to understand if connotative meanings differ for sustainability terms, and it was found that the terminology used in academic and business circles was not understood by the public. Although in this thesis the aim is not to construct a terminology for the public that is well understood, it is argued that terminology influences behaviors and efficacy and the meaning of definitions should be considered in a business context.

In academic research, definitions are also of importance. Baden and Harwood (2013) argue that if a term is not well understood, it is difficult to conduct empirical research on business. For example, there have been attempts to understand how the term *CSR* (Corporate Social Responsibility) affects business success, but it is hindered by the lack of consensus of what CSR involves. In this academic thesis, the situation can be said to be of similar nature with the term of *green* IoT. It can be valuable to consider having a uniform definition of what technology is being discussed, and how to construct a terminology that accomplishes the aim of the thesis.

3. Methodology

This chapter incudes an explanation and justification of the chosen research methodology. It includes the research strategy, approach, method, and quality aspects.

3.1. Research strategy

The strategy of this study is connected to the purpose, investigating how companies owning green IoT technology can enable a utilization of the technology on a broader scale. The study is qualitative, with both inductive and deductive elements forming an abductive approach to develop a grounded theory answering the main research question (Bryman & Bell, 2015). The underlying reasoning is that there is existing, although broad knowledge in the field of spreading green tech. Therefore, the study is partly based on preconceived themes, hence deductive (Bryman & Bell, 2015). To answer the first sub-research question of what can be learnt from green tech sharing initiatives, secondary data were gathered through a literature review of both previous and currently active green tech patent sharing initiatives. The green IoT manufacturing technology is dependent on software, hence software based green technologies were used as the technology of topic during the interviews. The primary data from the green tech sharing initiatives were used to answer the second sub-research question; what do intellectual property decision makers prefer for sharing green tech in general and green IoT manufacturing technology in particular. Together, the primary and secondary data inductively form a grounded theory answering the main research question (Bryman & Bell, 2015).

3.2. Research approach

Since the study is based on a specific real-world business subject, the study follows a case study approach. Case study research is concerned with the complexity and particular nature of a case and is widely used in business research (Bryman & Bell, 2015). The case study research design will generate concrete, contextual and in-depth knowledge about how green IoT manufacturing technology can be utilized on a broader scale. The nature of the research questions is limited to a specific case, green IoT manufacturing technology, however, to transfer and implement the technology to the full capacity, it needs to be transferred to multiple industries outside of the industry that developed the technology. Therefore, interviews were conducted with decision makers in several industries, such as industrial technology, manufacturing, IT, etc.

Since the results of the study will be partly based on the interviewees' perceptions and understandings of sharing green tech patents, interpretivism is a suitable epistemological approach. Furthermore, since intellectual property is included and the intellectual property governance systems are social constructs, interpretivism is appropriate (Bryman & Bell, 2015).

As for the ontological approach in the study, constructivism is most suitable. This is because the study aims to construct a theory of how green IoT manufacturing technology can be utilized on a broader scale, based on the social ideas of organizations owning IoT technology and there are other industries which might be prone to utilize the green IoT manufacturing technology. (Bryman & Bell, 2015)

3.3. Research method

3.3.1. Literature review

The literature review will present a structured summary of different green tech sharing initiatives that have existed and that exists today. The literature review method is based on Bowen's (2009) method of document analysis as a qualitative research method, which is connected to developing a grounded theory. Document analysis is a systematic procedure for reviewing or evaluating documents (Bowen, 2009). Documents used in the study were electronic, containing text and pictures, such as journal articles, books by professionals, webpages by organizations, etc. Document analysis is suitable in the study since it is also less time consuming than other research methods, it requires data *selection* instead of data *collection.* Since analyzed documents are available in the public domain, the method has a high availability and does not require the authors of the document's permission. Documents are also unobtrusive and non-reactive, meaning the documents are unaffected by the research process.

3.3.2. Semi Structured Interviews

To understand companies' perception of sharing green tech in general, and green IoT manufacturing technology in particular, data was collected via semi structured interviews. The interviewees are listed in Table 1.

Interviewees	Title
Interviewee 1	National manager for IP in a multinational industrial technology company
Interviewee 2	Senior counsel in IP Law at a multinational ICT company
Interviewee 3	Senior Vice President IP at a multinational technology conglomerate
Interviewee 4	Manager for IPR at a multinational ICT company
Interviewee 5	Senior IP licensing counsel at a global industrial conglomerate
Interviewee 6	Innovation manager at a multinational manufacturing company
Interviewee 7	Legal director IP at a multinational IT company
Interviewee 8	IP manager at a logistics conglomerate
Interviewee 9	Executive managing director of Japan Intellectual Property Organization

Table 1, Interviewees and their respective titles

To achieve an interview, the interviewees were offered that their opinions would not be connected to their names or affiliations. This was done due to the sensitivity of patented inventions and IP-strategies. It was promised that data would be presented anonymously and only a notion from what industry the data was collected is presented. Interviewee 9 did not wish to be anonymized; therefore, the organization is presented.

The questions for the interviews are constructed to be open-ended, allowing the interviewee to tell their opinions on a topic without leading to an answer. The interview protocol required revision during the data gathering, since the path to discovering grounded theory can be troublesome. Slightly revising the questions depending on where the conversation is led by the interviewee can be good for uncovering new concepts (Gioia, Corley, & Hamilton, 2012). The collected data through the interviews was analyzed and common responses were found and put into categorizes, so called 1st- order concepts. The concepts were analyzed and connected to each other into 2nd-order theoretical levels of themes, emerging themes (Gioia, Corley, & Hamilton, 2012). In the analysis process of the themes, it was possible to see if the emerging themes might be helpful in describing and explaining the phenomena that is observed. Special attention is put on concepts that do not seem to have suitable theoretical connections in the existing literature, or concepts that "leap out" because their relevance to a new domain (Gioia, Corley, & Hamilton, 2012). After a set of 2nd-order themes, it was possible to refine them further into "aggregate dimensions". The 1st-, 2nd and the aggregate dimensions together provides the possibility to build a data structure. The data structure shows the data in a visual way, providing a graphical representation of how the data has been processed from raw data into themes, which is important in order to show rigor in qualitative research (Gioia, Corley, & Hamilton, 2012). The interview guide can be seen in Appendix A: Interview guide.

3.4. Quality of research

The most prominent criteria for valuating business and management research are reliability, replicability, and validity (Bryman & Bell, 2015). According to Bryman and Bell (2015), replicability is highly valued by business researchers working within quantitative research, hence in this qualitative study replicability will not be assessed. Both so called external and internal reliability and validity are of importance when assessing qualitative research.
Bowen (2009) claims that combining documentary evidence together with interviews and observation can minimize bias and establish credibility. The research method is constructed to achieve this by the literature review according to Bowen (2009), in combination with semi-structured interviews. The risk with the literature review in the form of documentary analysis is biased selectivity, considering the fact that the documentary analysis can never be fully completed.

3.4.1. Reliability

Reliability regards the question whether the results of the study are repeatable. Reliability is aimed for and is important when taking measurements in qualitative research, as argued by Bryman and Bell (2015). The measurements, which in this study is the qualitative data collection, should not fluctuate over time. *External reliability* is the measure to what degree a study can be repeated (Bryman & Bell, 2015). Although it is impossible to "freeze" a social setting and the current circumstances, the study is constructed and documented with the aim that future potential researchers can replicate the study with results that are similar. The data collection through interviews was made possible only when the interviewees were offered to be anonymized and not directly quoted, and without future researchers knowing which companies and persons were interviewed, reaching a high level of reliability can be hindered. However, including the interview guide used in the study will enable future researchers to have a higher chance of replicating the study. *Internal reliability* regards that when there is more than one researcher, the research team agree on what they see and hear (Bryman & Bell, 2015). Internal reliability has been a consistent factor during the study and especially when analyzing collected data. Even though interview transcripts are not included in the thesis, comprehensive mutual analysis of the data has taken place to obtain a high internal reliability.

3.4.2. Validity

Validity is important for research quality because it brings integrity to the conclusions generated from the research. Bryman and Bell (2015) describe different types of validity for qualitative research, where external validity is concerned with whether the results of the study can be generalized beyond the specific research context. Since the data collection takes place both inside and outside of the specific IoT-field, this method generates a stronger external validity. This study's results will potentially be useful for technology actors faced with similar questions regarding spreading green tech in their technology-based industry. Using wide ranging literature in combination with interviewing decision-makers in different industries aims to strengthen the validity of the study. The interviewees knowledge in the field of software-based innovation, and thus software based green tech differed, which can impact the validity of the study negatively. Furthermore, the results are not transferable for any other industry without adaptations, neither to make general conclusions. Nine interviews were made, and while additional interviews could provide additional strength to the validity of the study, considering the ongoing Covid-19 pandemic, obtaining interview subjects limited the sample size.

Regarding the literature review, factors such as relevance of documents to this study's research aim, assessing document comprehensiveness and considering original purpose of the document are consistently considered in the study (Bowen, 2009). To further achieve a high quality of documents, Scott's (1990) criteria of assessing document quality was incorporated and used when analyzing documents for the literature review. The criteria are authenticity, credibility, representativeness and meaning. *Authenticity* refers to whether the evidence is genuine and from reliable sources, *credibility* refers to whether the evidence is free from error and distortion, *representativeness* refers to whether the documents are typical of its kind and *meaning* refers to whether the evidence is clear and comprehensible.

4. Results

Firstly, this chapter presents the results from the literature review where selected green tech patent sharing initiatives are addressed. Secondly, the results from the semi-structured interviews are presented together with emerged themes.

4.1. Literature review

This section will present the results from the literature review.

4.1.1. Selected green tech patent sharing initiatives

Through the literature review, three distinctive strategies for sharing green tech were discovered. These strategies are broadly categorized as closed, semi-open and opened (Taubman 2009).

An open patent strategy entails the inventor making the IP free to access with no commercial restrictions. Patents are made accessible either by the patentholder ceasing to pay patent maintenance fees, thus releasing them into the public domain, or by pledging patents, or by committing patents to a commons (Vimalnath, Tietze, Prifti, & Akriti, 2020).

Ehrensperger and Tietze (2019) defines a patent pledge as follows:

"A patent pledge is a publicly announced intervention by patent owning entities ('pledgers') to out-license active patents to the restricted or unrestricted public free from or bound to certain conditions for a reasonable or no monetary compensation using standardized written or social contracts."

