MASTER

Capturing value from intellectual property in Dutch high-tech supply chains

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Capturing value from intellectual property in Dutch high-tech supply chains

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Preface

Before you lies the thesis ''Capturing value from intellectual property in Dutch high-tech supply chains''. It has been written to fulfill the graduation requirements of the Innovation Management master's program at the Eindhoven University of Technology. Looking back on my time in Eindhoven, I have learned an incredible amount in a very motivational atmosphere.

Many people have made this thesis possible, and I would like to thank these.

First of all, I want to thank the interviewees. Not only did I gain the necessary input for this study, in an incredibly short time I also learned about the industry, its companies and how they relate to each other. Furthermore, I want to thank Brainport Industries for putting me into contact with these people.

The project was undertaken at the request of The Netherlands Patent Office (Octrooicentrum Nederland). Thank you, Hans Helsloot, for putting forward an interesting research setting, giving me a quick course on anything patent-related and showing me that in practice the topic of intellectual property is a lot more relevant and interesting than many people think. I also owe thanks to the people in The Hague for sharing their ideas on the subject and providing me with a large chunk of quantitative data.

Furthermore, my supervisors at the university proved invaluable. Myriam Cloodt, thank you for steering me in the right directions, providing input and feedback every step of the way and aiding me in dealing with some administrative inconveniences along the way. Thank you too, Rudi Bekkers, for sharing your expertise on the subject as well as your feedback on writing the thesis.

Last but not least, I am grateful for the everlasting support of my family and their efforts to help me through bad and good times.

I hope you enjoy reading this,

Jeroen Musch,
Eindhoven, May 19, 2017

Management Summary

The Dutch government has set the goal for The Netherlands to be in the top 5 of knowledge economies around the world by 2020 (House of Representatives, 2011). Out of 9 key sectors, High Tech is currently the largest in terms of production, added value, and export (Seip & Stoop, 2011). Almost 50% of all research and development (R&D) expenditure by Dutch companies is done in this sector (Ministry of Economic Affairs, 2015). This means a vast amount of intellectual property (IP) is generated every day. However, analysis shows that original equipment manufacturers (OEMs) apply for patents about three times as much as suppliers. This seemed odd because OEMs outsource more than ever and suppliers become increasingly responsible for the design of innovations (Arruñada & Vázquez, 2006). The Netherlands Patent Office (NL Octrooicentrum) therefore wants to know how companies throughout the Dutch high-tech supply chain capture value from their innovations.

Central in this project is the concept of *appropriation*, also known as *appropriability*; the degree to which innovating firms can capture value generated when innovations are introduced (Ceccagnoli, 2009; Teece, 1986). Appropriability has become synonymous to the mechanism that firms employ to prevent imitation by other companies (Hurmelinna et al., 2007). Therefore it is key for a firm to protect its innovations and related intellectual property. Firms can employ strategic methods to do so. These are called appropriation strategies or appropriation mechanisms and describe how a firm prevents imitation and captures innovation benefits. These fall into three categories;

Formal appropriation mechanisms

These are the traditional IP rights (IPRs). These are attained by disclosing information to the public domain in order to gain exclusionary rights. Examples include patents, industrial design rights, trademarks and copyrights.

Informal appropriation mechanisms

These focus on preventing knowledge spillovers and keeping information proprietary. The main two examples in this category are the pursuit of lead time advantages (by continuously faster product development) and trade secrets.

Complementary assets

These are assets that are strategically needed for gaining competitive advantage and the successful commercialization of an innovation. For example assets and capabilities related to marketing, manufacturing, distribution and after-sales services (Teece, 1986).

Appropriation requires significant managerial attention and can also entail considerable transaction costs. Firms must choose the right mechanism or combination of mechanisms to reduce costs and competition. The choice is different per firm and depends on four categories of factors (James et Al, 2013); the institutional environment, industry-, firm- and technology-level factors. A fifth category; supply chain dynamics was superposed on this theory to provide additional depth. An overview of the main concepts is given in figure A.

Eleven companies within the Dutch high-tech sector were interviewed. The main results are presented hereafter.

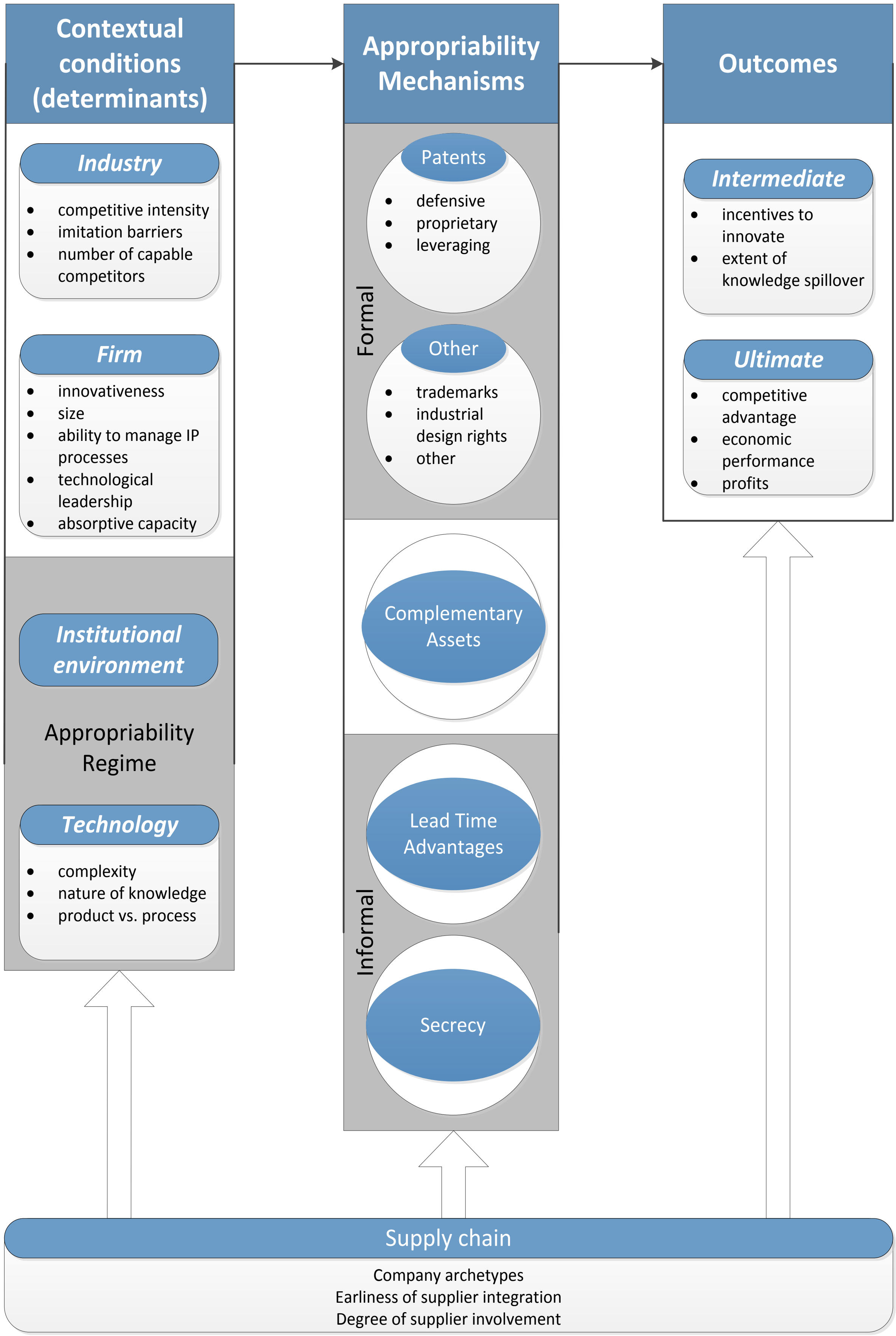


Figure A: conceptual model

Companies in the Dutch high-tech sector can use any of the appropriability mechanisms to capture value from their IP. The position of the company within the chain, or more precisely; the specific new product development (NPD) processes a firm is involved in strongly influence the choice of the chosen appropriability mechanisms. The explanation for this is that the emphasis gradually shifts from product knowledge towards process knowledge throughout the NPD process. Using a basic model of NPD as depicted in figure B and the following (simplified) definition of firm archetypes, the results can be specified.

OEM (original equipment manufacturer):

a company that sells an end-product and is typically at the end of a supply chain. Typically performs steps 1, 2 and 3 in the NPD process.

Engineering agency:

a company that develops and engineers a (sub)product or module for an OEM. Typically performs steps 3, 4 and 5 in the NPD process.

CM (Contract manufacturer):

a company that manufactures end-products or modules for an OEM. Typically performs steps 5 and 6 in the NPD process.

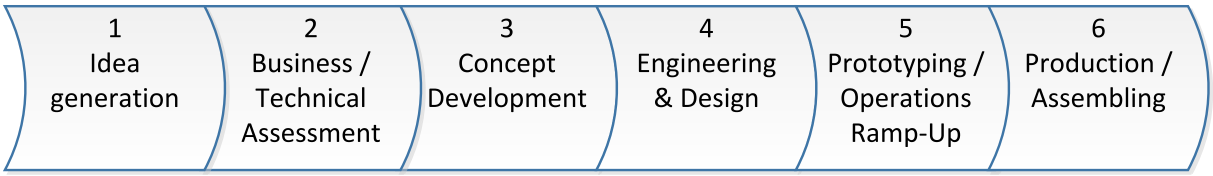


Figure B: new product development process. Adapted from Handfield et al. (1999)

Knowledge can be codified or not. When it is hard or impossible to codify knowledge, it is called tacit knowledge. When companies innovate, some knowledge is revealed in end-products (usually product innovation), and some is not (usually process innovation).

CMs typically deal with tacit knowledge and process innovations. These can be protected with informal mechanisms or by a focus on complementary assets. Since process innovations are generally invisible to outsiders, they can more easily be protected by secrecy. Engineering agencies typically deal with product innovations. In addition to informal mechanisms, this knowledge can additionally be protected with formal mechanisms. However, since these agencies typically work on a project basis, hired by OEMs, the IP rights go to the OEMs as well. OEMs deal with mainly product innovations, and to a lesser extent process innovations. Because of their bargaining position, they typically accrue most IP rights.

Technology factors together with supply chain characteristics seem most influential in the selection of appropriation mechanisms. Formal mechanisms are typically pursued by or under the auspices of OEMs. Secrecy is used by all firms but is especially effective for CMs. The pursuit of lead time advantages happens across all firms. When it comes to complementary assets, every company tries to differentiate itself from its competitor by trying to specialize technologically.

This study's most important insights and its implications are listed below. The first three pertain to companies in general throughout the high-tech sector.

1. There likely is untapped potential in some of the formal appropriability mechanisms. Patents are mainly used defensively, trademarks are not highly regarded as a business tool and other rights such as industrial design rights seem non-existent. This begs the question whether firms fully know, value and utilize the potential of IPRs. The nodal point is not to possess an IP portfolio, but to understand how to manage and exploit one strategically, which calls for attention and consciousness towards these subjects. The Netherlands Patent Office could play a role in this. Ultimately, companies should explore these topics and then reevaluate their IP portfolio, and see if there is any lost potential by skipping a mechanism that is suitable to their conditions.

2. Companies can improve the efficacy of secrecy. Companies seem satisfied with physical measures taken, but seem to be insufficiently aware of the additional administrative precautions they need to take. Companies across the spectrum need to put greater effort in specifying or defining what information it is that they want to keep secret and who has access to it.

3. When it comes to complementary assets, most companies seem to focus merely on their technological capabilities and forget to realize that there may be other assets they could try to improve or obtain to gain additional advantages.

4. Small firms have less experience with IPRs than large firms. A strategic vision on IP often lacks and the topic is not approached pro-actively. Furthermore, small firms tend to underestimate their chances of success in patent litigations. The education department of The Netherlands Patent Office could play an important role here.

5. Currently, the locus of IP generation lies with the OEM. The driving force in the generation of IP stems from the OEMs and as the OEMs are the owners of the end-product, the bulk of the IP gravitates towards the OEMs. This locus is shifting; suppliers upstream take on more responsibilities and start to perform activities earlier in the NPD process.

6. In addition to 5; when engineering agencies or other companies design a (sub)product or module for OEMs and IP is generated, OEMs claim ownership of that IP. They state that they will provide a license to the designing firm to use that IP, if desired. However, this does not always seem to be the case in the perception of those firms. Furthermore, when those licenses are actually provided, they often prove to be of limited use because they are technically too specific to find customers for, or companies are restricted from operating in the market space of the OEM. If engineering agencies, or suppliers in general, would be allowed to own more IP when designing for another company, it could help in bridging the capability gap as described in the following point.

7. There is (often) a mismatch in expectations between OEMs and their suppliers when it comes to their technical capabilities. OEMs tend to over expect and upstream companies tend to underperform. The development of certain capabilities does not go as fast as either company would like. Additionally, contract manufacturers mention the speed of this growth is hindered financially. If OEMs want their suppliers to become more capable, they will need to provide (more) resources to allow them to make this transition.