Although patent pledges might appear as unconditional, pledges often have some sort of catch or hidden objective to put the pledger in a favorable position. It can for example limit the licensees right to assert other patents against the initial licensor through defensive termination. By pledging patents or releasing them to the public domain, it can also promote the spread and usage of a specific technology and steer the technological development in a direction where the initial patent holder has extensive competence. Thus, the pledger can potentially license proprietary improvements on the freely accessible technological standard which has been set through pledged or released patents (Vimalnath, Tietze, Prifti, & Akriti, 2020).

Committing patents to a commons is similar to pledging patents, but where multiple actors pledge patents together. These types of arrangement generally aim to create a good impression in the publics' eyes (Vimalnath, Tietze, Prifti, & Akriti, 2020).

A semi-open patent strategy often entails, in contrasts to a fully open patent strategy, a transfer of patent rights in exchange for monetary means. This can either be done through exclusive or non-exclusive licensing, where the licensor only has one licensee, respectively, several licensees (Vimalnath, Tietze, Prifti, & Akriti, 2020).

A closed patent strategy essentially entails the patent holder to refuse licensing to other actors. No case was however found where companies refused to license any green tech patents. In some sense one could however argue for that all businesses adopt a closed patent strategy to some extent. Trade secrets for example can be seen as a part of a closed strategy, where businesses keep them for themselves to provide a competitive advantage (Vimalnath, Tietze, Prifti, & Akriti, 2020).

Several different patent sharing initiatives were found during the literature review. These are presented in Table 2 , followed by a more thorough explanation of the respective initiatives.

Name of initiative	License agreement control	Type patent strategy	Founders	Lifespan	Technology domain
Eco-patent commons	Free to license under the terms of defensive termination	Open patent strategy	IBM, Sony, and Nokia	2008 – 2016	Broadly relating to environmental or sustainability technology. E.g. energy conservation, pollution control, environmentally friendly materials.
GreenXchange	Standardized terms where the licensor had some flexibility depending on license-choice	Semi-open patent strategy	Nike, Creative Commons, and Best Buy	2010 – 2012	Broadly relating to IP that can lead to new sustainability business models and innovation.
WIPO Green	Licensing terms are set by the licensor	Semi-open patent strategy	WIPO	2013 – active	Environmentally sound technologies in energy, water, farming/forestry, pollution/waste, transportation, products/materials/processes, building/construction.
Low-carbon patent pledge	Free to license under the terms of defensive termination	Open patent strategy	HP, Facebook, and Microsoft	2021 - active	Preventative or adaptive technologies that can help combat climate change. Including power management, enablement of zero-carbon energy sources, efficient data center architecture, and thermal management.
Tesla patent pledge	Free to license under the terms of defensive termination	Open patent strategy	Tesla	2014 - active	Vehicle electrification
Toyota patent pledge	Unknown	Open patent strategy	Toyota	2015 – 2030 2019 – 2030	Fuel cell drive systems and vehicle electrification

Table 2, Selected green tech sharing initiatives and their characteristics.

Eco-patent commons

Eco Patent Commons (EcoPC) was an initiative launched by IBM, Nokia, Pitney Bowes, and Sony. The idea was to create a platform where businesses around the world could pledge patents covering technologies with positive environmental applications. By making the patents freely accessible the hopes were that environmental technologies would be embraced and used on a broader scale to protect the environment (Contreras, Hall, & Helmers, 2019).

To make patents freely available in EcoPC, pledgers was obligated to make an irreversible covenant not to pursue any assertions on pledged patents. Patent owners did however retain the defensive termination right to assert pledged patents against non-pledgers who had asserted any patents against them or assert against EcoPC pledgers who asserted environmental patents against them (IBM, 2008).

EcoPC was cancelled in 2016 due to lack of patent tracking, shortage of technology transfers, and a difficulty in scrutinizing available patents. Pledgers were unable to track which patents were being used and whether their commitment to the platform resulted in environmental benefits. Furthermore, a mere patent is rarely sufficient for licensees to be able to implement and use the technology it covers. Technology assistance is generally required, something which EcoPC fell short of. Finally, finding patents for one´s demand proved difficult. No additional information to the patents where available and potential users would have to read patents one by one to understand the technology covered (Contreras, Hall, & Helmers, 2019).

GreenXchange

GreenXchange was launched in 2010 by Nike Yahoo!, Best Buy, Creative Commons, IDEO, Mountain Equipment Co-op, Genera, Outdoor Industry Association, salesforce.com, and 2degrees. The initiative was founded on the idea of providing an interactive platform that promoted the open exchange of best practices on issues related to sustainability (Roya & O´Brien, 2012). The mechanism for sharing intellectual property was known as “GX semi structured public license”. It was a licensing structure which was based on the principle of Creative Commons of “some rights reserved”. Through it, the IP owner could decide which aspects of their IP was accessible for free, for a payment and freely accessible for research purposes. This meant IP owners could choose to upload their using three different licensing structures: a standard option, a standard PLUS option and a research non-exempt option.

The standard option was a license structure where the IP owner would make their IP free of charge. Licensees were able to use IP however they wished without needing to pay a royalty or agree on certain terms. Essentially, the IP owner would give away the IP for free. The standard PLUS option was available for IP holders who either wanted to monetize from licensing their IP or restrict the usage through terms which the licensee would have to agree upon to license IP. Similar to a patent pledge, it could entail a right of defensive termination, but it could also revolve around how the IP holder wanted the technology to be used. The University of California Berkley for instance, used the standard PLUS option to restrict usage of uploaded IP to be used by people from developing countries, with the purpose of creating a marketable product. Lastly, the research non-exempt option gave non-profit organizations the right to conduct research on the licensed IP. Non-profits where free to make adaption and improvements on the licensed technology and they were even able to patent the improvements for non-commercial use (Roya & O´Brien, 2012).

The licensing protocol of GreenXchange can be seen to be in the borderline between a fully open and a semi-open patent strategy. With its different licensing options, the protocol had the more traditional licensing characteristics of a semi open model, where rights are transferable through a monetary exchange and aspects of the fully open model where licensees could be granted access of rights as long as licensing terms were upheld (Roya & O´Brien, 2012). The patent sharing philosophy of GreenXchange was marked to be under the influence of open innovation. Open innovation has many different meanings, where some argue for it constituting an absence of intellectual property rights. When Chesbrough (2006) coined the term, he was referring to a more open approach towards knowledge management where IP can be used proactively to share knowledge and promote innovation. In this sense IP is not a means of limiting technology and knowledge to the IP holder. It should be used as a vessel to sell, license, or give away knowledge for free (Christensen, Olsen, & KJÆR, 2005).

GreenXchange was after two years cancelled. The first challenge of GreenXchange that led to its cancelation was the lack of belief regarding safety and utility of licensing and exchanging patents on the platform. It was patent attorneys, and not sustainability experts that chose and made the final decision of whether a company would commit its IP to the GreenXchange, which led to low level of patents and low development of the platform. Companies often saw IP as means to achieve *freedom to operate,* and if then the patents are on the GreenXchange, it could negatively impact their ability to manage competitive threats. Another insight was that the founders of the initiative realized that their focus on the tangible exchange of patents where not what licensees were interested in. Both universities and businesses had more interest in the knowledge behind the creation of the patents over simply obtaining the patents themselves (Ghafele & O'Brien, 2012).

WIPO Green

WIPO Green was launched in 2013 by the World Intellectual Property Organization (WIPO). The initiative is essentially a matchmaking platform for patent supply and demand. Licensors can upload patents for licensing and potential licensees can post technology needs, with the hopes of being contacted by a licensor with the relevant patented technology. The platform also has a network of experts within different technological fields, who can assist in the implementation of patented technologies. The patent database of WIPO green is categorized in seven different areas of science: Energy, Water, Farming/Forestry, Pollution/Waste, Transportation, Products/Materials/Processes, and Building/Construction. Thus, the platform focuses on spreading and enabling usage of technologies related to these seven fields through a semi-open patent strategy. No standardized licenses are set, the licensor is free to decide the terms (WIPO, 2019).

The degree of successfulness of WIPO Green is unknown. The platform has had 650+ connections from the beginning until 2019 (WIPO , 2019). However, it is not specified what a *connection* entail.

Low-Carbon Patent Pledge

Hewlett Packard Enterprise, Facebook and Microsoft launched in Low-Carbon Patent Pledge (LCPP) in April 2021. LCPP is an initiative where the founders pledged hundreds of patents to be available free of charge. The patents are meant to support the usage and development of low-carbon solutions for generating, storing and distributing low-carbon energy (Bauer, Morea, & Breasseale, 2021).

LCPP provides pledgers with the right of defensive termination in exchange for them to license pledged patents free of charge. Defensive termination is applicable if the licensee does not act in good faith with respect to the pledgor. A definition of what “good faith” entails is however not provided (HPE, Facebook, & Microsoft, 2021). The pledge was recently made public, and there are no sources found on its successfulness.

Tesla's pledge

Tesla engaged in a substantial patent pledge in 2014. Their expressed reason for the pledge was to positively impact the climate change by opening their patent portfolio, and hence benefit the electric car sector. A few years after the initial pledge, Tesla published a more detailed version of the license terms, to clarify what "good faith" means in the license terms. Tesla defines "good faith" as:

A party is "acting in good faith" for so long as such party and its related or affiliated companies have not:

- asserted, helped others assert, or had a financial stake in any assertion of (i) any patent or other intellectual property right against Tesla or (ii) any patent right against a third party for its use of technologies relating to electric vehicles or related equipment.
- challenged, helped others challenge, or had a financial stake in any challenge to any Tesla patent; or
- marketed or sold any knock-off product (e.g., a product created by imitating or copying the design or appearance of a Tesla product or which suggests an association with or endorsement by Tesla) or provided any material assistance to another party doing so. (Tesla, 2021)

This means that if a business chooses to use Tesla's pledged patents, Tesla receives defensive termination rights to use against the using party. For instance, by using Tesla's patents, the using party cannot engage in lawsuits against Tesla, if Tesla were to infringe on the party´s IP rights. Furthermore, by using Tesla's patents, a using party cannot enforce its patents against any other business in the electrical automotive industry (Vimalnath, Tietze, Prifti, & Akriti, 2020).

Since Tesla now have the established infrastructure for charging stations, and have the manufacturing facilities in place for parts, batteries, etc., a movement from the traditional fossil fueled automotive industry towards electric cars can yield substantial dividends for the company. By making patents covering electrical cars accessible for the automotive industry, Tesla´s pledge might serve as an effective tool to play the industry towards their home turf (Contreras J. , 2015). Worth noting is that even though Tesla´s patent filings has increased, they do not possess the most important patents in the electric and automotive sector. These patents are held by Bosch, Denso, Ford, Toyota, etc. (Diakun, 2019). In this sense multiple authors have argued for that the pledge was a smart move from Tesla to grow its market position by promoting the adaption of their technology, and by clearing the tension of some of the patents in the electric automotive field.

In 2014, the electrical car sector was small, but today Tesla faces more competition. It is likely good that Tesla retained control over their patents with their relatively strict license terms. One claim is that the patent pledge has made it more difficult for Tesla to seek out more capital (IAM Media, 2019).

Toyota's pledge

Not long after Tesla´s pledge, in 2015 Toyota issued their own patent pledge covering automotive hydrogen fuel cells. The aim was to steer the industry towards hydrogen fuel cells instead of electricity. a technological field in which Toyota is in the forefront. Toyota pledged approximately 5680 patents relating to fuel cell vehicles, including pending applications. The patents were pledged to be allowed on a royalty-free basis to companies that are manufacturing and selling fuel cell vehicles, and to those operating hydrogen stations (Toyota, 2015). Toyota claims that the reasoning is to promote the widespread use of such vehicles and contribute to a hydrogen-based society.

Toyota offers support to parties choosing to use Toyotas pledged patents. The support is provided upon payment; hence the business angle of the pledge could be to create a demand for Toyota´s expertise by making their IP accessible (Vimalnath, Tietze, Prifti, & Akriti, 2020). The offering of support to implement the IP from Toyotas pledge may also assist in the adaption towards hydrogen fuel cells. Hence the offered support might also be a strategy to steer the automotive market towards hydrogen fuel cells.

In 2019, Toyota announced that they would pledge more patents. The patents in this pledge were covers vehicle electrification-related technologies, nearly 24 000 patents and pending applications. Again, at no cost. However, Toyota offers a fee-based technical support to other manufacturers that takes a license. Toyota explains:

Ultimately, by granting royalty-free patents and providing technical support on its vehicle electrification systems, Toyota aims to help further promote the widespread use of electrified vehicles, and in so doing, help governments, automakers, and society at large accomplish goals related to climate change (Toyota, 2019).

As for the offer for service for hydrogen technology, it is both a way for receiving income, but also because Toyota likely understands that more than the rights to a patent is required to foster successful technology transfer. As with Tesla, the desire is to build a platform for electrical cars, and litigations will not be a positive measure to achieve that goal.

The license terms are not publicly available, an interested company must contact Toyota to discuss taking a license. Since the specific license terms and conditions must be discussed with Toyota, the scope is likely more defined than Tesla's pledge. Compared to pledges that does not require a written agreement, such as Tesla's, EcoPC and LCPP, it is likely favorable for Toyota.

There is lacking publicly available information regarding the successfulness of the pledges. For the first pledge, there has been criticism that Toyota knew that hydrogen fuel-cell technology would out-competed by electric vehicles and it either a publicity stunt or an attempt to create hydrogen refueling infrastructure. The usage of the pledged patents is unclear; however, the truck manufacturer Nikola has benefited from the fact that Toyota does not want to block out competitors of the fuel cell field (IAM Media, 2019).

4.2. Semi-structured interviews

The results from the semi-structured interviews are presented in this chapter. Second order observations were generated from the interview data, which will be presented. 4.2.1 covers themes closely related to green tech sharing opinions and in 4.2.2 another less related theme which emerged from the interviews is presented. Lastly in 4.2.3 concepts from the aggregate dimension will be presented, which is based on the 1st- and 2nd – order concepts. Key 1st - order concepts of opinions and perceptions raised by the interviewees in relation to different sharing mechanisms of green tech are presented in Table 3. Additionally, the businesses' general usage of IP is presented in the second column.

Respondents	Usage of IP	Opinions on green tech licensing	Opinions on patent pledges	Opinions on green tech sharing platforms	Opinions on technology transfer
Interviewee 1	Removing the risk of infringement and gaining freedom to operate.	Interesting if the right technology is found	- Using pledged patents limits one's ability to enforce their own patents	Unknowing of green tech sharing platforms	Do not license-in technology. Finds the process to be tricky
Interviewee 2	Gain revenue streams from licensing and protect product uniqueness	Beneficial for branding purposes	- A good way to steer development, - Substantial risks to use pledged patents	- Offers good branding for little work. - Seldom results in licensing agreements	Only the patent rights are licensed
Interviewee 3	Gain revenue streams from licensing and protect product uniqueness	Beneficial for branding purposes	- Substantial risks to use pledged patents	- Offers good branding for little work. - Seldom results in licensing agreements	Only the patent rights are licensed
Interviewee 4	Gain revenue streams from licensing and protect product uniqueness	Difficult, but could reduce environmental impact and generate financial value	- The loss of IP rights through defensive termination is not acceptable	Unknowing of green tech sharing platforms	Costly to include transfer of know-how services
Interviewee 5	Gain revenue streams from licensing and protect product uniqueness	The difficulty in licensing will exceed the benefits	- Entails to much risks	Unknowing of green tech sharing platforms	No opinion
Interviewee 6	Gain revenue streams from licensing and facilitate freedom to operate	Could be interesting. It is however difficult to find the right technology	- Can be effective to remove patent-tension	Unknowing of green tech sharing platforms	Necessary for successful technology transfer
Interviewee 7	Facilitate freedom to operate	The difficulty in licensing will exceed the benefits	- Effective to use to steer development in a certain direction	Must entail effective licensing processes	Does not engage in licensing in or out technology. The process of licensing is tricky and expensive
Interviewee 8	Removing the risk of infringement and gaining freedom to operate.	Uncertain of the value creation for licensees	- Entails to much risks	Unknowing of green tech sharing platforms	Licensing of patent rights is seldom enough for technology transfer.

Table 3, Interviewees' key opinions and perceptions on green tech sharing mechanisms.

4.2.1. Themes relating to green tech sharing

Below are the themes presented which were found to be closely related to how the interviewees perceived different green tech sharing mechanisms.

4.2.1.1. Positive but hesitant attitude towards green tech sharing

Several interviewees expressed positiveness towards engaging in green tech patent sharing initiatives. However, many of the interviewees expressed a concern that the value gained by licensing and implementing green tech would not exceed the difficulty and cost of establishing the relevant licensing agreements to access the green tech. From a licensing perspective, the general opinion from the licensors was that by engaging in green tech sharing initiatives, underutilized patents could provide some value. The resources spent on identifying patents to license out, finding potential licensees and engaging in negotiations was however believed to exceed the potential revenue streams gained from licensing. Furthermore, by engaging in a licensing negotiation, the interviewees pointed out that there is always the risk of not reaching an agreement. Thus, the resources spent to prepare and run negotiations can result in bigger losses than if an agreement was reached.

On the positive side, as a licensor of green tech, interviewee two and three expressed it to be beneficial for the company brand.

From a licensee's perspective, the interviewees raised the same risks of the technology not providing sufficient value in relation to what it would cost to investigate relevant patents to license and reach an agreement through negotiations.

Interviewee 5 was explicitly questioning the reason for taking a license if it costs multiple times more to use than the current technology; *"If so, green tech is wrong, because companies revolve around generating more revenue and profit, and needs to continue doing so"*. It was brought to attention that it might only be worth to take a license if government subsidies the investment. If the technology really is beneficial from a monetary aspect, then market forces work well, and license royalties can easily be paid while the licensee still makes a profit from using the patented technology.

4.2.1.2. Green tech sharing initiatives are unheard of

Overall, the awareness of green tech sharing initiatives was low. Merely two interviewees knew about at least one initiative. Several of the interviewees had heard of Tesla´s patent pledge but did not see it as a green tech sharing initiative. As mentioned, when heard of the different active and canceled initiatives, several of the interviewees wanted to investigate the initiatives further, but they were hesitant to the value it might bring. Both as a licensee and a licensor.

Being connected to a green tech sharing platform was believed by interviewee two and three to benefit the brand of a company. With both companies of interviewee two and three having published patents on WIPO Green they did however not see any substantial value being generated since they uploaded their patent, although they are showing licensees that they are open to license.

4.2.1.3. Low tracking of patent usage

It was found that there seldom is an awareness if patents are being used in products and services. Interviewee 6 explained that *"We don't know which patents we use or not, we forget about it. Patents does not have a direct connection to products"*. The interviewee further explained that when a product reaches a certain degree of technological complexity, it becomes too difficult to keep track of what patents are being used in which products.

4.2.1.4. Patent pledges for spreading one´s own technology but not for embracing others'

Regarding more open patent sharing initiatives, such as a patent pledge, a theme amongst the interviews were that companies were hesitant. As explained in 4.1.1 regarding patent pledges, pledges often offer significant judicial competitive advantages for the pledging company, since if licensees use pledged patents, it would often be highly risky because of the terms in the license. If by using the patents limits the licensee to assert against the pledging company, the value of taking a license is minimized. That type of legal risk is seldom acceptable for large corporations, even if the patented inventions are free to use.

Not only were interviewees strongly against using pledge patents because of the loss of their own rights, but they also believed it to be ineffective to spread technology. Interviewees two and eight did raise the possibility of steering technology in a certain direction through a patent pledge but they were still highly against utilizing pledge patents. Thus, their opinion can be seen as slightly counter intuitive. Since if they would not use pledged patents, then it would be unlikely that other businesses would license their patents if they were to issue a pledge.

4.2.1.5. Releasing patents into the public domain

Releasing patents into the public domain makes the patent holder lose their patent rights to the released patents, which makes the patent holder to lose potential safeguards that can be incorporated in a license. The interviewees saw it as positive in the aspect of costs, since no patent maintenance fees would be paid, while allowing for usage of the patents. However, choosing to release patents which includes the loss of rights with no turning back is deemed to be risky. Interviewees explained that patents that are not used in the business today might be of value in the future, hence the choice of choosing to releasing patents into the public domain by ceasing to pay maintenance fees must consider the value of the patent in the future even more than other options.

4.2.1.6. Inclusion of know-how in license deals

A theme regarding the willingness to include know-how in license deals emerged. The opinions differ, e.g., interviewees two, eight, and four were hesitant to include more than the patent right in a license, but two interviewees saw it as important for successful technology transfer. Interviewee 6 were willing, and the company is including know-how transfer in basically all their licenses. This can be connected to the organizational capabilities of engaging other departments than the patent department, since including know-how in the form of service is outside of the patent departments duties.

In the case of including know-how for software based green tech, the know-how is often in the form of code. The interviewees explained that depending on the context, transferring software-based know-how can be easier than other types of know-how, e.g., best practices for production. However, it was emphasized that it is case-dependent of what technology that is the subject to be spread and the implementation scenario.