8. Support in regards to IP related matters within the supply chain is available but often not found. OEMs claim they provide such support but suppliers do not acknowledge this claim. Organizing support on a supply-chain level instead would relieve OEMs and at the same time would provide support to be more visible and sustainable.

There is room for The Netherlands Patent Office to expand their educational activities or improve them in several ways. First of all in current workshops, an emphasis could be put on providing extra clarity to certain issues. For example the identification step in secrecy or creative ways of reaching a beneficial settlement in patent litigations. Second, it could develop an educational tool or activity to educate firms on the use of appropriability on a more strategic level. This could help companies evaluate their IP portfolio more pro-actively, make them more aware of other mechanisms and possibly unlock untapped potential. Third, it could reach more companies by shifting its educational activities from mostly inbound to outbound as well. This could be done by targeting umbrella organizations, such as supply chain organizations or trade associations. For example, The Netherlands Patent Office could help set up educational programs for those organizations, instead of educating individual companies. This way, more companies could be reached and supply chains could become more self-sufficient at the same time.

1: Introduction

In order to stimulate the Dutch knowledge economy, the government has come up with the policy of key sectors. The ambitions of this policy are threefold; to get the Netherlands in the top 5 of knowledge economies in the world by 2020, to increase Dutch R&D expenditure and to stimulate the creation of public-private consortia worth over €500 million by 2015 (House of Representatives, 2011). Nine distinct industries had been classified as the most important drivers to sustainably grow the economy of The Netherlands.

One of these is the top sector High Tech & Smart Materials (HTSM), previously known simply as 'High Tech'. In terms of production, added value and export HTSM is the largest of all top sectors, making it the most valuable industry currently in The Netherlands and the most promising for the future. Almost 50% of all research and development (R&D) expenditure by Dutch companies is done in this sector (Ministry of Economic Affairs, 2015). This means a vast amount of knowledge is being generated every day. Much of this knowledge translates into intellectual property (IP). IP rights (IPRs) can be attained by formalizing the IP, resulting in trademarks, design rights or patents for example. IPRs in general give an exclusive right to the owner for a certain amount of time. This means they hold a certain value and in business traditionally they are gained for predominantly economic reasons, especially patents.

Consistent with the economic figures, most patent applications in The Netherlands are based on high-tech (Seip & Stoop, 2011). These applications go through The Netherlands Patent Office (NL Octrooicentrum). The Netherlands Patent Office implements (inter)national patenting regulations within the Netherlands and also educates businesses on the use of patents and other IP. It was also here where, from contact with many firms in the industry, a suspicion arose that suppliers patent significantly less than the final customer downstream; the original equipment manufacturers (OEMs). A preliminary analysis determined this to be the case indeed. Figure 1 illustrates this. It displays the amount of patent applications filed by Dutch commercial organizations split into either suppliers or OEM organizations. These patent applications were filed through the Dutch, European Patent (EP), or Patent Cooperation Treaty (PCT) procedures from 2005 till 2013. These applications can lead to the grant of a patent in respectively The Netherlands, most European countries and other countries worldwide, as long as they are participants in the corresponding treaty.

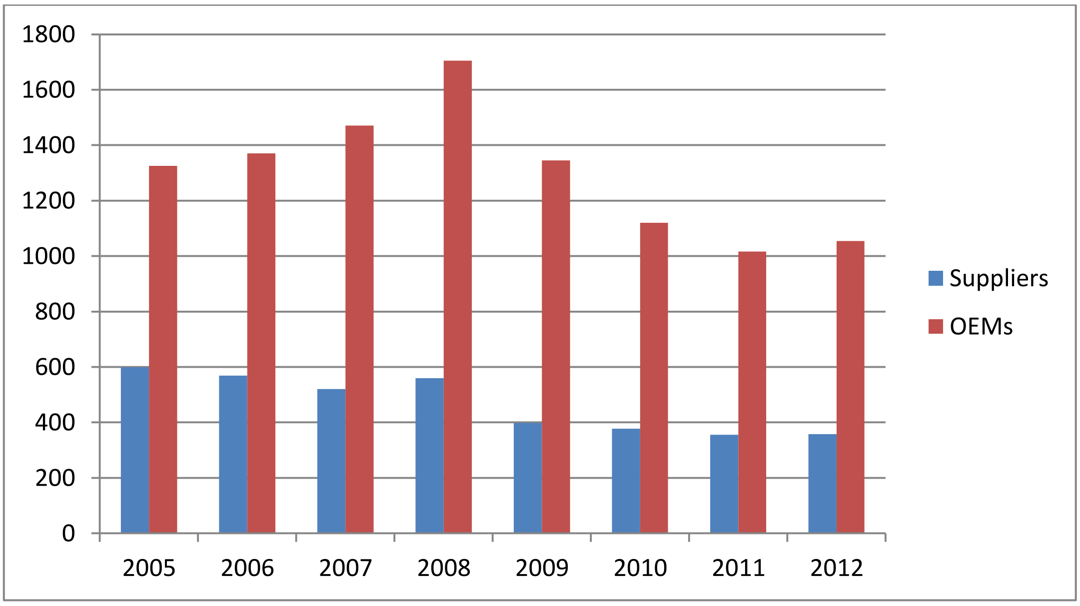


Figure 1: amount of NL, EP & WO patent applications by Dutch firms

Throughout these years Dutch OEMs accounted for 73,6% of these applications, leaving 26,4% on the account of suppliers. However, the distribution of OEMs and suppliers was not even either. OEMs accounted for 48,6% of the companies in this analysis, exacerbating the difference. In an industry where open innovation is the norm (Chesbrough, 2003; Chesbrough, 2003), this discrepancy in patenting behavior seems odd. Nowadays, OEMs outsource more than ever. This leads to suppliers becoming increasingly responsible for activities earlier in the design of innovations (Arruñada & Vázquez, 2006). Suppliers must be more knowledgeable to perform these activities well. It is logical to assume that more intellectual property is then generated as well. But why does this not lead to a (relative) increase in patent applications by suppliers throughout the supply chain? Does this leave the suppliers vulnerable to competitors? In order to answer these questions, one needs to look at the underlying theory of appropriability; how firms utilize their intellectual property and capture value from its innovations. This research aims to gain insights into the determinants for selecting various appropriability mechanisms and their intended outcomes. Though scholars have large amounts of quantitative data on this subject, they emphasize there is a need for qualitative studies to be able to explain quantitative observations (James et al., 2013; Somaya, 2012). This study contributes to filling this gap in the literature. Furthermore, it explores a new area in research at the crossroads of IPRs and supply chains. At the same time, this research is practically relevant because it identifies opportunities for improvement for firms in Dutch high-tech supply chains on a strategic level. The main research question in this study is:

How do suppliers in the Dutch high-tech sector protect their intellectual property and capture value from their innovations?

The following research subquestions were defined to break down the main research question:

1. *What appropriation mechanisms can be relevant for firms in the Dutch high-tech industry?*

2. *What are the determinants in the selection of (an) appropriation mechanism(s) by these firms?*

3. *Does this vary between firm archetypes within the Dutch high-tech supply chain?*

Answering these questions is of practical relevance because;

- *firms* in the Dutch high-tech sector can adjust their strategies or take measures to avoid or improve suboptimal practices and capture more value from its intellectual property,

- in *the supply chain* weaknesses in its dynamics can be identified, leading to the identification of areas of improvement for inter-firm relations and cooperation,

- *The Netherlands Patent Office (Octrooicentrum Nederland)* can evaluate its current education and counseling services and make adjustments to better fit the needs of the high-tech industry in the foreseeable future.

Structure of the thesis

The thesis has a structure resembling that of scientific literature. Therefore, it can be read from start to finish, or one could jump to the parts the reader is most interested in. The contents of the chapters are explained below.
In chapter 2 the theoretical background is presented. Key literature is put forward and important concepts are presented and explained. A number of propositions are generated which are tested in this study. At the end of the chapter, a conceptual model is presented (figure 7), which gives a clear overview of the most important concepts discussed.

In chapter 3, the method of the research is put forward. It explains the type of research, the scope of the research and what steps were taken to come to the end result, this thesis. Scientific requirements such as the controllability, reliability, and validity are also put forward there.

Chapter 4 presents material from the interviews that were conducted. It is a condensation of what was said during the interviews. The reader gets to see the perspective from the companies. Content is presented per concept as in the conceptual model.

Chapter 5 provides the interpretation of the data as presented in chapter 4. It evaluates the results from the interviews and secondary data. This is done by going over the concepts one by one again. Then the results are summarized and insights are presented from a helicopter view.

In chapter 6 the research questions as defined in the introduction are answered. The research subquestions are answered first and the main research question is answered subsequently.

Chapter 7 forms the discussion of the research. First, the results of this study are compared to findings in literature, so differences or similarities can be identified and explained. Then the managerial implications are put forward. Finally, the study's limitations and ideas for future research are provided.

2: Theoretical background

This chapter presents the theoretical background. Key concepts and findings from literature are put forward here. The aim of the chapter is to develop a conceptual model (figure 7, page 35) and a number of propositions (appendix A, page 84). These could then be tested in the remainder of this study. The selection process of literature is described in appendix E, after which a literature review was written. Essentially, this chapter is a condensation of that literature review.

Chapter 2.1 introduces the topic of appropriability: the degree to which innovating firms can capture value generated when innovations are introduced. In 2.2 a framework is presented which shows appropriability strategies and its determinants. These are elaborated upon in 2.3, where propositions number 1 to 22 are presented. Chapter 2.4 presents certain supply chain characteristics in the context of appropriability. The remaining propositions are put forward here as well. In 2.5 the conceptual model is presented.

Readers are advised to take a look at the conceptual model (figure 7, page 35) beforehand and revisit it occasionally to see concepts in a larger perspective whilst reading through this chapter.

2.1 Appropriability

Central in this project is the concept of *appropriation*, also known as *appropriability*; the degree to which innovating firms can capture value generated when innovations are introduced (Ceccagnoli, 2009; Teece, 1986). Evidently, firms strive to achieve a high level of appropriability to profit as much from their innovations as possible. After all, most innovations are the fruits of knowledge generated by costly R&D activities. Furthermore, competitors can attempt to imitate the innovation in order to claim their share of the marketplace. Therefore the ownership of critical pieces of intellectual property is an important strategic source of competitive advantage (Granstrand, 2000). Hence, appropriability has become synonymous to the mechanism that firms employ to prevent imitation by other companies. It is essential for innovators to be able (i) to make intellectual assets less transferable, and (ii) to increase the costs of copying. In brief, generating market imperfections for knowledge assets is the basis of the firm's competitive advantage (Hurmelinna et al., 2007).

The basic premise of appropriation is that knowledge pertaining to innovations comes from various sources of information. And when this information can be easily imitated, the returns from the innovation may accrue solely to the owners of complementary assets or capabilities, or to competitors instead of the original developers of the intellectual assets (Teece, 1986). Therefore it is key for a firm to protect its innovations and related intellectual property. Firms can employ strategic methods to do so. These are called appropriation strategies or appropriation mechanisms and describe how a firm prevents imitation and captures innovation benefits.

Traditionally, patents have been regarded as the main mode of appropriation. However, there are many more mechanisms for the appropriation of innovation returns. Companies usually employ several instead of just a single one (Cohen et al., 2000). In the current industrial organization literature, appropriation strategies are often divided into two or three categories (Cohen et al., 2000; Levin et al., 1987). For clarity, this research distinguishes three. Formal appropriation strategies, informal appropriation strategies and the use of complementary assets. The former strategy was sometimes categorized as an informal strategy in older research, hence the case of two strategies.

Formal appropriation strategies

These are state granted legal instruments often captured in documents. Examples include patents, design rights, trademarks and copyrights. Typically, these are rights that exclude others from using whatever is protected by these rights for a certain amount of time. Although these legal instruments prevent rival firms from utilizing technology developed by the focal firm, the subject matter is public and knowledge can therefore spill over.

Informal appropriation strategies

These strategies focus on preventing spillovers of own innovation efforts and as such, do not necessarily require the publication of codified knowledge, contrary to formal appropriation strategies. Rather, these strategies typically include practical measures stemming from internal activities. These strategies include trade secrets (hereafter mentioned as 'secrecy'), complex design of new products to counter imitation or reverse engineering and finally extremely rapid product launches to generate a lead time advantage.

Complementary assets

Complementary assets (and capabilities) relate to those assets (or activities) that are strategically needed for gaining competitive advantage and the successful commercialization of an innovation. For example assets and capabilities related to marketing, manufacturing, distribution and after-sales services (Teece, 1986). By way of explanation, if an innovation cannot be protected well and is easily imitated by rival firms, the firm that has the best strategic capabilities to commercialize an innovation will triumph.

Appropriation requires significant managerial attention and can also entail considerable transaction costs. Examples of the latter include fees for applications and upholdings of patents, trademarks and costs associated with establishing lead time, organizing secrecy from competitors and gaining access to complementary assets (Arora & Ceccagnoli, 2006; Teece, 1986). Clearly, firms must choose the right strategy. So in order to understand how companies can capture most profits from an innovation for itself as opposed to competitors, one has to not only define the appropriate appropriation strategies, but also gain insights into its determinants.