4.2.1.7. Multiple weak barriers for software patent infringement

A theme which emerged in relation to the technical nature of green IoT was that the interviewees expressed it to be multiple barriers in place of utilizing the technology. Copyright protected code and trade secrets were barriers of usage apart from the patents covering the technical function. In this sense, the interviewees raised the idea of software utility patents being redundant. However, most of the interviewees highlighted that there often are multiple ways to achieve the same function through different software. Hence, the only way to protect the technical innovation would be through software utility patents.

4.2.1.8. Compulsory licensing is not an efficient measure

The topic of compulsory licensing was brought up during the interviews. A theme that emerged was the negative aspects of a compulsory license happening. Interviewee 5 said *you will open a can of worms, and everything will be compulsory licensed.* If a compulsory license is issued for one type of green tech, there is a large possibility that more will follow. Several of the interviewees expressed that if compulsory license is issued, then the whole patent system will lose its purpose and there will be no incentives to carry out research and develop new technologies. Interviewees two and four took the discussion further with the counterproductive measures of compulsory licensing. They argued for that if compulsory licensing is issued than organizations will become more closed with their operations and products. This is because the incentives to innovate and sell products will not exist due to compulsory licensing. Businesses will hide their research or relocate operations to not lose invested capital, argued the interviewees.

Interviewee two explained that by at least having patents uploaded on WIPO green, they reduced the risks of them being targeted by compulsory licensing. Interviewee two explained, that by showing some engagement in spreading green tech, it can be used as grounds for argumentation with governments.

Additionally, a general opinion amongst the interviewees was that simply issuing a compulsory license on businesses to relief their patent rights will not result in a broader usage of any technology. To facilitate technology transfer for both green tech and software based green tech, the interviewees expressed that trade secrets and tacit knowledge is often required.

4.2.2. Less related emerged theme

4.2.2.1. Making a definition of green tech is secondary

One theme that emerged early on was the importance, or lack of importance regarding of what is considered to be green tech. As mentioned in the background, the UN claims that green technologies "protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual waste in a more acceptable manner than the technologies for which they were substitutes" (United Nations, 1992). With this definition, many innovations that use their resources more sustainable, i.e., more efficient, would be considered green tech. The argument for the importance of having a green tech definition can be that to engage in patent sharing initiatives for green tech, a company must be in the possession of such green technology.

Reviewing the transcripts and categorizing the findings into categories visualized a red thread about companies' perception on definitions of green tech. The findings indicate that generally little attention is spent on defining green technologies. For example, interviewee six explained that: *We don't use "green tech". It's a bad focus on classification of green tech here, it's a side-thing.".* This trend was apparent in other discussions, which showed that companies paid little attention to the process of classifying their IP as green tech. To clarify, interviewee four expressed "*I don't differ inventions if it is green tech or not. If it's good stuff, we patent it".* Interviewee 6 explicitly explained that it was hard to see the reason of having a definition. Having a broad definition, covering many technologies were not seen as beneficial or hazardous. It is understandable that spending resources on classifying technology must provide value, and without seeing the benefit of classifying it will not be prioritized. The data from the interviews are clear, no interviewed company have a definition for green IP.

Based on the first theme, that the interviewed companies do not consider their inventions as green tech, it can be said that definitions seem to be of low importance IP-professionals. However, having a definition of green tech does affect business's ability to engage in patent sharing initiatives for green tech. If a green technology is not defined as green, it is difficult to pledge the patents, because it is unknown if it is green. How a definition should be constructed was discussed during a conversation with interviewee nine, where it was claimed that a broad definition was most useful, contrary to the interviewed companies. Interviewee 9 worked with the patent sharing initiative Green Technology Package Program, that merged into WIPO Green. To be able to join a patent sharing initiative and upload patents, a broader definition was advised; "*I think it is better to think about green technology broadly. If the new technology is for easier, lighter, or long life than existing technology, we can say it is more environmentally friendly".* Regarding discussions with a more precise definition, interviewee seven claimed that it will pick out winners and losers. Having a narrower definition of green tech that would showcase which technologies that are included or excluded could result in less green patents being e.g., available to share on a patent sharing initiative. There, a broad definition is positive to be able to include as many of green technologies as possible without excluding any actor, which can be good for branding purposes to see many actors engaging in the initiative. Again, the results show that there is no low engagement for companies to use definitions for green tech and to see a benefit of the definition.

4.3. Aggregate dimensions

Next, two concepts from the aggregate dimensions will be presented, which has been based on the 1st- and 2nd – order dimensions, as recommended by Gioia, Corley, & Hamilton (2012).

4.3.1. Fear of the unknown

In combination of the interviewees unknowing of past and present green tech sharing initiatives, together with their hesitancy of engaging in green tech licensing, a concept that emerged was the "Fear of the unknown". Many of the interviewees, apart from interviewees two and three had their closest relation to green tech sharing initiatives in Tesla´s patent pledge, although few considered it as a green tech sharing initiative. The general interpretation of Tesla´s pledge was the risks and relief of patent rights it would entail when licensing Tesla´s pledged patents. Together with the idea of a green tech license not being able to generate sufficient value to exceed the costs that would emerge to reach an agreement, the concept "Fear of the unknown" represents the interviewees quick generalization of green tech sharing initiatives. There was a disbelief of green tech value generation, although no interviewee could supply us with an unsuccessful green tech licensing agreement.

4.3.2. Disregard of the golden rule

Many of the interviewees expressed the need for transfer of tacit knowledge and implementation assistance for successful technology transfer. However, merely one of the companies represented by the interviewees did offer implementation assistance and transfer of tacit knowledge in the event of licensing. The rest of the interviewees only offered patent rights in the event of licensing. They claimed that the offering of implementation services and transfer of know-how entailed too many complex organizational arrangements. These organizational arrangements were rarely defendable in relation to the licensing revenue received.

5. Analysis and Discussion

An analysis and discussion around the results from the literature review and the semi structured interviews are made in this chapter. Firstly, the chapter presents influencing factors for spreading green IoT. The characteristics of past green tech sharing initiatives are then evaluated based on the influencing factors to see what patent strategy is most suitable to achieve broad spread and usage of green IoT.

5.1. Influencing factors for spreading green IoT

The literature review together with the emerged themes identified several factors which will be necessary to address for the spread of green IoT to be successful. Firstly, to reach broad usage, the technology must be used extensively. This can either be done by the patent holder utilizing his invention internally to a great extent, or by sharing the technology to others through different arrangements. Since the utilization of certain technologies will be far greater if multiple actors use the technology than if the sole patent holder utilizes the technology, the success factors will henceforth address what is necessary to enable spread to other actors (Chesbrough, 2003).

Second, it must be incentivizing for the patent holder to spread green IoT technology initiative. Organizations invest heavily in the development of innovation. With no incentives to spread green IoT, businesses are likely to keep the innovation for themselves and rather use it for defensive purposes (Hill, 1992).

Thirdly, for an agreement to be made between a patent holder of green IoT and a licensee, it must be incentivizing for the licensee to enter into the agreement as well. The technology must hence generate some sort of value (Hill, 1992). This was also expressed by the interviewees, where some interviewees were hesitant to green tech´s ability to generate value. Connected to the need of generating value, a success-factor which emerged was the need for low risks. If the risks to enter into a licensing agreement are low, then the incentives to collaborate will be higher. The identified risks hindering licensors´ and licensees' commitment to spreading green tech is illustrated in the Figure 6 below.

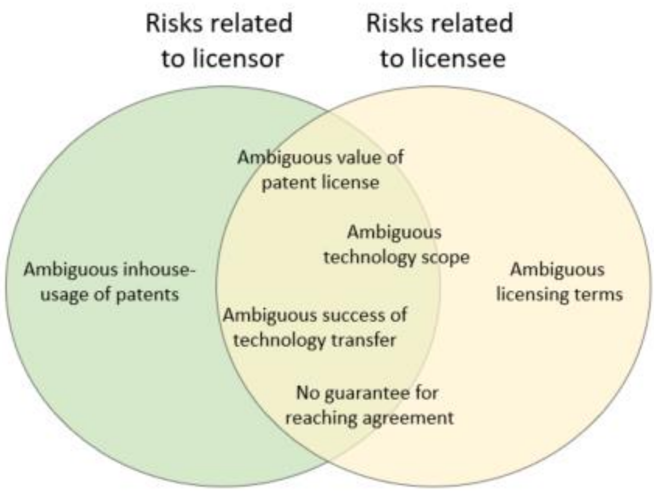

Figure 6, Hindering risks of licensees and licensors to commit to spread green tech.

The majority of the identified risks were applicable for both licensees and licensors. For licensors, the ambiguity around the value of a patent was found to create a hinder in a potential green tech sharing commitment. By not understanding patents´ value, licensors might miss out on opportunities for spreading and utilizing green technologies to generate value, by letting the patent be inactive. From a licensee´s perspective, the ambiguity of the value of a patent license is a hindering factor in, for example, the event of a negotiation with a patent holder of green tech. By not knowing what value a patent-license will generate, the decision to agree on certain terms to license technology can be difficult to do (Hill, 1992).

Another risk which was found to be applicable to both the licensor and licensee was the risk of not reaching an agreement. For a licensor, preparing for a license entails substantial costs in terms identifying patents to license, find potential licensees and enter negotiations (Chesbrough, 2006). None of these investments guarantees that an agreement is made. Hence, the investments can resolve in nothing. This was also clear in the theme which emerged from the interviews: *Positive but hesitant attitude towards green tech sharing*. The interviewees expressed a similar concern as Chesbrough (2006) highlight. The essence of the risk of not reaching an agreement is the same for licensees, making investments in preparations and negotiations with no guarantee of reaching an agreement.

Ambiguous technology scope refers to the licensee's difficulty in acquiring patents to license in order to receive the sufficient rights to lawfully implement a technological solution. This was especially eminent in the retrospection of GreenXchange, where one of its main reasons for failure to spread technology was deemed to be because the licensees had to conduct their own analysis of what patents to license in order obtain a complete solution (Roya & O´Brien, 2012). As explained in chapter 2.7.2, Chesbrough (2006) further argues that this is a prominent problem in the field of ICT and therefore IoT due to the weak appropriability regime. With an ambiguous technology scope, the risks of infringement become higher since it is difficult to identify the adequate licenses required to lawfully implement a technical solution. Hence, an ambiguous technology scope poses as a hinderance for licensees to license green tech. The ambiguity around the technological scope also creates a risk for licensors. With a complex technology scope, the licensor might incorrectly promise the licensee a complete "rights-package". The licensee might then require additional licenses from other patent holder to lawfully use the coveted technology function. If this is discovered by either the required patent holders and/or licensee, it may affect the willingness to license from the primary patent holder. The potential infringement can also result in litigations.