Going forward, the appropriability strategies are elaborated. Determinants and outcomes of appropriation strategies are then discussed. After certain passages of literature, propositions are listed. These shortly summarize the literature and are there for extra clarity. Furthermore they provided guidance during the writing of the thesis. They are abbreviated by the letter P followed by a number and an overview of them can be found in appendix A.

2.2 Appropriability framework

James et al. (2013) performed a thorough meta-analysis on the drivers and intended outcomes of appropriability mechanisms. They went through the most influential literature in the field and came up with a comprehensive framework revolving around appropriation. This framework consists of (i) contextual conditions, (ii) appropriability mechanisms (strategies) and (iii) outcomes. The contextual conditions serve as determinants for selecting the appropriability mechanisms for a firm, which in turn lead to a particular intended outcome. This is illustrated in figure 2. The contextual conditions are depicted as the column on the left. The main mechanisms are depicted as the middle column and finally, some outcomes are mentioned on the right. Since this framework is central to the theory of appropriability, these concepts are discussed in detail hereafter.

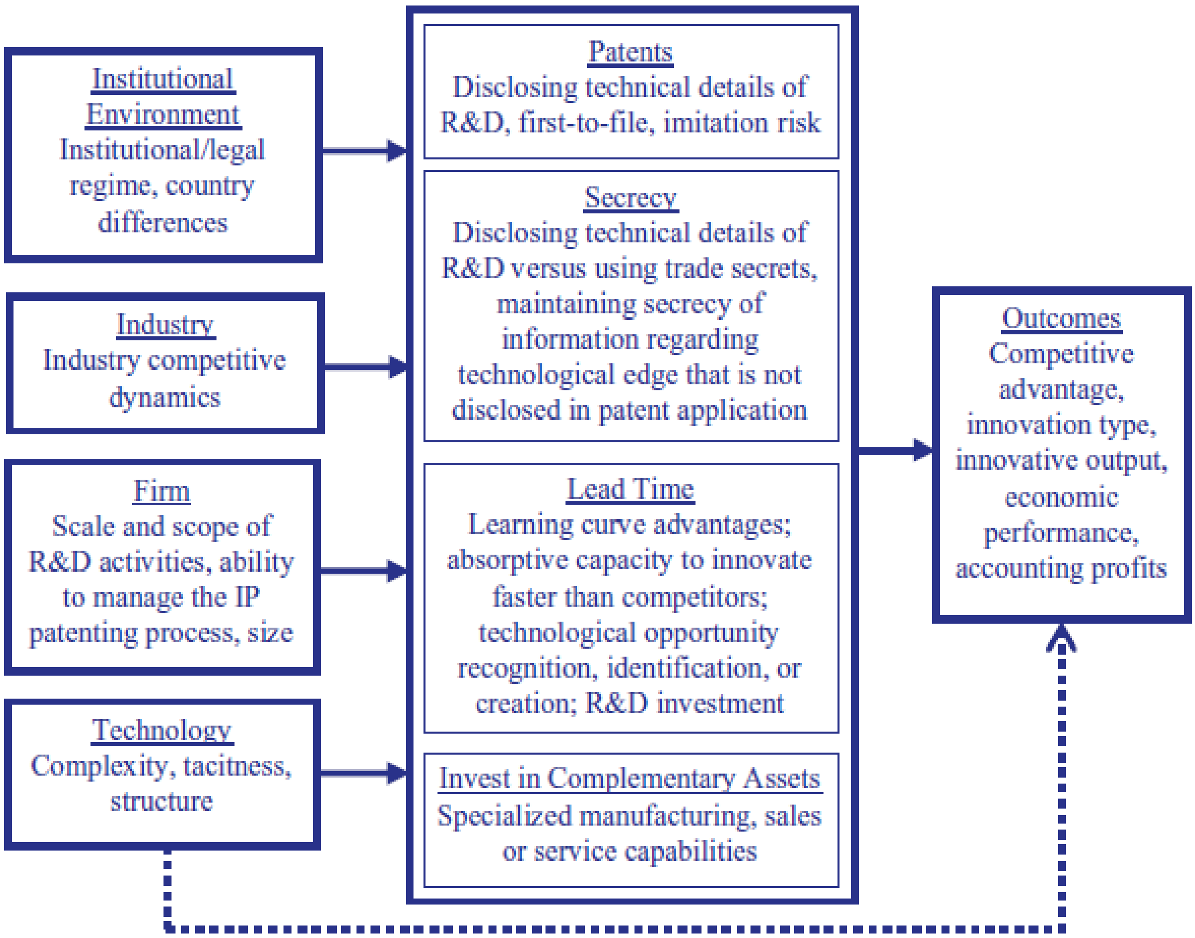


Figure 2: contextual conditions, appropriability mechanisms & outcomes. Source: James et al. (2013)

2.3 Appropriability concepts

2.3.1 Appropriability mechanisms

Patents (formal)

Patents refer to *legally* granted rights to exclude others from making, using, selling, or importing an invention, for a limited time, within a given country. Research on patents is abundant and patents are in fact the most studied appropriability mechanism. A notable meta-analysis (Somaya, 2012) identifies three generic patent strategies; proprietary, defensive and leveraging strategies.

Proprietary

The proprietary strategy is, in essence, the conventional resource-based logic of using patents as isolating mechanisms that shield the firm's key competitive advantage from imitation (Lippman & Rumelt, 2003; Rumelt, 1984). A proprietary strategy is executed by performing various actions, for example; blocking an opponent by securing crucial patents, building fences or patent thickets that make identifying and patenting certain pieces of technology difficult or resource-intensive for rivals, preventing copying and so on (Somaya, 2012). These patents are used to create a competitive advantage by claiming an exclusive patent position and sealing it shut. Therefore they are usually carefully maintained by having them renewed, reexamined and reissued.

Defensive

These are strategies that aim to ensure that the firm is not put at a competitive disadvantage or at risk of being held up for rents because of patents held by others. In fast-paced or high-technology industries firms often make substantial investments in business opportunities before it is clear who owns all the patents for the required technologies (Somaya, 2012). If the set of technologies required to commercialize products is very large, the exposure to others' patents could be particularly problematic (Hall & Ziedonis, 2001; Somaya & Teece, 2001). Once a rival has ownership over a crucial segment of technology, other firms can be seriously held up if this rival decides to threaten with a court-mandated injunction or when it imposes high license fees (Lemley & Shapiro, 2007). To counter this, firms can decide to patent their own inventions and related technology. This provides them freedom to operate. These defensive strategies can be divided into ex-ante and ex-post strategies. Ex-ante strategies include preemption; obtaining patents or licenses to all the needed inventions, or disclosure; preventing patents from issuing. Sometimes it is not clear which patents will be needed beforehand though. This is where ex-post defensive strategies come at play. A common approach is that firms build large defensive portfolios. When a competitor threatens or sues this firm, the firm can then threaten or sue back with its own patents. In this situation of mutual holdup, the conflict often results in a settlement which both parties can benefit from (Somaya, 2003). Other defensive ex-ante strategies include licensing and cross-licensing.

Leveraging

These strategies allow firms to pursue direct and indirect profit opportunities by leveraging bargaining advantages conferred by the exclusionary power of patents (Somaya, 2012). Patent licensing to gain revenue is the most obvious leveraging strategy. Licensed patents are often found in technologies that are not central to a firm's core competence or market but are still valuable outside of it. Even in cross-licensing, a firm may be able to realize a surplus of profit by offsetting compensation for its stronger, more valuable patents. An infamous type of firm that uses a leverage strategy is the 'patent troll'. These firms do not commercialize technologies themselves, but leverage patent litigation to extract rents from putative patent infringers through the threat of injunctions, large damage awards and significant switching costs to invent around their patents (Reitzig et al., 2007). They then often manage to obtain settlements from targeted firms.

Secrecy (informal)

Secrecy is a straightforward appropriability mechanism; it refers to a firm's efforts to protect the uniqueness of an innovation by withholding its technical details from public dissemination. Secrecy can actually enjoy legal protection as trade secrets, provided that the underlying formula, method, technique or process derives independent economic value from not being known and the owner of this information makes reasonable efforts to maintain its secrecy (Arundel, 2001; Winter, 2000). So, companies can resort to taking legal action after the trade secret was acquired by improper means.

Lead time advantages (informal)

This appropriability mechanism is straightforward as well. Lead time advantages result from the early timing of developing and introducing an innovation (Lieberman & Montgomery, 1998). It is also often referred to as a first mover advantage. This advantage varies greatly across product categories and geographic markets (Lieberman & Montgomery, 1998). This strategy involves a trade-off between early resource commitment, providing preemptive competitive advantages, often at the cost of flexibility disadvantages with respect to future investment opportunities. This entails a risk. However, this risk can be moderated by a sufficiently fast development process. Early-mover strategies are most appropriate in contexts where there is high uncertainty, long time spans between innovations and a high degree of intergenerational learning (Leiblein & Ziedonis, 2007).

Complementary assets

The reliance upon complementary assets is dictated by the *appropriability regime*. An appropriability regime can be classified as strong (tight) or weak. A strong (tight) appropriability regime refers to an environment where protection of technology is easy and a weak one refers to the opposite. The key dimensions that determine the strength of the appropriability regime, first defined by Teece (1986) are *nature of the technology* and the *efficacy of legal instruments.* Nature of technology refers to whether the knowledge fundamental to the technology is tacit or codified and efficacy of legal instruments refers to much the same as the institutional environment. Literature states that:

P1: The more tacit the nature of knowledge of an innovation, and the better the efficacy of legal instruments is, the stronger is the appropriability regime and vice versa.

Teece (1986) distinguishes three types of complementary assets. *Generic assets* are general purpose assets which do not need to be tailored to the innovation in question. *Specialized assets* are those where there is unilateral dependence between the innovation and the complementary asset. For example, EMI labs pioneered the CT scan but quickly lost most market share to General Electric because distribution and marketing were especially important in this case and GE had both a greater distribution network and marketing expertise. *Cospecialized assets* indicate a bilateral dependence. For example, strong biotech patents rely upon big pharma marketing & distribution resources and vice versa.

In a strong appropriability regime, if complementary assets are (co-)specialized and the innovator does not own them, the profits will be shared between the innovator and the owner of the complementary assets or capabilities (Teece, 2000). In this case, when complementary assets can be legally protected and replication is hard, the firm owning these can expect the majority of returns (Hurmelinna et al., 2007). In a case of a strong appropriability regime where complementary assets are generic, the innovator will be the winner, for imitators cannot leverage any complementary assets exclusive to them (Stuart, 2001). In a weak appropriability regime where complementary assets are generic, any rival firms can imitate the innovation with relative ease. This increases competition in the market and profits decrease. In a weak regime where complementary assets are (co)-specialized, the owner of these will win.

P2: The stronger the appropriability regime, the less reliant a company needs to be on its (co-) specialized complementary assets to profit from innovations and vice versa.

2.3.2 Outcomes

Literature on performance outcomes, as an effect of chosen mechanisms, is actually scarce. Most of the research focuses on direct links between the use of appropriability mechanisms and performance consequences. A distinction can be made between intermediate (e.g. market entry, incentives to innovate, extent of knowledge spillovers) and ultimate economic performance indicators (e.g. competitive advantage, economic performance, profits) (James et al., 2013). Unsurprisingly, evidence points out that appropriability mechanisms have a positive relation to the performance effects. For example, a strong patent position correlates positively with economic performance, lead time advantages with persistent superior performance and the ownership of specialized complementary assets with value capture outcome. Because of the scarcity of literature, this thesis will talk about specific outcomes directly in relation to the strategies instead of categories of outcomes.

2.3.3 Contextual conditions: determinants for appropriability mechanisms

Institutional environment

The institutional environment refers to the strength and availability of legal protection (Lanjouw & Schankerman, 2001). This determines the effectiveness of legal instruments such as patents, trademarks and copyrights, the formal appropriability mechanisms. Since these instruments are valid on a country-level, the effectiveness is also different per country.

Where legal protection is weak, infringement is more likely because rival firms face insignificant penalties. An expected increase in the number of infringers raises the innovator's costs associated with identifying infringement and pursuing litigation.

P3: the weaker the institutional environment, the more competitors tend to infringe upon an innovator's patents and the higher the innovator's associated costs (identification & litigation)

Ultimately, the weaker the protection, the less likely companies are to employ formal mechanisms as a value capture strategy (James et al., 2013). Unbeknownst to many, secrecy as a protection mechanism is leveraged by trade secret law (James et al., 2013). For example, governments can enforce contractual obligations such as confidentiality agreements (Winter, 2000). So just like patent law, the strength and availability of legal protection may vary for trade secret laws. Though enforcing legislation is an ex-post measure for patents and secrecy, secrecy alone can work as an ex-ante measure to prevent spillovers. Therefore, secrecy is typically used in those appropriability regimes that provide weak intellectual property protection (Cohen et al., 2002).

P4: the weaker the institutional environment, the less an innovator is inclined to employ formal appropriation mechanisms and the more he's inclined to employ informal appropriation mechanisms

Literature on institutional characteristics pertaining to lead time is scarce but does suggest that first-mover advantages vary greatly across product categories and geographic markets (Lieberman & Montgomery, 1998). However, the empirical evidence seems to be limited to cases from the United States (James et al., 2013).

The Ginarte-Park index, The World Economic Forum's Global Competitiveness Index and the World Intellectual Property Indicators are notable sources that classify intellectual property protection strength per country (James et al., 2013). More on these measures can be found in appendix B. Contrary to the case of patents, literature does not point out an accurate measure of strength and availability of trade secret law.

Industry factors

Survey-based work found that the appropriability mechanisms used vary among industries and between process or product innovations (Levin et al., 1987) (Mansfield, 1985)(Cohen et al., 2000) Important findings include that companies do not rely on a single appropriability mechanism. Instead, they use multiple appropriability mechanisms simultaneously. In a few industries, all appropriability mechanisms are used whereas in most industries two or more are used. Only several industries found only one appropriability mechanism highly effective. appendix C presents these findings. For this research, it is important to find out in what industries the sample population of the study is active. The high-tech industry is a collective term for multiple industries after all. These surveys give no qualitative insights but it is logical to assume that managers across industries employ those mechanisms that yield high returns.

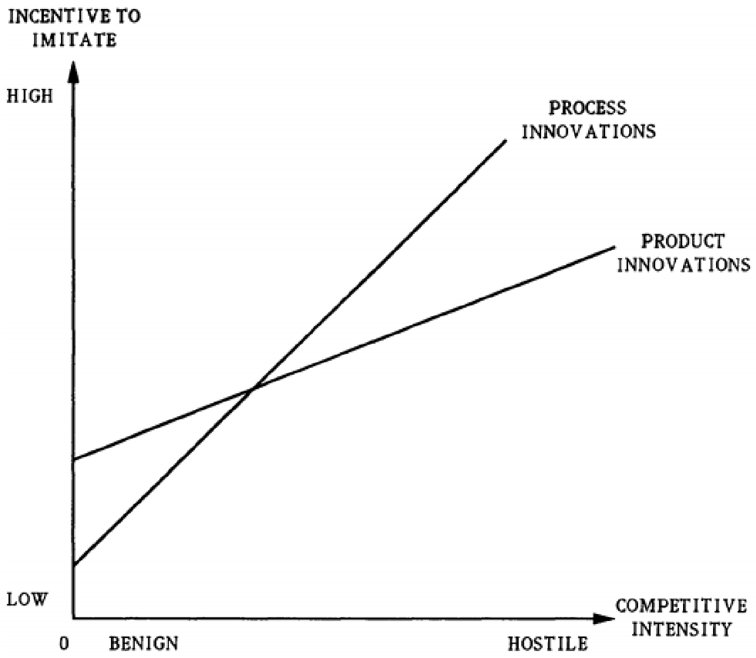
The most important industry characteristics are the degree of *competitive intensity*, the *number of capable competitors*, and the *legal enforceability of intellectual property* (e.g., barriers to imitation) Hill (1992). These industry characteristics affect a firm's propensity to patent and license an innovation. They also moderate a rivals' imitation cost.

Competitive intensity refers to the degree of intensity within an industry and is a function of several factors. These include (a) industry concentration, (b) exit barriers, (c) entry barriers, (d) demand conditions and (e) product characteristics. A competitive environment can broadly be defined as being on a continuum from highly competitive (hostile environment), to one of low competition (benign environment).

P5: the higher the competitive intensity within an industry, the higher the incentive for competitors to imitate the focal firm's innovation. An industry with a high competitive intensity is characterized by; (a) a low industry concentration, (b) high exit barriers, (c) low entry barriers, (d) low product demand and where (e) the product is a commodity

Hill (1992, p. 430) notes a difference illustrated in figure 3 between process and product innovations;

> "Competition in a benign environment typically focuses on nonprice factors such as advertising, design, quality and service. Insofar as product innovations enable firms to better differentiate their product along these dimensions, the incentive to imitate a product innovation is correspondingly higher than the incentive to imitate a process innovation."



(p.430)

Figure 3: competitive intensity and incentive to imitate. Source: Hill (1992)

Technological information from new innovations, or R&D projects, tend to spill over within 12 to 18 months of the decision to develop an innovation (Mansfield, 1985). The extent of these spillovers varies between industries (Bernstein & Nadiri, 1988), but more importantly, it is dependent on the competitive intensity (Kafouros & Buckley, 2008). The higher the intensity of competition, the higher the risk of unintentional knowledge spillovers will be. Consequently, maintaining secrecy will be more resource intensive.

The **number of capable competitors** directly influences the degree of competitive intensity. However, their degree of capability also influences the speed of imitation; the more capable, the quicker they are able to imitate an innovation. This is dependent on two factors; R&D skills and access to complementary assets. The former roughly correlate to prior R&D spending (Hill, 1992) and the latter was discussed already.

P6: the higher a competitor's R&D skills, the more capable it is and the quicker it can imitate the focal firm's innovation.

Barriers to imitation come in a few forms. Obviously, IPRs in a strong appropriability regime is one. Another barrier to imitation, however, is causal ambiguity; the degree of difficulty to which rival firms can successfully leverage complementary assets in order to exploit an innovation in the marketplace. This difficulty is made up of two factors; technological and organizational complexity. The former speaks for itself. The latter is when a large number of interdependent routines are required to bring together complementary assets in order to transform technological know-how into a successful product or process (Reed & DeFillippi, 1990).

P7: the higher the technological complexity of an innovation, the less competitors are able to successfully exploit an imitated innovation in the marketplace

P8: the higher the organizational complexity of an innovation, the less competitors are able to successfully exploit an imitated innovation in the marketplace

Firm factors

Firm-level characteristics that play a role in the selection of appropriability mechanisms are the scale and scope of R&D or more generally *innovativeness*, the *ability to manage the appropriate IP process*, and *firm size*.

Innovativeness - Research shows that in general the more innovative a company is, the more experienced it is in these matters. Superior innovation capabilities minimize inefficient patent disputes. Being able to cross-license intellectual property minimizes disputes for example, which implies that firms with small patent portfolios are at more risk (Lanjouw & Schankerman, 2004).Furthermore, being able to leverage intellectual property in contracts and doing so repeatedly over time improves collaboration and patenting strategies (Aggarwal & Hsu, 2009).

P9: the larger the scale & scope of a firm's R&D activities, the higher the (relative) value it can capture with, and the more it is inclined to employ formal appropriation mechanisms

Ability to manage IP processes - Firms with more experience in IP can better identify infringement and pursue litigation than those firms with less experience (James et al., 2013). Also, firms with specialized in-house patent lawyers are likely to capture more value from intellectual property than those firms who outsource these lawyers (Somaya et al., 2007).

P10: the more experienced a firm is at managing its intellectual property, the higher the (relative) value it can capture with, and the more it is inclined to employ formal appropriation mechanisms

Company's culture and efforts to maintain secrecy may inhibit learning or postpone success and cause employees to become discontent (James et al., 2013). So whilst secrecy impedes information spillovers, at the same time, this could undermine future innovation. Cassiman & Veugelers (2002) demonstrate this by showing that joint R&D with suppliers and customers reduces the efficacy of strategic protection mechanisms when it comes to secrecy.

P11: the stricter a firm is in preventing unintended knowledge spillovers (maintaining secrecy), the more likely it is to protect its innovation from imitation

P12: the stricter a firm is in preventing unintended knowledge spillover (maintaining secrecy), the more likely it inhibits future innovation

Firm size - Because small firms typically have a small(er) intellectual property portfolio and generally do not possess in-house legal experts and have less experience in IP, they are less likely to leverage these assets and benefit from formal appropriation mechanisms. For small firms, secrecy is simply less resource intensive and easier to accomplish.

P13: the larger the firm, the higher the (relative) value it can capture with, and the more it is inclined to employ formal appropriation mechanisms

P14: the smaller the firm, the higher the propensity to pursue secrecy as the dominant appropriability mechanism

Firm: specific factors regarding lead time advantages

Firm-specific factors in the pursuit of lead time advantages are identified as the *degree of technological leadership*, the *ability to preempt scarce assets* and *buyer switching costs* (Lieberman & Montgomery, 1998). **Technological leadership** is attained through a unique breakthrough in R&D and can be sustained if the technology, and the learning curve to acquire it, can be kept proprietary.

The ability to preempt scarce assets is based on superior information; if a company can gain assets that will prevail in the evolution of the market, then it can select the most attractive niches and limit followers' space. This is also known as **absorptive capacity**. James et al. (2013) state:

> "A superior ability to acquire and use information may reduce negative spillover effects and increase the benefits of pursuing a lead time value capture strategy." (p. 1135)

Buyer switching costs are costs that late entrants must invest in order to attract customers away from the first mover. These are higher the more customers are locked-in. For individual customers the benefits of finding a superior brand are seldom great enough to justify the additional search costs that must be incurred.

P15: the higher a firm's degree of technological leadership, the ability to preempt scarce assets and buyer switching costs, the larger the propensity for firms to pursue lead time advantages as the dominant appropriability mechanism

P16: the higher a firm's absorptive capacity, the less negative spillover effects and the higher the benefits of pursuing lead time advantages

Technology

The main three technology characteristics are the *nature of knowledge* pertaining to the innovation, *the complexity of the innovation* and whether the *innovation is a product or a process*.

Knowledge can be tacit or codified by nature. Tacit knowledge is inherently hard to transfer, which impedes imitation, but also learning. Codified knowledge facilitates learning, but is also prone to easy imitation. Codified knowledge is relatively easy to capture in IP rights such as patents and other formal instruments. The opposite is true for tacit knowledge (Langlois, 2001).

P17: the more tacit the nature of knowledge or the less codified it is, the less suited formal appropriation mechanisms are and the more informal mechanisms are

This has direct consequences for establishing lead time advantages. The more codified and teachable a capability, the more rapid second-movers can come into play.

P18: the more codified the nature of knowledge is, the less the benefits of pursuing lead time advantages

Innovations that have low complexity are often referred to as discrete products (e.g. pharmaceuticals). James et al. (2013, p. 1131) explain:

> "In discrete product industries, it is easier to identify and defend against infringements because of the limited number of patentable elements, the limited overlap of firms that own these patentable elements, and a limited number of rival firms that need to be monitored. Consequently, firms in discrete product industries, which can successfully make stronger claims of novelty in patent applications, are more likely to prevail in patent litigation suits and thus are more likely to choose patents as a value capture mechanism."

The opposite holds for complex product industries. These innovations have more patentable elements and more firms who could possibly control these (Cohen et al., 2000). This makes identification of those elements harder, as well as identification of infringement and the demonstration that a firm owns the relevant intellectual property. Also, countersuits are more likely because the infringing rival may have intellectual property that is, in general, more closely related to the original intellectual property, than in the case of discrete products. Therefore, firms in industries of complex technology are less likely to choose patenting as the dominant mechanism.

P19: the more complex a technology, the smaller the propensity for firms to pursue formal appropriation strategies as the dominant appropriability mechanism

Additionally, complex innovations are inherently harder to imitate and more costly to reverse engineer. Protection through secrecy is then easier and less costly than formal methods. A small downside to greater complexity is that it also requires a greater organizational effort to control information which increases the cost of maintaining secrecy.

P20: the more complex a technology, the larger the propensity for firms to pursue secrecy as the dominant appropriability mechanism

Product innovations are meant to increase the quality or value of products, visible to the customer and in turn, to the market and industry. Process innovations on the other hand, usually pertain to less visible elements in the supply chain, for example manufacturing. This difference makes product innovations more prone to reverse engineering than process innovations (Mansfield, 1985).

P21: for process innovations secrecy is more effective than product innovations

Cohen, Nelson & Walsh (2000) reported that for product innovations, both secrecy and lead time were the most effective appropriability mechanism. For process innovations, secrecy was found to be the most effective mechanism.

Concerning lead time advantages, Dierickx & Cool (1989) identify assets which can be critical in maintaining a first mover advantage. If such assets are nontradable, inimitable and nonsubstitutable, competitors are forced to build these assets in-house and the first mover enjoys relative protection for the time being.

P22: the more critical assets a firm has, the higher the benefits of pursuing lead time advantages

2.4 Supply chain characteristics

The previous chapters focused on intellectual property and value capture for firms in a broad sense. This chapter will zoom in on the subject from a supply chain perspective and provide clarification on the types, roles and relations of firms within supply chains. This is important because ultimately the success of innovations and new products is not solely dependent on the last firm in the supply chain, but the chain as a whole. Therefore, in 2.4.1 a generic model of new product development process is introduced. In 2.4.2 company typologies are discussed after which three archetypes are used from then on in the thesis, as defined in 2.4.3. Supply chain involvement and integration is then discussed in 2.4.4.