The ambiguity around the success of technology transfer entails a risk for licensees and licensors and creates a hinderance for spreading green tech. There is no guarantee when entering into a licensing agreement that the technology will be successfully implemented and used by licensees. This risk is closely related to the ambiguity around license-value, but it refers more to the risk of businesses not being able to implement the technology, rather than what value the technology will generate. The interviewees suggested that this was the main reason for why it was necessary to include or offer services for technology transfer to reach an agreement. However, as mentioned, merely one of the companies represented by the interviewees offered implementation services. Depending on the payment method the ambiguity whether the technology transfer will be successful can pose as a risk for licensors as well. Licensors often receives payment in the form royalties from savings made or products sold (Hill, 1992). If the technology transfer and implementation is unsuccessful then the investments made to reach a license agreement and to implement the technology can result in no return. Thus, only creating a cost. With a set one-time cost for the license the licensor would not have to bear the same risk, but in that case, he might receive less value for his license. The licensee may sell far more products or generate more savings than estimated, making the royalty-based transaction model more profitable over the one-time transaction model.

The ambiguity of licensors usage of patents is mainly a hinder for businesses who either use the defensive or offensive patent strategies, explained by Hill (1992). The theme of *Low tracking of patent usage* highlighted that businesses have a low understanding of which patents are being used in their products and/or operations. When the business completely or partly revolves around the selling of products, where patents are used to enable freedom to operate or to gain a competitive advantage, the engagement of green tech licensing bears the risk of losing competitive advantages and/or losing as Chesbrough (2006) puts it, bargaining chips, in situations of cross licensing.

Lastly, a disapproval of licensing in relation to ambiguous licensing terms was highlighted through the theme of *Patent pledges for spreading one´s own technology but not for embracing others´*. Licensing in with ambiguous terms such as *"good faith"* entailed more risks because of the lack of understanding of what the licensing agreement would constitute.

5.2. IP-strategies for sharing green IoT

This thesis has highlighted Chesbrough´s (2006) four standard models for IP sharing, and past green tech IP-strategies, following the framework of Taubman (2009) with open, semi-open and closed patent strategies. In this chapter the different strategies will be evaluated based on the technology nature of green IoT, the conceptual themes generated from the interviews and based on the characteristics of past green tech sharing initiatives.

5.2.1. Closed patent strategy

To achieve a broad spread and usage of green IoT by having the IP only used by the company that created the green IoT inventions is argued to not be the most suitable strategy. Comparing to a semi- and fully open patent strategy, a closed strategy requires the green IoT company to implement the inventions broadly alone. Through licensing, technology can instead be used by more businesses and generate more value (Chesbrough, 2006). Closed strategies are mainly used to achieve *freedom to operate* with products, which is not the purpose of spreading and allowing more actors to use patents (Chesbrough, 2003).

In the case of green IoT manufacturing technology, the ICT industry´s weak appropriability regime indicates a patent thicket problematic. Since IoT is part of ICT, the patent thicket is present in IoT as well (Chesbrough, 2006). In situations of patent thickets, actors tend to use patents as "bargaining chips" as a means for enabling informal cross-licensing. Green IoT could hence be spread through closed, or defensive patent strategies by the patent rights being used in cross-licensing deals. However, this would lead to a low spread since the technology transfer would only happen between the actors that have complementary technology that is mutually desirable. Since the nature of a closed patent strategy is not including licensing, it is therefore not likely that a large-scale spread and usage would occur for green IoT manufacturing patents.

The emerging themes from the interviews did not portrait a closed strategy for spreading green tech to be either suitable or effective. In summary, a closed strategy is argued to not be suitable for the purpose of spreading patents covering green IoT solutions.

5.2.2. Fully open patent strategies

The fully open patent strategies which have been identified through the literature review are patent pledges, releasing patents into the public domain, and joining cooperative patent pledges (Vimalnath et al., 2020; HPE et al., 2021). The literature review did show that fully open strategies provide benefits to the firm that founds an initiative, however, mainly benefits in terms of corporate social responsibility (CSR) and branding.

5.2.2.1. Pledging patents

In the case of all cases of licensing, an argument must be made that the value of taking a license is higher than not taking a license for the licensee. However, in the sharing mechanisms of pledges, the ambiguity around the value of a patent license is not the main concern since it is free to use the pledged patents. As the interviewees expressed, the uncertainty of what value the patent license would generate is a hindering factor to ultimately agree on licensing terms. In the case of a patent pledge, this uncertainty therefore disappears, at least in terms of agreeing to a certain licensing or royalty fee, since pledged patents accessible for free. The risk of investing resources in negotiating a license agreement, to ultimately not reach an agreement, is neither a concern in patent pledges. The terms are generally set; thus, negotiations are irrelevant. Costs concerning the investigation of relevant patents to pledge, and license is however still consisting through a patent pledge. Furthermore, the ambiguity around licensing terms in patent pledges is deemed to be a high hinderance for the spread and usage of green tech.

The general opinion on patent pledges from the interviewees was that it would entail a lot of risks to use. Interviewees found it to be too risky to use pledged patents and thus disclaim their own patent assertion rights towards the licensor. In the literature review and analysis of licensing terms in pledges, defensive termination is always used in some form. The pledge that Tesla issued in 2014 had to be further explained a few years after to clarify what the clause was referring to as using the patents in good faith (Tesla, 2021). The LCPP does not specify what good faith is (HPE, Facebook, & Microsoft, 2021). Toyota does not publicly provide the license terms of their pledges (Toyota 2015; Toyota 2019). Thus, it becomes difficult for potential licensees to understand what the license entails and what they commit to by licensing-in pledged patents. For licensors to issue a patent pledge, the value that the pledged patents bring in must be higher than the loss of rights that occur through a pledge. By pledging, licensors risk losing value generation from e.g., product implementation or licensing revenue.

In the context of vague licensing terms, Radović, Marković & Aidin (2018) explains that to be able to reach agreements and discuss technology, there must be a set standard for the terminology used. By using vague terms, the likelihood of broad usage of pledged patents are hindered. The emerging themes from the interviews confirms this.

Even though the pledged patents would provide value to an interested firm, the defensive termination clauses create a risk that is unacceptable by licensees. If a company uses the freely pledged patents and manages to successfully implement the technology it covers, the resources invested to make the technological transition is likely substantial (Hill, 1992). Knowing the high transition costs, the pledgor can take the opportunity to infringe on the licensee's patents. The licensee will then be in an unfavorable position since the assertion on the infringed patents can resolve in the pledger applying defensive termination, thus making the licensee having to make a costly transition again. From a licensor perspective, having defensive termination clauses is beneficial for the licensor to still have some competitive safeguard left in place (Contreras, Hall, & Helmers, 2019).

The ambiguity of technology scope and the successfulness of technology transfer has the tendencies to hinder the spread and usage of green tech through patent pledges as well. In industries such as the ICT industry where an appropriability regime exists, as indicated by Chesbrough (2006), a licensee might need to license not only from the pledged patent but from another patent holder as well to acquire a complete "rights-package". To reduce the risks of licensees missing out on patents, thus being more prone to license from a patent pledge, the licensor who have complementary patents can pledge their patents together to offer a complete "rights-package", similar to a patent pool (Maggiono, Marin, Charry Morales, Orlando, & Guegan, 2020). Such an arrangement could however resolve in the licensee potentially being infringed upon by multiple actors through defensive termination.

Only through Toyota´s patent pledge was assistance of technology transfer publicly offered in relation to licensing their pledged patents (Toyota, 2015). Having this arrangement, where the technology transfer assistance is commercially accessible, the arrangement of patent pledges can be incentivizing for the pledgor to further innovate, by receiving service-payments (Chesbrough, 2006). It would also solve one of the main issues with Eco-patent commons where the low traceability of patents being used, was lowering pledgors willingness to pledge patents (Contreras, Hall, & Helmers, 2019). By being contacted by licensees for implementation assistance, the tracking of pledged patent usage could be done.
However, the willingness of licensees to license would still be reduced due to the disclaimer of patent assertion through defensive termination.

The success and the technological domains of the fully open strategies differ. As explained, patents relating to green IoT manufacturing solutions often include software (Heckeler, 2019). The technological domains of e.g., EcoPC were broad, and although green IoT patents could have been included, it is likely that more than the rights to a patent would be required for a successful technology transfer. Effective technology transfer often requires some sort of support from the technology source (Lichtenthaler & Lichtenthaler, 2010). In the case of a similar pledge or commons for green IoT, having pledged patents that would require software that is protected by trade secrets and/or copyright from the founding company could be a way of forcing the licensee to reach out to the founding company. An even more approach would be to state that the company is willing to include transfer of know-how in the form of service.

In summary, patent pledges for green IoT have a possibility to increase spread and usage of green IoT. However, with the addition of defensive termination indicates licensees will be hesitant to utilize green IoT, since it will entail disclaiming one´s own rights to assert patents against the green IoT pledgor. Additionally, by pledging green IoT patents, competitive advantages might be lost if there is low trackage of which patents are being utilized. Furthermore, there is no certainty that a pledge will generate value for the licensor.

5.2.2.2. Releasing patents into the public domain

By releasing patents into the public domain, the patent holder disposes of the patent rights once acquired. Although this strategy can generate value for a licensee, who then can utilize the technology freely with no licensing terms to relate to, the strategy would not resolve in any direct value creation for the initial patent holder. Releasing patents into the public domain might also result in a loss of value generation for the patent holder. For the party using the patents, it is less ambiguity surrounding the license terms, since there are no terms. The implementation assistance of patented technology will be lost since the primary patent holder does not have any ties to originally patented technology. The organization could however launch a new business model where they benefit from service implementation, similar to the path explained for pledging patents. In this way the technology can be spread while also generating value for the original patentholder, incentivizing continuous innovation, while limiting the ambiguity regarding technology transfer for both parties. However, the successfulness of the technology implementation can never be certain. Depending on the business model, primary patent holders can potentially end up with increased costs.