2.4.1 New product development process

The academic field of supply chain management is incredibly broad and fragmented (Chen & Paulraj, 2004). A quick search in academic databases demonstrates this; thousands of results for related subjects pop up such as purchasing and supply, logistics and transportation, marketing, operations management and management information systems. For our study, the new product development (NPD) process is the most relevant subject within this field, because it focuses on the different type of activities companies must carry out to design a new product. This provides a framework in which we can designate different types of companies and the consequences for IP.

A new product development process is a process consisting of various stages during which a new product is developed from a mere idea to full-fledged production or service delivery. These stages are interdependent and often overlap. A basic model is provided in figure 4 (Handfield et al., 1999).

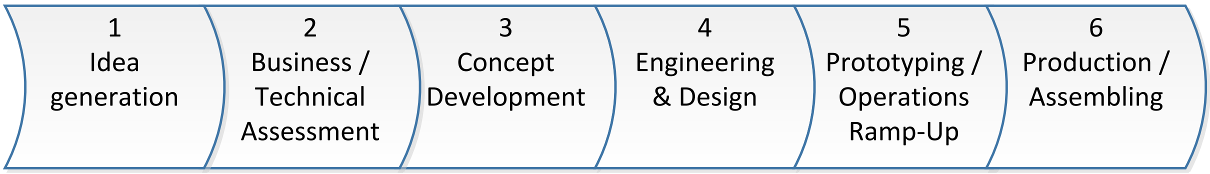


Figure 4: new product development process. Adapted from Handfield et al. (1999)

In the first stage, the need for a product is considered and ideas are generated, often as the result of customer input or R&D output. Then the business and technical feasibility is assessed, resulting in technical specifications. In the third stage, an actual concept is conceived with precise performance specifications. After this, the actual development starts, resulting in design specifications and blueprints. During the fifth stage, a working prototype is created and production systems can be tested before full-scale production can be initiated, stage 6.

Using this figure it is clear that an innovation goes through these stages from conceptual (to the left) to tangible (to the right). Although ideas cannot be transformed into IP directly, sketches or drawings of it certainly can (e.g. industrial design rights or patents). It is clear that in the earlier stages of the NPD process, such drawings and sketches can already be created. Trademarking a new product or brand name can even be done when a draft has not even taken shape yet. Whereas the later stages can provide a proof of principle/concept, these are not necessary to apply for IPR. Using this logic, this leads to the following proposition.

P23: the earlier a firm's involvement in NPD activities, the more likely it is to generate IP

Traditionally, companies would perform the first five stages themselves and attract suppliers only during the stages of full-scale production. This shifted as companies realized that by integrating suppliers into the new product development process they would gain access to more or better information earlier in the development process by leveraging the supplier's expertise (Petersen et al., 2005). More specifically, in new product development a firm's financial performance and the performance of the new design are positively influenced by having carefully selected a supplier with complementary capabilities and business culture, and when this supplier was greatly involved technically (Petersen et al., 2005). This begs the question; to what extent and when exactly should a company involve its supplier(s)?

Research on early supplier integration is very outspoken on the fact that earlier involvement of the supplier is generally better (Handfield et al., 1999). Because the total cost of development is greatly dependent on the early stages the new product development process, namely the concept and design phases, changes later on become increasingly difficult and costly (Handfield et al., 1999). A large factor in the success of new product development is the degree of technological uncertainty, which is uncertainty regarding technologies that may emerge or be combined for a new solution (Tatikonda & Stock, 2003). This uncertainty can be mitigated through openly sharing cost and technology information with suppliers, which can drive closer relationships with suppliers through early involvement (Teece, 1986). In short: earlier integration is beneficial in cases of higher technology uncertainty. However, this can also bring with it the disadvantage of being locked into a particular supplier. Understandably, this can become a big issue when there are multiple competing technologies striving to become the industry standard (Handfield et al., 1999).

P24: the earlier a supplier is integrated into a firm's new product development process, the more technological uncertainty can be mitigated

P25: the earlier a supplier is integrated into a firm's new product development process, the higher the risks of supplier lock-in

2.4.2 Company archetypes

Numerous names and models exist to clarify the degree of supplier integration. This is synonymous with the level of responsibility for suppliers (Petersen et al., 2005). Although exact definitions of these are actually hard to find in literature, in practice several of these terms seem well-integrated. To familiarize the reader, the most common ones are discussed below.

White box to black box

This typology is depicted in figure 5. In white box integration, companies do have discussions with suppliers regarding specifications and requirements, but only the buying companies make decisions in that respect. In gray box integration, the buyer and supplier make these decisions jointly. In the black box situation, the buying company merely provides a list of specifications and the supplier is (almost) completely responsible for the new product design (Petersen et al., 2005).

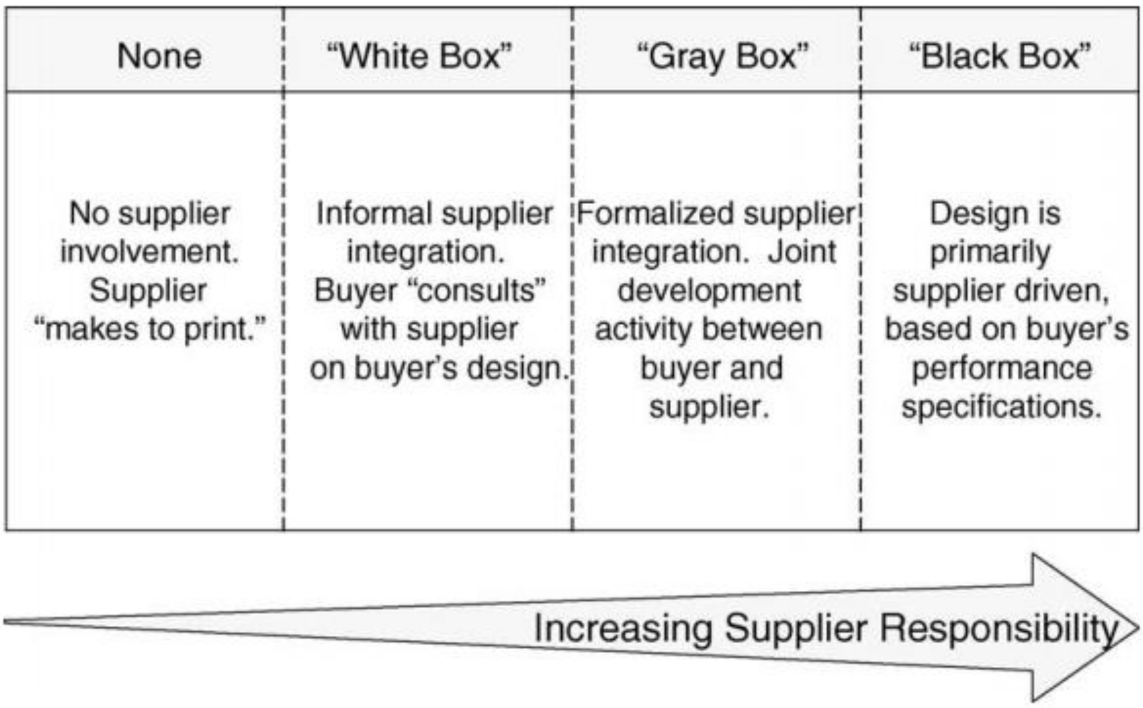


Figure 5: white box - black box supplier integration. Source: Petersen et al. (2005)

Build-to-print to build-to-roadmap

A few different names are used in this typology. The following ones are increasing in supplier responsibility (Schuurmans et al., 2016).

Build-to-print: the buying company designs components for the most part and provides exact technical/performance specifications so the supplier can manufacture according to, often quite literally, a blueprint.

Build-to-print-plus: the supplier also assembles tests and installs subassemblies in addition to build-to-print activities

Build-to-spec/build-to-requirement: the buying company provides a list of design specifications or requirements. The supplier has the liberty to utilize their design expertise and manufacturing skills to manufacture parts/products according to these specifications.

Build-to-roadmap: the supplier proactively develops parts entirely by itself. Buyers can use these parts readily in their products.

Manufacturer typologies

Many acronyms are used to express the roles of companies from a manufacturing perspective.

OEM (original equipment manufacturer): in the narrow sense an OEM is a company whose products are used as components in the products of another company, referred to as the value-added reseller. In the broad sense, it can also mean the value-added reseller itself, in the sense of that company being the producer of an end-product. In this document, the broad sense is used.

ODM (original design manufacturer): a company that designs and manufactures a product that will ultimately be rebranded and sold by a different company.

CM (contract manufacturer): a company that manufactures components or products for another company that provides the design. A CM acts as the buying firm's factory.

OMM (original module manufacturer): a company that designs and produces a module that buying firms can readily use in their own products. This module fulfills a specific function and can therefore be seen as a subproduct on its own with greater complexity than mere components. Therefore the relationship with a buying firm is on a more equal basis than that of an OEM in the narrow sense.

Supplier tiers

Another typology of companies within a supply chain is one where the commercial distance is indicated between companies. For example, tier 1 suppliers are direct suppliers to an OEM. They therefore refer to major suppliers of parts. A tier 2 supplier indicates that a company does not directly supply to an OEM, but to a tier 1 supplier instead. A tier 3 supplier supplies a tier 2 supplier, and so on. The lower the tier of a company, the lower the modularity or integral the product or part is. For example, a tier 1 company could supply an OEM with a module. A tier 2 company would then supply parts for that module and a tier 3 company could be a raw materials supplier in this example. This typology comes from the automobile industry but is also used in other industries. The high-tech region around the city of Eindhoven also uses this typology. Although it indicates the significance of companies in relation to each other, it is not supply chain specific, but company specific. For example, a company can be a tier 1 supplier to one OEM but be a tier 2 supplier to a different company. This makes the typology not fit for generalization purposes, therefore a different typology is used in this thesis, as explained in 2.4.3.

2.4.3 Thesis archetypes

For clarity, three distinct company archetypes are distinguished in the remainder of the thesis. They are differentiated by the NPD process steps they perform, which makes for a very clear distinction and is generalizable to all supply chains. They are defined in the rest of the thesis as follows.

OEM (original equipment manufacturer):

a company that sells an end-product and is typically at the end of a supply chain. Typically performs steps 1, 2 and 3 in the NPD process (figure 4).

Engineering agency:

a company that develops and engineers a (sub)product or module for an OEM. Typically performs steps 3, 4 and 5 in the NPD process.

CM (Contract manufacturer):

a company that manufactures end-products or modules for an OEM. Typically performs steps 5 and 6 in the NPD process.

Also, when mentioning *suppliers*, any company that supplies another company is meant. In the reasoning above, this means that both a CM and an engineering agency can be regarded as suppliers. Note that these are merely definitions to keep the discussion straightforward. Though these are classical definitions, in practice they are not this rigid and many variations exist when it comes to specific NPD activities

2.4.4 Supply chain integration

Companies increasingly focus on sales growth, cost reductions and development of new products (KPMG, 2015). In doing so, they become more innovation-led for the long-term. As a result, there is a major shift in R&D expenditure. Instead of spending 2-3% of revenues on R&D, many OEMs nowadays spend more than 6% on R&D (KPMG, 2015). At the same time, supplier performance in terms of risk, reliability & quality is under pressure. Therefore, in order to not carry the risk alone, OEMs increasingly outsource part of their development/production to third party manufacturers (suppliers). Outsourcing these activities reduces labor costs and frees up capital. Additionally, when it comes to manufacturing specifically, it also improves worker productivity (Arruñada & Vázquez, 2006). An OEM's focus can then shift towards the activities that enhance the product's value most, such as R&D and marketing. As a result, the vertical supply chain becomes more horizontal (Schraven, 2015) and OEMs trust and rely more on their suppliers, which shifts the power balance (KPMG, 2015). To illustrate; it is now common practice that competing suppliers are now partners in projects, which often boosts their level of part-specific knowledge far beyond that of the OEM. So, high-tech companies need to go beyond their own product roadmap to truly innovate and be part of the integrated supply chain (Schraven, 2015).

P26: OEMS increasingly outsource development activities in NPD processes to suppliers; supplier integration in the NPD process is increasingly early

This trend where suppliers enjoy increasing conceptual NPD activities is perhaps best illustrated in figure 6. From top to bottom, the supplier enjoys an increasing responsibility as well as an earlier involvement in the NPD process of an OEM. The develop and build stages together are comparable to stage 1 to 6 of figure 8.

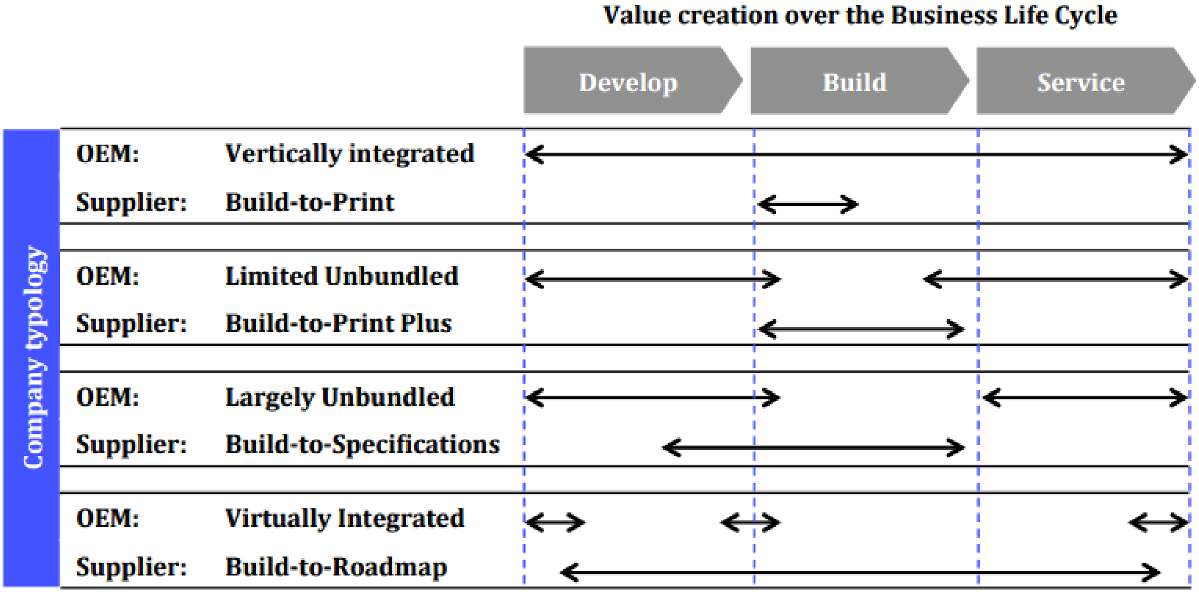


Figure 6: increasing supplier involvement typologies. Source: Schuurmans et al. (2016)

Building on proposition 26 and 23 there is reason to expect an increasing amount of IP generated by suppliers. This, in turn, could lead to less opportunism when it comes to IP (Arruñada & Vázquez, 2006). Contract manufacturers have to use an OEMs intellectual property in order to be able to manufacture its products. After all, they have to know what component goes where in an assembly. A CM can transfer this knowledge to other client OEMs, legitimately or not. Leakage can occur easily, for example in the form of CAD drawings, CAM files or 3D scans. Years of research and design can be copied in a matter of minutes. Naturally, OEMs can resort to litigation, though there are always downsides to this. It will cost extra resources, the verdict is often years away and often uncertain since the burden of proof lies with the claimant. When the trend is that CMs slowly enjoy more developmental responsibilities, relatively more IP is created by them and less by OEMs.

P27: suppliers generate increasingly more IP as their development activities are increasingly early in the NPD process

2.5 Conceptual model

This chapter reviewed the literature on the topic of appropriability on its own as well as in the context of supply chains. This lead to 27 propositions as listed in appendix A. Furthermore figure 7 presents a conceptual framework based on the reviewed literature (and partly adapted from James et al., 2013). The appropriability mechanisms and (sub)types are shown in the middle column. Potential outcomes are shown in the right column. The four main contextual conditions, which can be regarded as determinants for the appropriability mechanisms, are shown in the left column. On the bottom, the influence of supply chain considerations is illustrated. The categorization for the concepts encompassing the appropriability regime and the formal and informal appropriability mechanisms is depicted by the shaded areas. For various concepts, important factors on a lower hierarchical level are shown as well, because they represent separate propositions.

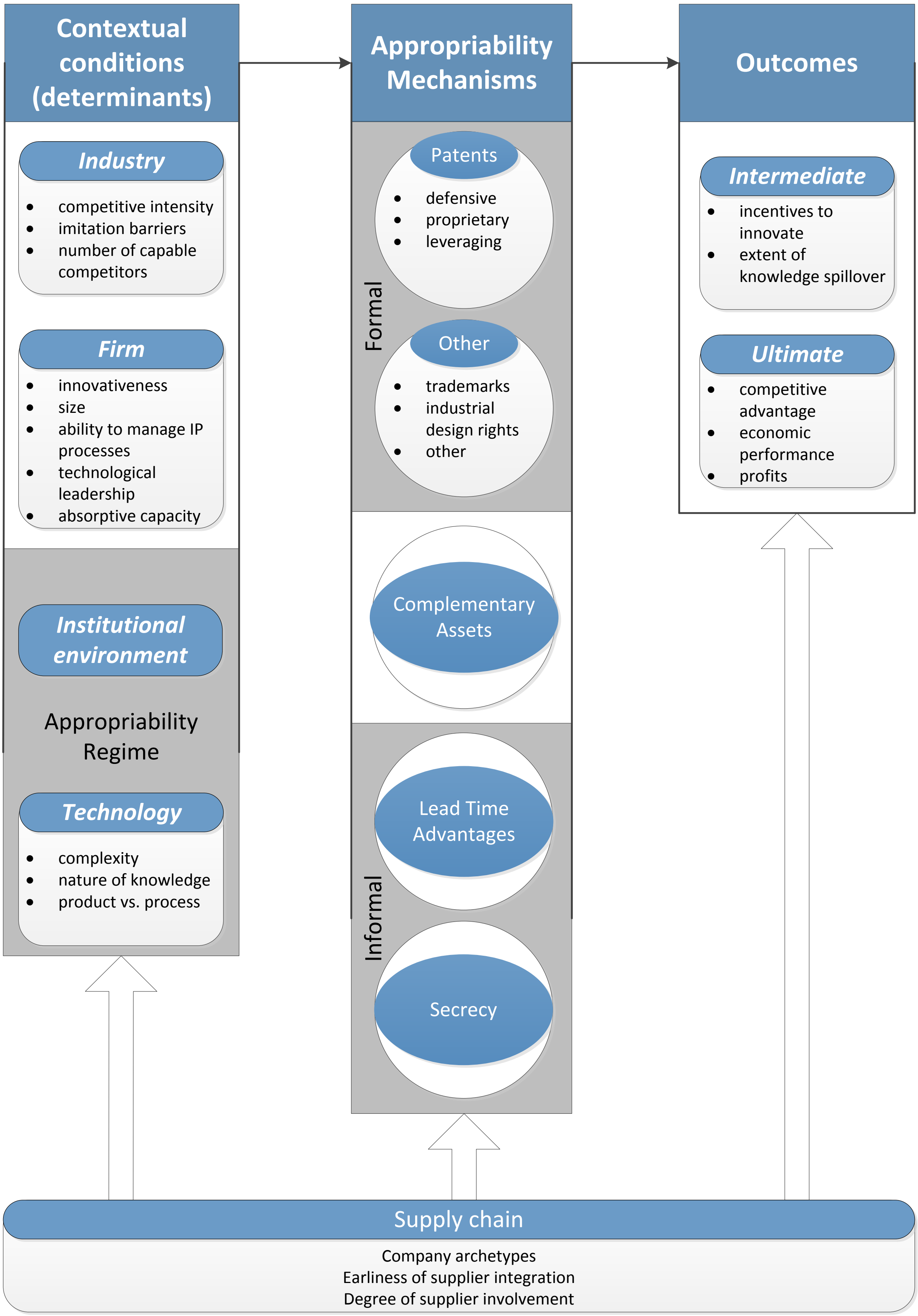


Figure 7: conceptual model theoretical background

3. Research methodology

This chapter presents this study's methodological approach and various scientific descriptives. It tells us about the type of research, the scope of the research and what steps were taken to come to the end result, this thesis. Furthermore it explains why these steps are necessary, from a scientific point of view. Therefore scientific requirements such as the controllability, reliability and validity are also put forward here. In the end, the goal was to have a meaningful study with theoretical and practical relevance. This chapter essentially underpins that claim. Much like chapter 2, this chapter is a condensation of preliminary work called the research proposal.

Chapter 3.1 explains that this is a qualitative and explorative study. This type of research is performed by following certain steps as described in this chapter. Chapter 3.2 presents the population of the study on which it can generalize the findings. The sampling and stratification procedures are also mentioned here. What data and how that data was collected is explained in 3.3. Once the data was gathered, it needed to be prepared to be able to be used in this study. How that was done is described in 3.4. Finally, 3.5 discusses several quality criteria for this research. After all, to a certain extent, it needs to be controllable, reliable and valid in order for it to be meaningful.

3.1 Research type & design

This master thesis is an explorative study grounded in theory. It is grounded in theory as it builds upon the current state-of-the-art theories and knowledge in the relevant fields of research. It is explorative for it ventures into a new direction of research; the cross-over between the topics of supply chains and appropriability, on which little previous research is conducted. This study is primarily qualitative in nature. Qualitative research is done to gain an understanding of underlying reasons or motivations. This provides more depth into the research matter and allows the study to have practical relevance.

The research was designed following the methodology for qualitative research from Baarda, De Goede & Teunissen (2005). The methodology is a procedure that follows several steps illustrated in appendix D. It is important to realize that throughout the project, an iterative approach was used, resulting in (re)adjustments of previous steps. This finetuning enhances quality and relevance. Following this method, the research was designed as in figure 8.

Initially, preliminary reading was done and conversations were held with various persons in business and research. This was to assess whether reasons to perform further research were sufficiently valid. After this was determined to be the case, the research questions were constructed and a literature review was written. The former was presented in the introduction and a condensed version of the latter was presented in chapter 2. Literature was found according to a search plan (appendix E). Insights gained from literature lead to propositions which guided the direction for the data collection. Interviews were held with managers of various Dutch companies in the high-tech supply chain. The interviews were a source of primary data. Secondary data was also collected. Together this provided input for the analysis. Going forward, important aspects of this study are elaborated.

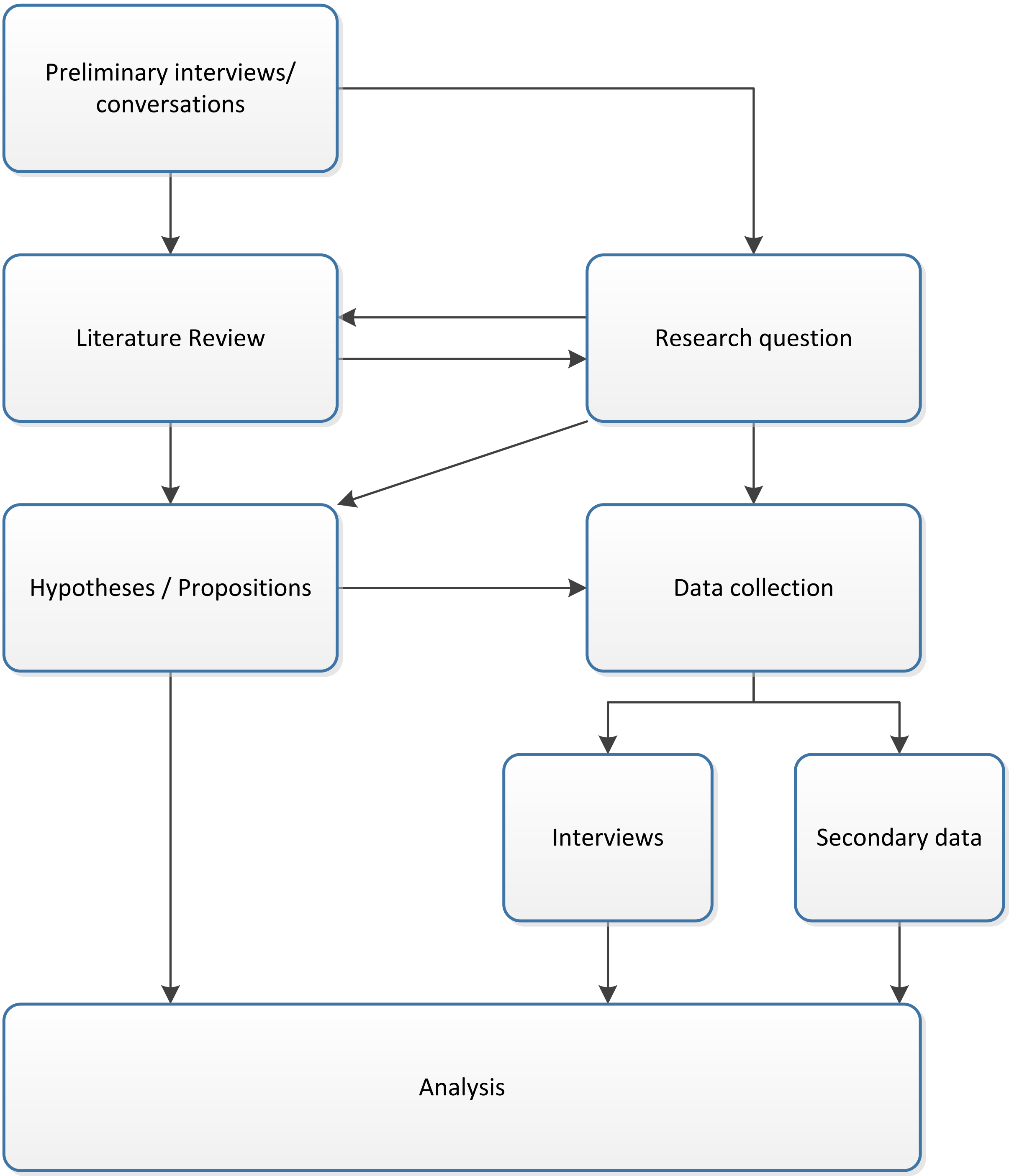


Figure 8: research method

3.2 Population & sampling

3.2.1 Population

The research focuses on firms in the Dutch high-tech sector. Firms are commercial organizations. This excludes organizations such as schools, universities and hospitals. These firms being Dutch means companies which are registered at the Dutch chamber of commerce and are based in The Netherlands. The definition of high-tech used in this study is: 'systems which are either (i) highly intelligent (embedded systems, software, sensors), (ii) very precise (nano-electronics, high precision manufacturing), (iii) highly efficient (mechatronics)' (Schraven, 2015). There are other definitions grounded in economics. For instance, the relative R&D spending in relation to production and value added (Hatzichronoglou, 1997). However, these economic definitions will not fit every high-tech company because certain company archetypes will not have a high R&D spending although they do work in high-tech; for example as contract manufacturers for those companies that do spend a lot on R&D. Therefore this study will consider firms operating in the industries of the definition provided by Schraven (2015) as high tech. According to the Dutch Enterprise Agency, the HTSM key sector employed 446.000 people across 75.700 companies in 2012, according to the latest available figures (Ministry of Economic Affairs, 2015). It is not known how these numbers are divided across the company archetypes.