As discussed by Chesbrough (2006), releasing patents into the public domain can also generate value for the primary patent holder by steering the development in a certain direction, where the patent holder has extensive knowledge and can then benefit from licenses on complementary patent protected technologies. A drawback of releasing patents to the public domain is that in the event of a green IoT technology developer driving business through the manufacturing and selling of products, the ambiguity around inhouse-usage of patents could impose a risk to reduce the developing companies' competitive advantage (Chesbrough, 2006). Additionally, an ambiguous technology scope might entail other patents being required to lawfully implement a technological solution, which is a risk both for the licensor and licensee. If other patent holders are reluctant to license their patent, the release of patents into the public domain can result in no value generation for either party. Furthermore, the flexibility of using patents to generate value through different sharing mechanisms will be completely lost if patents are released into the public domain. Patents exist to drive innovation forward by creating incentives for developing organization to invest in R&D and develop technologies which are beneficial for society (Kitch, 1977). Although releasing patents into the public domain might serve as a good short-term solution for spreading green IoT, it puts the innovating organization in a risky situation of not gaining any value from their costly innovation. If no value is generated, then the industry might shift into a less competitive state where technology advancement is no longer driven by competitiveness. Thus, society would not be able to benefit to the same extent from new technologies. This correlates well with the identified theme which emerged from the interviews, where the interviewees expressed a positive aspect of reducing patent renewal costs by releasing patents into the public domain, but where the ambiguity around the present and future patent value made it difficult to decide.

5.2.2.3. Technology spread and usage through compulsory licensing

Compulsory licensing is not a strategy for businesses, it is a mechanism that government can use to achieve short term spread. Compulsory licensing fails to solve the ambiguity relating to several risks related to both the licensee and licensor. Firstly, the ambiguity regarding the success of the technology transfer remains due to only a release of patent rights will be made, without further transfer of necessary complementary non-patented assets. The ambiguity around the technology scope will remain due to the difficulty to set the technology scope covering all necessary patents for an implementation of green IoT manufacturing solutions. Fair (2010) argues that the nature of green technologies is not appropriate for compulsory licensing. Partly because there is not *one* type of green technology that solves a crisis, which connects to the technology scope ambiguity. Using green IoT manufacturing technology is one way of improving efficiency for manufacturing scenarios, but it is not the one and only way. Therefore, compulsory licensing is not effective mechanisms for spreading and enabling broad usage of green tech.

5.2.3. Semi-open patent strategies

In the following section three different types of semi open patent strategies will be presented and evaluated in relation to the technical nature of green IoT and the areas of consideration, based on interview-themes and the literature review.

5.2.3.1. Licensing strategy

Licensing is an offensive or transactional patent strategy as described by Chesbrough (2006). Licensing can be done both exclusively, and non-exclusively (Vimalnath, Tietze, Prifti, & Akriti, 2020). Exclusively licensing to only one actor would be inefficient if the goal is large scale spread and usage. Non-exclusive licensing is a strategy that still allows the licensee to retain control over patent usage, while receiving royalties from several licensees. Licensing does raise the risk of hindering the spread and usage of green IoT in the context of ambiguity around the value of a patent license. It is in the interest of both the license and licensor to generate value from a licensing agreement (Teece, 1988). With the expressed opinions from the licensees, most of the risks of licensing green tech revolved around the mistrust of the technology generating value and if it would generate enough value to cover the licensing cost. Since green IoT improves the efficiency of manufacturing machines, a possible licensing agreement, to reduce the licensees risks of paying for a license which will not generate value, could entail the licensee to make a percentage-based payment of the energy costs saving through green IoT. Through this structure, the licensee would not bear the risk of paying for something which has not yet generated value. Depending on if the licensor includes know-how and trade secrets in the license, which has shown to be key to attract licensees and reach a successful technology transfer, the licensor might bear some costs and risks of not successfully achieve a technology transfer. To mitigate the risk of the licensor losing invested resources, licensees could pay for the implementation services, alternatively the percentage-based payment could be higher until the implementation services are paid off.

An issue of having a percentage-based payment model is the tracking of correct payments. Licensees may leave faulty reports to the licensor. Thus, the licensor will receive less payment than entitled to. Depending on the implemented technology and how the measurement of energy savings is done, a control system can be in place to correctly measure energy consumption and savings and calculate the royalty the licensee should pay. If there is a need, monitoring activities on site could be done to revise that the correct payments are being made. However, those activities will entail costs in the form of sending inspectors (Teece, 1988). The possibility of implementing such a control-dimension has not been investigated in this thesis.

The interviewees highlighted that for licensing programs to be successful, they had to entail effective licensing structures. The reason for this indicates to be because licensors and licensees are not fond of the transactional costs which entail traditional licenses (Hill, 1992). Furthermore, there is a risk of not reaching an agreement after investments in the preparation of licensing. In this sense the percentage-based payment model for green IoT tech licenses is beneficial. Business will not have to negotiate of a certain license cost. The percentage cost will be flexible since it will depend on the energy saving it makes. Licensees will not have to worry about paying more than other licensees. A worry which might hinder licensing according to Hill (1992). Higher licensing payments would only mean the technology would make more energy savings. Thus, the technology will be more beneficial for businesses who pay more in licensing fees.

Non-exclusive licensing to all actors that are interested would result in broader spread of green IoT manufacturing technology. While it is important that interested licensees are found, as explained by Chesbrough (2006), It requires time and resources for the licensor to find licensees, and the risk is that there is no guarantee for reaching an agreement. To lower the investment needed in formulating license terms, and to mitigate the ambiguity around licensing terms from the licensee's perspective, standardized licensing terms can be made. Standardized terms would also limit the ambiguity around the technology scope if a clear explanation of the included patents relating to the function is communicated.

The ambiguous inhouse-usage of patents for licensees is deemed to be of low risk in the context of licensing green IoT and where the licensor still has the proprietary patent for the technology. Having process innovation can grant a competitive advantage in terms of relative cheaper product offerings where the technological nature is similar (Hay & Morris, 1991). That competitive advantage could be lost if the same process innovation is licensed out to product competitors. However, through a semi open patent strategy the licensor is free to decide to whom to license (Vimalnath, Tietze, Prifti, & Akriti, 2020). Thus, the competitive advantage can be maintained while spreading and generating value from green IoT through licensing in other industries.

A problem that might occur is in the event of a licensor not having patents to licensee a complete "rights-package". In this event a patent pool can be helpful (Chesbrough, 2006).

5.2.3.2. Patent pool licensing strategy

A patent pool licensing strategy can follow the same principles as for licensing strategy. Licenses can be standardized, with percentage-based cost structures, and implementation services can be provided. Additionally, a patent pool can make it easier for licensees of green IoT to acquire a complete "rights-package". Thus, licensors will mitigate the risk of infringement and licensees will be more prone to license.

Chesbrough (2006) shows that in the ICT industry, including IoT, there are often several patents that protect an invention. If several green IoT manufacturing patents are required to successfully implement an invention, then a patent pool can be suitable for sharing the technology. A patent pool that is clear regarding which patents are necessary to license to cover the whole technological scope of green IoT manufacturing inventions reduces the ambiguity around the technology scope for the licensee. The patent pool can be structured so companies with appropriate patents get value from cross-licenses (Maggiono, Marin, Charry Morales, Orlando, & Guegan, 2020), and that companies that are interested in licensing can have a "one-stop shop" and easily take a license including all necessary patents. Similarly, to the fully open strategies and the nature of green IoT manufacturing inventions, a transfer of related software and code would be beneficial to mitigate the ambiguity around the success of technology transfer.

Lastly, in a patent pool licensing strategy the distribution structure for percentage-based payment will need to be decided. Patent holders who have contributed with more patents to the patent pool will likely argue for a bigger share of the value generated. Other contributors will likely argument for a higher quality of their contributed patents and that they facilitate the technological function to a higher degree. An investigation of plausible distribution structures has not been investigated in this thesis but is deemed to be necessary for the function of a patent pools licensing strategy.

5.2.3.3. Platforms for green tech sharing

Platforms for green tech sharing generally allows the joining company to have high control over their patents. Having more control allows the licensor to choose who to licensee, and to receive royalties and to have individualized license terms for different licensees. The WIPO Green platform offers joining actors to structure the agreement as they want, which can be beneficial for the licensor and could lower the ambiguity around the license terms for the licensee if the terms are clearly communicated and agreed upon (WIPO, 2020). Additionally, WIPO Green have a partner network of different actors that can be contacted. The available network could help to mitigate the ambiguity around the success of the technology transfer, by aiding with e.g., knowledge and skills for implementation. Also, the network of actors can help with the technology scope and licensing terms to limit the ambiguity for the licensee.

Platforms for green IoT sharing can be beneficial for the spread and usage of green IoT technology. As was highlighted by the interviews, the platforms can offer marketing benefits in the sense of showing potential licensees that a licensor have patents to license.

Uploading licensable patents to platform for green tech, such as WIPO green does not need to exclude the use of a licensing strategy or patent pool licensing strategy. Marketing benefits can instead be obtained by uploading patents on green tech sharing platforms.

5.3. Additional findings

Next, additional findings and reflections are presented, which has been deemed to not be specifically addressing the aim of the thesis.

5.3.1. Definition of green IoT

Regarding the importance of definitions, and if a green tech definition should be broad or precise, the emerging themes from the interviews was that broad definitions were seen as less beneficial. The insight goes well with Hoff (2012), that claims that the problem with all green tech definitions is that the definitions does not clearly state which technologies they exclude or include. Having a clear and common framework can improve the efficiency of green IoT technology transfer for technology providers, users, and investors (Guo, o.a., 2020).

5.3.2. Misconception of the economic benefits of green IoT

As Hill´s (1992) model points out, businesses will only find it desirable to imitate or license in technology if the technology generates some sort of value to them. Hence, to spread green IoT and allow it to generate value, there must be a demand from licensees. Green IoT has large potential in reducing GHG emissions by improving energy consumption in multiple industries (GeSI & Accenture, 2015). Less energy is required, hence burning fossil fuels for power generation will not be necessary. Power consumption is a distinct cost carrier in many operations. Applying green IoT can reduce power consumption and cut costs for businesses. Hence, there are clear arguments for businesses to obtain green IoT. However, based on the interviews, a theme of disbelief was highlighted in green tech´s capability of generating value. Several of the interviewees expressed the perception of green tech or sustainable investments to only carry costs to reduce businesses´ carbon footprint. In reality, green IoT, which belong to the category of green tech, has the ability to reduce costs and lower the carbon footprint of businesses.

An argument can be made that green IoT should either be distinguished from green tech to not be related to the wrongful notion of green tech. Alternatively, the term green tech should be rebranded with emphasis on the technology´s ability to cut costs. By doing so a willingness to use green IoT can emerge, and the technology can be spread and broadly utilized.

6. Conclusion

This chapter includes the identified factors affecting the success of a green tech sharing mechanism. It also includes a recommended strategy for how to achieve a broad spread and utilization of green IoT manufacturing technology. Additionally, the chapter highlights additional findings made through the study. Finally, recommendations for further research are presented.