3.2.2 Sample

Obviously it is impossible to interview the entire population: a sample will serve as the focus of our study. Because the goal is to test various factors in our conceptual model, the sampling method used is purposive theoretical sampling. A sample decided on purpose based on theory. The sample is stratified according to criteria mentioned hereafter. The sample population is not perfectly proportional to that of the entire population. This is because it would otherwise include mostly medium to large OEMs with above-average patent portfolios. This would leave us with insufficient insight into the roles of CMs and engineering agencies and why they typically own less IP. The goal is to gain insights as well why companies specifically do not patent though. That is why the sample needs to have cases with greater variation. In a perfect world, the criteria containing variation would be mutually exclusive so the phenomenon of interest can be explained by purely the difference in variation in a specific criterion. However, because of practical limitations (gaining high-level access into companies is difficult) and not possessing prescience about certain criteria (it is hard to make forecasts on firm-internal factors) this is not possible. Nevertheless, an effort was made to make the sample sufficiently diverse as to match firms found throughout the whole population. In the end, the sample needs to be generalizable to the entire population in order to have a high external validity. The sample consisted of 11 firms in the Dutch HTSM key sector as shown in table 1. They were stratified according to the following criteria:

- Firm size (by number of employees)
- IP portfolio size (by number of patents)
- Firm archetype (OEM, contract manufacturer or engineering agency)

Firm	Firm Type	Firm size (employees)*	# Patents owned & valid*
1	OEM	Large	Large
2	OEM	Large	Large
3	OEM	Large	Large
4	Eng. Agency	Medium	Micro
5	Eng. Agency	Medium	Small
6	Eng. Agency	Medium	Micro
7	Eng. Agency	Small	Micro
8	Contract Manufacturer	Medium	Micro
9	Contract Manufacturer	Medium	Micro
10	Contract Manufacturer	Large	Micro
11	Contract Manufacturer	Large	Micro
* Large: size > 250	Medium: 50 < size <250	Small: 10 <size <50	Micro: size < 10

Table 1: Sample characteristics

The company representatives were asked to confirm if these criteria were right and whether they fit the description of the main population of the study. All confirmed.

3.3 Data collection

Primary data

Primary data was gathered from semi-structured interviews. As a direct form of information, interviews provide detailed insights from individuals' perspectives and as such, provide a deeper understanding of (social) research subjects than quantitative methods such as questionnaires. The semi-structured interview uses a list of predetermined topics and sample questions. This form of interview therefore excludes the possibility of relevant topics not being discussed during the interview, for at the end of the interview the interviewer can check whether all topics have been discussed or not. This also forced the interviewer to have a sufficient level of understanding of the topics, allowing for a more in-depth interview. Furthermore, because the topics and questions were set, but the order in which they were discussed was open, this made the conversation go more fluently, where the interviewee was encouraged to answer as he saw fit. Because of this, the interviewee was not held back, allowing also for unexpected answers providing valuable insights.

All interviewees received a hand-out with information on the research, how the data would be used and a guarantee of anonymity. This was also communicated verbally. All interviews were recorded so a transcript could be made. The interviewees were asked to review and if needed, correct the transcripts of the interviews in order to reduce errors. An employee of The Netherlands Patent Office joined most of the interviews (8 out of 11) and was asked to review and evaluate the interviews. This strengthened intra-interviewer reliability.

The interview protocol and topic list with sample questions can be found in appendix F.

Secondary data

Secondary data consisted of quantitative data on IP. For example, the amount of patents owned or applied for by firms as shown in table 1. This data is naturally objective and is reproducible. It aided the research by giving insights from a numbers perspective. Secondary data was found in the online database of Espacenet and LexisNexis. Another source of secondary data came from surveys performed in literature.

3.4 Data preparation

Data from the interviews needed to be prepared before it could be analyzed. This is why the interviews were recorded and subsequently transcribed. The transcriptions were then labeled. Labeling is the assigning of certain labels to specific, non-redundant bits of text so they can be categorized. The labeling was done hierarchically according to a scheme involving keywords from literature. Additional words that were not prominent in the literature (review), but were prominent in the interviews were added subsequently forming the final labeling scheme as in appendix G. This was done in an iterative way until all fragments of text from all interviews were labeled. The text was then sorted by topic (label) so it could be analyzed. These data preparation steps were performed in in the computer program 'R', more specifically using the plugin called 'RQDA', which is an open source software package designed especially for qualitative data analysis.

As mentioned earlier, secondary data came from the LexisNexis and Espacenet databases. These are highly respected sources. Secondary data preparation at this step mainly involved writing a precise search query and/or filtering the data after extraction from the databases. The former was done on a trial-and-error basis and the latter was performed using Microsoft Excel. Secondary data from literature (mainly survey results) came from authorities in their respective research fields and were unaltered. Due to the quantitative nature of the secondary data, cognitive bias was not involved.

3.5 Controllability, reliability & validity

The most important research-oriented quality criteria are controllability, reliability & validity, because they provide the basis for inter-subjective agreement (Van Aken et al., 2007). Inter-subjective agreement refers to consensus in dealing with a research problem.

3.5.1 Controllability

Controllability pertains to revealing how a study is executed. If research is explained in detail, it enables others to replicate it and check whether they get the same outcomes. Even if others do not replicate the study, the description can be used to judge the reliability and validity of the study (Van Aken et al., 2007). By way of writing chapter 3, explaining the research method step by step, an effort was made to achieve a high level of controllability.

3.5.2 Reliability

The results of the study are reliable when they are independent of the particular characteristics of that study and can therefore be replicated in other studies. Methodological literature recognizes four potential sources of bias: the researcher, the instrument, the respondents and the situation (Van Aken et al., 2007). The best strategy for reliability is by repeating the research. Because that was not possible, other measures are discussed below.

Researcher

Research results are (more) reliable when they are independent of the person who has conducted the study. Due to practical limitations and the individual nature of this master thesis, the research was performed by only one researcher. Nevertheless, there were frequent meetings with the supervisors. Further measures include having two persons present at the interviews as described in 3.3 and having the interviewees evaluate the interview transcripts. Finally, having little empirical experience on these topics beforehand provided an open mind, decreasing confirmation bias.

Instrument

The most notable measure to increase instrument reliability is *triangulation*; the use of multiple sources of data (see 3.2). Although the semi-structured interview allows for a fluid conversation, a topic list could be checked to prevent having omitted any. Furthermore sample questions were included, many of which were aimed to measure the same variable. Those can be regarded as separate instruments (Van Aken et al., 2007). Similarly, having conducted multiple interviews per stratification criterion also improves instrument reliability.

Respondent

Response bias is a cognitive bias and can come in many forms. First off, by ensuring the data would be treated confidentially respondents were not limited to withholding information. Secondly, the fluidity of a semi-structured interview did not force the interviewee to pause and store valuable thoughts as can happen in fully structured interviews. An obvious limitation is that most interviews were conducted with mostly one and sometimes two interviewees per company. On the upside, most of the respondents are high-level managers sharing many characteristics.

Situation

Since the topic of interest generally pertains to long-term strategic planning, interviews will not suffer from obtrusive measurement. Furthermore the interviews were held at a location and time at the interviewees' convenience.

3.5.3 Validity

A research result is valid when it is justified by the way it is generated. There are three main types of validity; construct, internal and external validity (Van Aken et al., 2007).

Construct validity

Construct validity describes the degree to which a certain operational measure claims what it is supposed to measure. Qualitative research often violates this measure as it is prone to subjective judgment. Therefore triangulation can help. Due to the confidential nature of the research topic, information in secondary sources was often absent for many of the concepts or contextual factors. Although triangulation between primary and secondary types for individual firms was limited, the information provided by interviewees could still be compared to those of others within the same stratification criterion, preventing serious validation biases.

Internal validity

Internal validity describes the extent to which causal relationships can be justified. Finding causal relations is a goal in explanatory and not explorative research though. Nevertheless, in the broad sense, internal validity describes the extent to which the findings of the research are valid for the researched sample. This is done by taking measures to reduce biases in order to improve accuracy. These measures were described in 3.4.2.

External validity

External validity describes the extent to which the research findings of the sample can be generalized to the greater population. High external validity can be achieved by having a representative sample. The three criteria for stratification in the sample were grounded in theory as follows. The amount of patents is a reliable and the most prominent indicator of innovativeness and the amount of knowledge generated in an organization. Firm size is a characteristic that seemed to affect many other concepts and relations in the theory and therefore seemed important to diversify in the sample. Lastly, the firm archetypes specified were the most relatable in the perception of the interviewees, whilst maintaining a clear distinction in NPD-processes.

Besides having an accurate sample, analytical generalization can also be used to improve validity. This involves comparing the results of the study to a previously developed theory. In effect, this was done by reflecting on the results in relation to the general theory as in 7.1 (discussion).

4 Data from interviews

This chapter presents material from the interviews. This chapter aims to reach two goals by summarizing what was said during the interviews. First, it allows the readers to gain a deeper understanding of the theory, as this chapter shows the perspective of firms in practice. Second, it serves as a baseline which can be analyzed further in chapter 5. So this chapter merely reflects the interviewees' words and perceptions and does not include interpretation or value judgments from the researchers

The structure of this chapter largely follows that of chapter 2 and discusses the topics one by one as found in the conceptual model. Chapter 4.1 presents the data on the contextual conditions; the institutional environment and industry, firm and technology characteristics. Chapter 4.2 features the appropriability mechanisms; complementary assets and formal and informal mechanisms. In conclusion, content regarding the supply chain is presented in 4.3.

4.1 Contextual conditions

4.1.1 Institutional environment

The institutional environment refers to the strength and availability of legal protection (Lanjouw & Schankerman, 2001). This differs per country. For the companies interviewed, it was found that the efficacy of legal instruments is high for most of the countries where they operate or have their markets. These countries typically include The Netherlands, the USA, Japan, China and several countries in Western Europe. Companies indicate that especially in the case of China the institutional environment has greatly improved. As one interviewee remarks:

"Since 1984 they have their own patent law. Since then the Chinese have been constantly stimulating the value of IPRs. And they have come a long way with it. So nowadays, when you have a patent in China, you can actually do something with it." - OEM

At the same time, one company representative claims that for patents the situation in the USA includes a new feature they are not content with:

"Nowadays if you want to enforce your patent there is a procedure at the patent office where your patent can be challenged and invalidated. That has been a dramatic development." - OEM

Additionally, a few companies remarked they are looking forward to the European unitary patent. All in all the interviewed company representatives believe their IP rights can be protected or enforced well. Country scores from secondary data such as the Ginarte-Park index point to the same. In general, these companies do not seem to have concerns about the institutional environment.

4.1.2 Industry

Competitive intensity

From the interviews it becomes clear that in general most companies, including competitors, seem to have increasingly specialized into a certain market area or technological capability. Most companies claim not to compete on price since their services or products are not commodities.

Entry barriers for industries of most companies are high. To develop medical equipment, for example, requires the company to have very specific certifications in order to fulfill regulations. Another more common barrier comes in the form of large capital investments required to enter the market, which is a barrier that is found throughout the sample for all company archetypes.

No clear claims were made on product demand and exit barriers. However, the industry concentration is currently relatively low throughout the sample. Those companies that suffered the most from competition reported that their main competitor, or several competitors, have ceased to exist as a result of the economic crisis around the year 2009. A few companies reported not having had much competition in the first place.