6.1. IP-strategy recommendation for green IoT

This thesis aimed to answer the question of how a company that have a solution to make manufacturing more sustainable through IoT can create effective intellectual property structures to allow technology to be utilized on a broader scale. Green IoT solutions that aim to this can be called green tech. Such green tech is complex and incorporates both hardware and software. This study suggests that to reach a broad spread and usage of green IoT manufacturing solutions both the licensor and license must receive value from a license.

Through a literature review and interviews with several technology-based companies it was found that several factors affect if a technology transfer will be successful and for the strategy to enable a broad spread and usage of the technology. The foundation is that green IoT technology must be used extensively. To achieve extensive usage, more actors must be involved, and for more actors to be involved and license green IoT, there must be an acceptable level of ambiguity in relation to taking a license.

There was ambiguity around licensing deals both for licensors and licensees. Both parties required an intellectual property right sharing structure where the value generation through the license would entail low financial risks. Furthermore, for a licensor, issuing a license should not negatively impact the licensors operations due to ambiguity around inhouse patent usage.

For licensees, the license should include clear licensing terms, and the required patents for obtaining the complete “rights-package” to use a technical innovation should be specified and lastly, assistance in relation to implementing licensed technology and make it operational must be offered. If these requirements were fulfilled, the thesis suggests licensees and licensors are prone to enter licensing agreements.

The literature review highlighted three distinct strategies with several sub-strategies for how to spread green tech using intellectual property. Putting the strategies in the context of green IoT which is related to software and hardware, the research suggest that a semi-open patent strategy is most suitable for creating effective sharing structures. A semi-open patent strategy can either have the form of licensing or patent pool, with or without the addition of green tech sharing platforms. The advantage of a semi-open strategy is that the strategy is effectively contributing to solving identified ambiguity factors related to spreading green tech.

To limit ambiguity around the risks surrounding the value of a patent license, this work suggests a payment model, through the category of semi open patent strategies, where the licensor is paid a percentage of the energy cost reduction enabled by the licensed green IoT technology. With the licensees' required transfer of knowhow, trade secrets, and implementation assistance, the licensing agreement will entail a small cost for the licensor to make the licensed green IoT operational, to then in turn profit from the energy reduction cost percentage. The licensors risk of not benefitting from these investments is proposed to either be mitigated through a transaction for the implementation services, alternatively the percentage of the energy cost reduction can be higher until the implementation investments made by the licensor is paid off.

Potentially, the business of the licensor includes manufacturing and selling of products. In this situation, licensing process innovation, which might give a competitive advantage in terms of price compared to similar products, would not be beneficial. However, semi-open patent strategies do not require licensors to licensee to all who might be interested. Hence, through the strategy, the licensor can maintain competitive advantage while still spreading and generating value from licensees in other industries.

Lastly, clearly communicating the license terms through a semi-open licensing strategy mitigates the ambiguity surrounding the licensing terms, compared to other identified options. Furthermore, by clearly communicating the technology scope shows that the necessary patents that are needed to achieve the intended function is licensed to the licensee. If a licensor does not have the sufficient patents to license a complete rights-package, giving licensees the lawful right to implement and use a green IoT solution, this thesis suggests forming a patent pool with other patent holders who´s patents are necessary for the licensees to acquire the lawful right. By doing this the technology transfer of green IoT has a higher chance of being broadly spread and it will consequently generate value for licensees and licensors.

6.2. Additional findings

The study has also highlighted a possible misconception of green tech and how that misconception can negatively influence the spread and usage of green tech and green IoT manufacturing technology. No interviewed company has a definition for green tech, which concludes that the definition is of low importance. However, to join certain patent sharing initiatives, the technology must be *green* according to the initiative's definition. In this context, a definition is important.

Additionally, interviewees expressed a disbelief in green tech´s ability to generate financial value. The underlying theme identified was that companies saw green tech as additional costs for reducing climate impact, and not as a technology which can reduce climate impact and generate value. With the purpose of spreading and enabling broad usage of green IoT, this thesis purposes to distinguish green IoT from green tech, or attempt to rebrand green tech, to highlight its financial benefits as well.

6.3. Further research

Spreading and enabling broad usage of green tech to developing countries is not the main topic of research in the study. To allow developing countries to access green tech this study might not be generalizable enough, considering the focus on patents in the study, and that the patent system in many developing countries is weak. With a focus on spreading green technology to developing countries, other mechanisms are likely suitable over a form of patent licensing.

Further analyzing what technology that constitutes green IoT manufacturing would increase the applicability the proposed strategy. Patent pools are used for technologies that are enabled by standards, and if green IoT manufacturing technology should become a standard, a patent pool can be an option to spread green IoT. A patent pool could solve the potential patent thicket issue for green IoT manufacturing technologies, while providing value for both licensees and licensors. Having a patent pool for green IoT manufacturing would require more research into what specific technology, and patents, are needed to facilitate a technology transfer to the specific licensees' industry.

Investigating the nature of software-based green technologies and the intellectual property mechanisms that is involved to protect an innovation would be beneficial. Such a study could be done by interviewing inventors and developers of software-based innovation.

The analyzed framework presented in the study regarding closed, semi-open or fully open is one framework. Other frameworks depending on other factors than degree of openness can be used to recommend a suitable strategy.

References

3GPP. (2021, Mars 31). *About 3GPP*. Retrieved from 3GPP - The Mobile Broadband Standard: https://www.3gpp.org/about-3gpp

Abbas, M. Z. (2013). Pros and Cons of Compulsory Licensing: An Analysis of Arguments. *International Journal of Social Science and Humanity*, 254-256.

Baden, D., & Harwood, I. A. (2013). Terminology Matters: A Critical Exploration of Corporate Social Responsibility Terms. *Journal of Business Ethics* , 615-627.

Baron, J., & Pohlmann, T. (2018). Mapping Standards to patents using declarations of standard essential patents. *Journal of Economics & Management Strategy*, 504-534.

Bauer, A., Morea, K., & Breasseale, T. (2021, April 22). *Hewlett Packard Enterprise, Facebook and Microsoft grant free patent access for low-carbon innovators*. Retrieved from Hewlett Packard Enterprise: https://www.hpe.com/us/en/newsroom/press-release/2021/04/hewlett-packard-enterprise-facebook-and-microsoft-grant-free-patent-access-for-low-carbon-innovators.html

BBC. (2021, May 6). *Covid: US backs waiver on vaccine patents to boost supply* . Retrieved from BBC: https://www.bbc.com/news/world-us-canada-57004302

Bird, R. C. (2008). Can Compulsory Licensing Improve Access to Essential Medicines?

Blind, K., Gauch, S., & Hawkins, R. (2010). How stakeholders view the impacts of international ICT standards. *Telecommunications Policy*, 162-174.

Bowen, G. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal*, 27-40.

Bryman, A., & Bell, E. (2015). *Business Research Methods (4.th ed.).* Oxford: Oxford University Press.

Chesbrough, H. (2003). The logic of open innovation: managing intellectual property. *California Management*, 33-58.

Chesbrough, H. (2006). *Emerging secondary markets for intellectual property: US and Japan comparisons.* Lafayette: National Center for Industrial Property Information and Training (NCIPI).

Chesbrough, H., & Garman, A. R. (2009). How Open Innovation Can Help You Cope in Lean Times. *Harvard Business Review*.

Christensen, J. F., Olsen, M. H., & KJÆR, J. S. (2005). The industrial dynamics of Open Innovation—Evidence from the transformation of consumer electronics. *Research Policy* , 1533-1549.

Contreras, J. (2015, - -). *Patent Pledges.* Retrieved from HEINONLINE: https://heinonline.org/HOL/LandingPage?handle=hein.journals/arzjl47&div=23&id=&page=

Contreras, J. L., Hall, B. H., & Helmers, C. (2019). Pledging Patents for the Public Good: Rise and Fall of the Eco-Patent Commons. *Houston Law Review*.

Diakun, B. (2019, May 17). *The pledge that may reduce Tesla's value as it seeks additional funds.* Retrieved from IAM: https://www.iam-media.com/finance/pledge-may-reduce-teslas-value-it-seeks-additional-funds

Ebrahim, T. Y. (2020). Clean and sustainable technology innovation. *Current Opinion in Environmental Sustainability*, 113-117.

Ehrnsperger, J. F., & Tietze, F. (2019). Patent pledges, open IP, or patent pools? Developing taxonomies in the thicket of terminologies. *PLOS ONE*, 1-11.

Ericsson. (2020). *Breaking the energy curve - An innovative approach to reducing mobile network energy use.* Stockholm.

Fair, R. (2010). Does Climate Change Justify Compulsory Licensing of Green Technology? *Brigham Young University International Law & Management*.

Frankefield, J. (2021, January 5). *Trade Secret.* Retrieved from Investopedia: https://www.investopedia.com/terms/t/trade-secret.asp

GeSI. (2009, June). *ICT Sustainability through Innocation, GeSI Activity Report.* Retrieved from gesi: http://gesi.org/research/download/16

GeSI, T. G.-s., & Accenture. (2015). *GeSI SMARTer 2030: ICT Solutions for 21st Century Challenges.* GeSI & Accenture.

Ghafele, R., & O'Brien, R. D. (2012). Open Innvoation for Sustainability: Lessons from the GreenXchange Experience. *Policy Brief*.

Gibson, D., & Rogers, E. (1994). R&D Collaboration on Trial: The Microelectronics and Computer Consortium . *Harvard Business School Press*.

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2012). Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology. *Organizational Research Methods*.

Gunderson, A. (2014). Protecting the Environment by Addressing Market Failure in Intellectual Property Law: Why Compulsory Licensing of Green Technologies Might Make Sense in the United States: A Balancing Approach. *Brigham Young University Law Review*.

Guo, R., Lv, S., Liao, T., Xi, F., Zhang, J., Zuo, X., . . . Zhang, Y. (2020). Classifying green technologies for sustainable innovation and investment. *Resources, Conservation & Recycling*.

Hall, B. H., & Helmers, C. (2013). Innovation and diffusion of clean/green technology: Can patent commons help? *Journal of Environmental Economics and Management*, 33-51.

Hay, D., & Morris, D. (1991). *Industrial Economics and Organization: Theory and Evidence.* Oxford: Oxford University Press.

Heckeler, P. (2019, April 17). *Software patent applications: How the EPO examines innovative software.* Retrieved from https://www.bardehle.com/europeansoftwarepatents/software-patent-epo/: https://www.bardehle.com/europeansoftwarepatents/software-patent-epo/

Hernández-Chea, R., Vimalnath, P., Bocken, N., Tietze, F., & Eppinger, E. (2020). Intergrating Intellectual Property and Sustainable Business Models: The SBM-IP Canvas. *Sustainability*, 1-30.

Hill, C. (1992). Strategies for Exploiting Technological Innovations: When and When not to License. *Organizational Science*, 428-441.

Hoff, P. H. (2012). *Greentech Innovation and Diffusion - A Financial Economics and Firm-Level Perspective.* University of St. Gallen.

HPE, H. P., Facebook, & Microsoft. (2021, April 22). Low-Carbon Patent Pledge. United States of America: Hewlett Packard Enterprice, Facebook & Microsoft.

IAM. (2021, May 4). *IAM Media*. Retrieved from Brazilian Senate passes compulsory covid-19 know-how licensing bill: https://www.iam-media.com/coronavirus/brazilian-senate-passes-compulsory-covid-19-know-how-licensing-bill

IAM Media. (2019, May 7). *The pledge that may reduce Tesla's value as it seeks additional funds*. Retrieved from IAM Media: https://www.iam-media.com/finance/pledge-may-reduce-teslas-value-it-seeks-additional-funds

IAM Media. (2019, May 24). *Toyota showcases the dynamism of IP strategy in the auto sector*. Retrieved from IAM Media: https://www.iam-media.com/patents/toyota-showcases-dynamism-ip-strategy-auto-sector

IBM. (2008, January). *The Eco-Patent Commons.* Retrieved from https://www.ibm.com/ibm/environment/news/Eco-PatentCommonsBrochure_011008.pdf

ITU. (2012). *Internet of Things Global Standards Initiative*. Retrieved from ITU: https://www.itu.int/en/ITU-T/gsi/iot/Pages/default.aspx

Kastenmeier, R. W. (2013). software patents and the return of functional claiming. *Wisconsin Law Review*, 905-964.

Kenton, W. (2020, September 13). *Copyright.* Retrieved from Investopedia: https://www.investopedia.com/terms/c/copyright.asp

Kitch, E. W. (1977). The Nature and function of the patent system. *The Journal of Law and Economics*, 265-290.

Kopetz, H. (2011). Internet of Things. *Real-Time Systems*, 307-323.

Kuji, N., & Cannady, C. (2011). Propagating Green Technology: A Japan Intellectual Property Association Proposal. *Les Nouvelles*.

Landes, W., & Posner, R. A. (1987). Trademark Law: an economic perspective. *The Journal of Law and Economics*, 265-309. Retrieved from United States Patent and Trademark Office.

Layne-Farrar, A., & Lerner, J. (2011). To join or not to join: Examining patent pool participation and rent sharing rules. *International Journal of Industrial Organization*, 294-303.

Lerner, J., & Tirole, J. (2004). Efficient patent pools. *American Economic Review*, 691-711.

Lichtenthaler, U., & Lichtenthaler, E. (2010). Technology Transfer across Organizational Boundaries: Absorptive Capacity and Desorptive Capacity. *California Management Review*.

Lieberman, M., & Montgomery, D. (1988). First-mover advantages. *Strategic Management Journal*, 41-58.

Love, J. P. (2007). *Recent examples of the use of compulsory licenses on patents.* Knowledge Ecology International.

Maggiono, L., Marin, D., Charry Morales, L. N., Orlando, P., & Guegan, V. G. (2020). *Mandatory Patent Pools.* 4IP Council.

Mansfield, E. (1985). How Rapidlt Does New Industrial Technology Leak Out? *Journal of Industrial Economics*, 217-223.

Merriam-Webster. (2020, April 26). *Definition of Definition by Merriam-Webster*. Retrieved from Merriam Webster: https://www.merriam-webster.com/dictionary/definition

Misterovich, E. (2017, June 7). *Patents 101: The Different Types of Patents.* Retrieved from Revision/Legal: https://revisionlegal.com/trademark/intellectual-property/different-types-of-patents/

Morrison, A. (2020). The patent as a negative right and the claim as its business end. *Columbia University Press*.

New York Times. (2020, 05 14). *Biden Backs Suspending Patents On Covid Vaccines*. Retrieved from The New York Times: https://www.nytimes.com/2021/05/05/us/politics/biden-covid-vaccine-patents.html

Oster, S. (1990). *Modern Competitive Analysis.* Oxford: Oxford University Press.

Petrusson, U. (2004). *Intellectual Property and Entrepreneurship* . Göteborg: Center for Intellectual Property Studies.

Pitkethly, R. H. (2001). Intellectual property strategy in Japanese and UK companies: patent licensing decisions and learning opportunities. *Research Policy*, 425-442.

Pohlmann, T., Neuhäusler, P., & Knut, B. (2016). Standard Essential Patents to Boost Financial Returns. *R&D Management 46*, 612-630.

Porter, M. (1980). *Competitive Strategy.* New York: Free Press.

Prakash, S., & Raju, K. D. (2021). Standardization and Standard Essential Patents for Public Good: Application in Automotive Industry. *SASI*, 56-60.

Radović Marković, M., & Aidin, S. (2018). The Importance of Communication in Business Management. *Business Management, Entrepreneurship and Entrepreneurial Tendencies*, 11-28.

Richardson, K. (2004, June 4). Patent Licensing in the Semiconductor Industry. Palo Alto.

Rodau, A. G. (1985). RODAU, Andrew G. Protection of Intellectual Propert-Patent, Copyright, and Trade Secret Law in the United States and Abroad. *NCJ Int'l L. & Com*, 537.

Rogers, E. M., Takegami, S., & Yin, J. (2001). Lessons learned about technology transfer. *Technovation*, 253-261.

Roya, G., & O´Brien, R. (2012). *Open innovation for sustainability: Lessons from the GreenXchange experience.* MPRA.

Shapiro, C. (2000). Navigating the patent thicket: Cross licenses, patent pools, and standard setting. *Innovation policy and the economy*, 119-150.

Shapiro, C., & Varian, H. (1999). *Information Rules. A Strategic Guide to the Network Economy.* Cambridge: Harvard Business School Press.

Taubman, A. (2009, February). *WIPO.* Retrieved from WIOPMAGAZINE: https://www.wipo.int/wipo_magazine/en/2009/02/article_0002.html

Teece, D. (1986). Profiting from Technological Innovation. *Research Policy*, 285-305.

Teece, D. (1988). Technological change and the nature of the firm. *Technical change and economic theory*, 256.

Teppo, P., & Norrman, K. (2020, April). *Security in 5G RAN and core deployments.* Retrieved from Ericsson: https://www.ericsson.com/en/reports-and-papers/white-papers/security-in-5g-ran-and-core-deployments

Tesla. (2021, May). *Privacy & Legal*. Retrieved from Tesla: https://www.tesla.com/about/legal#patent-pledge

Toyota. (2015, January 6). *Toyota Opens Its Fuel Cell Vehicle Patents for Free Use*. Retrieved from Toyota Global: https://global.toyota/en/detail/4663648

Toyota. (2019, April 3). *Toyota Promotes Global Vehicle Electrification by Providing Nearly 24,000 Licenses Royalty-Free*. Retrieved from Toyota Global: https://global.toyota/en/newsroom/corporate/27512455.html

Trappey, A. J., Trappey, C. V., Govindarajan, U. H., Chuang, A. C., & Sun, J. J. (2017). A review of essential standards and patent landscapes for the Internet of Things: A key enabler for Industry 4.0. *Advanced Engineering Informatics*, 208-229.

United Nations. (1992). United Nations Conference on Environment & Development. Rio de Janerio.

United Nations. (2019). *The Climate Crisis – A Race We Can Win*. Retrieved from United Nations: https://www.un.org/en/un75/climate-crisis-race-we-can-win

United Nations, S. D. (2015). *Economic Statistics*. Retrieved from UN stats: https://unstats.un.org/unsd/classifications/Econ/CPC.cshtml

United Nations, S. D., Department of National Economic, U. N., Office, S., & Statistics, D. o. (2015). Central Product Classification (CPC): Version 2.1. New York, New York, United States of America.

Vimalnath, P., Tietze, F., Eppinger, E., & Sternkopf, J. (2020b). Closed, Semi-Open, or Fully-Open? Towards an Intellectual Property Strategy Typology. *Academy of Management*.

Vimalnath, P., Tietze, F., Prifti, V., & Akriti, J. (2020). IP Strategies for Green Innovations - An Analysis of European Inventor Awards. *Centre for Technology Management working paper series*.

West, J. (2006). The economic realities of open standards: Black, white and many shades of gray. *Standards and Public Policy*, 87-122.

WIPO . (2019). *WIPO Green Year In Review 2019.* WIPO.

WIPO. (2019). *WIPO GREEN Strategic Plan 2019-2023.* Geneva: WIPO.

WIPO. (2020, 04 13). *About the International Patent Classification*. Retrieved from WIPO - World Intellectual Property Organization: https://www.wipo.int/classifications/ipc/en/preface.html

World Health Organization. (2020, 05 14). *WHO*. Retrieved from WHO | Climate change: https://www.who.int/heli/risks/climate/climatechange/en/

World Trade Organization. (1994). *Agreement on Trade-Related Aspects of Intellectual Property Rights.* World Trade Organization.

World Trade Organization. (2001). *Declaration on the TRIPS agreement and public health.* WTO.

Appendix A: Interview guide

IP strategy and innovation

1. How is IP being used in your business?

2. Do you transfer more than patent rights in license deals?

    a. If not, what is your opinion on transferring e.g., know-how or other complementary assets relating to the invention?

3. What do you see as most important for achieving a successful technology transfer?

4. Are you aware of which patents are being used in the business today?

Green tech

1. Do you have a definition for green tech?
    a. Why/why not?

2. Do you have a specific IP strategy for green tech?

3. Are you aware of green tech patent sharing initiatives?

    a. If yes, what are your opinions?

    b. If no, explaining:

        i. Eco-patent commons, and Tesla's patent pledge.

            1. What is your opinion of the initiatives? Benefits and risks?

        ii. Green tech sharing platforms, such as WIPO Green.

            1. What is your opinion of the initiative? Benefits and risks?

4. How would you allow for broad usage of a patented green technology?

5. What is your opinion on spreading green tech through licensing?

6. What is your opinion on governments issuing compulsory licensing bills?

Software based green tech

1. Do you believe spreading software based green tech has to be handled different from other green technologies?
    a. Why/why not?

2. In the case of transferring software based green tech, what is your opinion on including know-how, such as software and code relating to the invention?

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