Number of capable competitors

Although the industry concentration is relatively low for most companies, no examples were given on the exact level of R&D or innovativeness of competitors. However, interviewees only consider competitors actual competitors if their level of capabilities are on par with their own as the following quote illustrates:

"If things get easy, they could do it in Eastern Europe and China as well. Our competition is not widespread, so luckily our clientele cannot just go and look for other companies in a radius of 100km, so to speak.'' - CM

Barriers to imitation

As described in the theoretical background, high organizational and technological complexity can form a barrier to imitation as well. According to the interviewees, the level of organizational complexity seems to be directly proportional to the company size. There was however one clear exception, in favor of one of the companies in the sample.

"Our competitor announced to launch its new technology in half a year. Eventually, we were the first to bring it to the market. But only because we had development cycles of a week. You can only achieve that with an exceptionally well-organized supply chain.'' - OEM

Typically the engineering agencies claim they are very flexible. However, this is inherent to this archetype since most of the engineering agencies work largely on a project-basis. Although there is some degree of competition amongst a few companies in the sample, they do not differ much in organizational complexity. But to measure the exact level of organizational complexity would need more work.

4.1.3 Firm

Size

Firms which are hired by large companies to develop or engineer a product or module often generate IP which is subsequently transferred to the buyer, often a large OEM. Two reasons for this come forward. The first is that since the buying company paid for the development, they impose the requirement that the IP should be theirs as well, as well as the option to formalize this into IPRs. The second reason is that when IP is generated jointly and for example a patent is filed, the larger firm has more resources to (successfully) engage in litigation. In both cases, OEMS state that the supplying firm can be granted a license to use the IP in non-competing markets:

"About the transfer and management of patents; company X [large] is capable of defending their portfolio, but company Y has only got about 100 or 200 employees. It's not a great idea if they own the patent then. In that case, I prefer that we get the ownership. But then they will get a license." - OEM

Most small firms in the sample have the idea that they do not have the means to enforce patents they own. Small companies who do not own patents have similar expectations.

Ability to manage IP

A company's experience in regards to IP seems very analog to firm size. Large OEMs have a lot of experience with various forms of IP. Smaller companies have a lot less experience. Whereas some companies know about the procedure to get a patent, for example, others do not. But those that do not know themselves, often do know where to find (hire) help to do so. Nevertheless, most of the companies with only a small patent portfolio lack experience in regards to monitoring or enforcing their patent (landscape). Most CMs and some engineering agencies seem to struggle with this. An answer from these companies to the question whether they have sufficient knowledge on IP generated the following quotes:

''No, I do not have the illusion that that will ever change.'' - Engineering agency

"The last time we had a meeting with the company lawyers we did not get further than general buying conditions. So then we have not reached the maturity yet to talk about patents, would be my conclusion. So I think there is a need within this company to know more about patents and protection of IP.'' - CM

The engineering agencies also face a dilemma and this quote illustrates this nicely:

''We are not that advanced yet when it comes to IP. Our knowledge is our product and that product is what we sell. That is what you make available to your clients. And at the same time, you must protect it. That's a dilemma for us.'' - Engineering agency

Knowledge spillover prevention:

All interviewed companies use NDA's as the first barrier to protect their knowledge when working together with a different company. Similar chapters seem to be integrated into employment contracts. Employees are also trusted to handle things confidentially. Most, but not all companies have stated they have taken some measures to limit access to files/databases to certain employees. For some companies this is where they deem security measures sufficient. For others this goes a lot further:

"Our security can always improve. Let's just say that sometimes we discuss the security of our IT systems on a national level. The IT system is, of course, a crucial system. But at least we are able to point out when we get hacked. That's quite something in itself. Many companies do not have a clue they are getting robbed." - OEM

All companies seem to be (fairly) comfortable where they are at though. They feel they have taken sufficient precautions to not let knowledge leak away.

"No, we do not have clean rooms or other such things. No. There is no need for that yet. When we will have to get it, we will get it, but now we do not need it yet." - Engineering agency

Technology leadership / Innovativeness:

All interviewed companies claim they are very innovative in their activities or innovations. The OEMs can back this up with a large proportion of revenue being budgeted for R&D expenses.

"We are right at the frontier of what is possible, actually in many fields simultaneously." - OEM

"We compete a lot on innovation and market knowledge. We never compete on price. We are very bad at that; we are virtually always more expensive. We are not very great in maintenance and customer service, I think others are better at that as well. But leading innovation and working closely in collaboration with our clients is what we excel at." - OEM

This goes for both process as well as product innovations. OEMs try to stay ahead with their products, companies at the end of the NPD process focus more on processes, trying to be on the forefront of makeability.

Absorptive capacity:

One company claimed to have a great absorptive capacity.

"We are an integrator of technologies. We have the exclusive right to certain technologies that dozens of suppliers develop just for us.''- OEM

Not many other responses were given, and when they were, they were inconclusive. So in short, not enough data was provided to make conclusive statements about this contextual condition.

4.1.4 Technology:

Process/product innovations

There is a very clear distinction between process and product innovations throughout the supply chain. The contract manufacturers in the sample mainly dealt with process innovations and not so much with product innovations. These were found mainly in the OEMs as their products were designed for the greatest part by their own R&D departments. The engineering agencies were also greatly involved with product innovations and for those that had their own product, also with some degree of process innovations. All the OEMs in our sample perform the final assembly and testing of products in-house and as a result, also get to deal with process innovations. For those innovations, formal IPR was mainly seen as unnecessary and a waste of resources. As an interviewee demonstrates:

"Testing is a costly process, so if you do an innovation that reduces the testing time or makes testing cheaper, that is an important innovation. But it is invisible for us what other companies do in these areas. So if you would establish a patent on such an innovation, it does not hold any value. " - OEM

The exception to process innovations being invisible is where reverse engineering comes into play. From the interviews however it becomes evident that companies find it difficult to reverse engineer their competitors' products. Two reasons are given; costs and complexity. And this seems to go for product innovations as well. When it comes to costs, competing products are simply too expensive for a company to buy to retain benefits from reverse engineering. As one company illustrates:

"Those devices costs several millions each. Did you think we could buy those? No, this is not the automobile or a consumer market." - OEM

Complexity

Complexity can also form a barrier to the imitation of innovations. On process innovations, a contract manufacturer illustrates:

''For end-products companies can see its features and you can notice copying behavior. You notice this on the internet or in the store when somebody introduces a similar product to the marketplace. But you cannot precisely determine how that product is manufactured. Even with reverse engineering that is extremely hard.'' - CM

All interviewees have similar experiences except one who states that it is actually easy to determine what processes are used in manufacturing a process, making process innovations visible through reverse engineering. However, this statement was made in the context of a low complexity, low-cost consumer product.

On a product innovation, another interviewee's statement illustrates how the complex nature of a product makes the source of a product feature or function unverifiable:

''The process of how you make the feature work is quite complicated, there is a lot of innovation involved. But that is also something you cannot verify with your competitor. Ultimately you can observe the result of the product feature, but you cannot see how it is made. So those are things you keep secret." - OEM

Other typical examples of this kind that were also mentioned during the interviews were software algorithms and embedded software on chips.

Nature of knowledge

There was a rather clear distinction between codified or tacit knowledge throughout the stages of the NPD process. This was very evident in the interviews without any exceptions.

''The kind of activity that does very specific things in mechanics for example, e.g. manufacturing, you cannot patent that. You have to really rely on your skills to get those jobs done." - CM

Some managers realized that the tacitness of certain activities had advantages as well as disadvantages.

''Both fortunately and unfortunately it is based on experience and skill. That is a very double answer. Unfortunately, because it is sometimes hard for us internally. The knowledge of our workers lies in how they use their hands. And sometimes it would be nice if we could get that on paper because then you can also train new people.'' - CM

This concludes the material on contextual conditions. The content on appropriability mechanisms is presented in the following chapter (4.2).

4.2 Appropriability mechanisms

4.2.1 Formal: patents

For those companies that do have patents, patents are mostly used defensively. The companies with a somewhat bigger portfolio tend to cross-license to resolve litigations.

"Well, we want freedom to operate, that's the most important thing." - OEM

"So we only attack if we have to defend. We do not want to make our money with patents. We want to make money with great products." - OEM

"The most important thing is the solving of conflicts. So when a company thinks we do not use patents and they end up violating one of our patents, then at a certain moment you come to an agreement. Preferably with a payment in our direction." - OEM

One company representative could not identify the reason why they did have several patents.

Companies in the sample with a sizeable patent portfolio do not seem to try and gain exclusive patents and then sealing them shut with patent thickets and so on. In other words, companies from the sample did not use patents in a proprietary manner. There was also no indication that companies actively pursued leveraging strategies, such as licensing their patents out for rents. However, OEMs did claim to grant licenses to engineering agencies who were hired to develop a technology for them. Though there are restrictions on the use of these, they are provided for free.

4.2.2 Formal: trademarks

Most interviewees could not give a rough estimation of the amount of trademarks their company owned. For most companies, there was no indication they use trademarks other than the trivial role of registering their company name and logo. In two cases, OEMs, trademarks were actively used or enforced.

"Trademarks are something for the corporate marketing department. That is being run from another country mostly. We also have a few copyrights here and there. I do not know how competitors handle trademarks, but I do know that for American companies branding and names are quite important. Yes, Americans are quite good at sales and marketing." - OEM

Another company used trademarks to stop free-riding counterfeit products .

"Brands are currently actively used to combat products that carry our name but are actually not ours. We have a brand for one of our products, and if you search the web you will see a lot of websites where that brand name is used for products that do not originate from us. We use that brand to get those websites offline." - OEM

4.2.3 Formal: other IP rights

None except one company handles industrial design rights. In this case, they are used for consumer products which they develop from a conceptual stage for its clients. Additionally, they use a combination of other rights to offer a complete package to its client.

"It is what we call an IP container. You can think about design, colors and materials. There are IPRs for a lot of things. Design is, of course, a very well known one. With all the projects we do, especially in retail, there are a lot of shapes that you need to exclude your competitor from. This is an issue in all projects. We develop a visual brand language for every client of ours." - Engineering agency

4.2.4 Informal: secrecy

When knowledge leads to innovations and new technology, secrecy is the first protection mechanism until a decision is made to formalize IP or not:

''Look, secrecy is standard practice until we have made a decision to protect it otherwise.'' - OEM

Secrecy seems especially prevalent in process innovations. The most important factor for secrecy is trust, at least for supplier-buyer relationships (cooperations between direct competitors rarely happen). Companies do not fear that their suppliers will shop around with their knowledge. IP leaking away unintentionally is something these companies worry about more.

4.2.5 Informal: lead time advantages

Several companies try to compete using this strategy. Obviously, the development speed is crucial.

"If competitors want to catch up with where we are now, it will take several years. But by that time, we will already be a few years ahead. Even fierce competitors could not keep up with us."- OEM

Development speed seemed most important in early NPD stages. However, development speed is not the only factor important for this strategy. One company shows that once a lead is established, customers can be 'locked-in':

"You have to find a window of opportunity that is synchronous with the development cycles of your customers. In our industry [medical], the incubation times are large because of many regulations. The advantage is that once you are established, you will keep that business for a while. Simply because customers cannot easily switch to a different supplier." - Engineering agency

However, this is the only company in our sample that has such a clear opportunity for customer lock-in. No examples were mentioned where companies showed superior preemptive capabilities leading to lead time advantages. Concerning the combination of secrecy and lead time advantages, one company illustrates:

"What we prefer is to keep the knowledge secret, put the product on the market, get a head start and then try to maintain our position." - OEM

4.2.6 Complementary assets:

Numerous examples were found where companies state they really have a unique superior capability that provides a competitive advantage. One firm claims to excel in customer innovation because of their superior market knowledge. Another company claims it can provide its services throughout many different countries so as to stay close to its customers. The most common assets though stem from technological leadership; firms specialize in certain technological areas.

"What we do internally comes down to specialized processes that others [competitors] cannot do. This leads to specialized products which others cannot make in the same way." - CM

4.3 Supply chain

4.3.1 Degree of supplier involvement

Various companies acknowledge that there is an outsourcing trend. OEMs increasingly outsource parts of their NPD process to suppliers which various interviewees illustrate by pointing out how this transforms the supply chain from vertical to more horizontal. Most interviewees perceive that their largely Dutch supply chain is a lot more horizontally integrated than that in other countries.

"If you look at the difference between German and Dutch supply chains for example. Siemens produces 80% of the things they bring to the market. For similar Dutch companies this is 20% and instead, 80% is outsourced. So our supply chain is a lot more intelligent." - OEM

Engineering agencies which are hired on a project basis by OEMs see their involvement in the NPD process grow in both directions as the following quote illustrates.

"Large customers like it when the supply chain is closed. It prevents them from having to deal with transfers. This is why we set up our own assembly department. The customer [OEM] wants a complete package from concept to production." - Engineering agency

Both engineering agencies and CMs report that they are developing own products or modules to sell to OEMs more and more. Both engineering agencies and CMs state they do this to be less dependent on the OEMs. Additionally, CMs specifically indicate another reason; to escape the current costing model to achieve higher margins.

4.3.2 Earliness of supplier integration

Companies recognize that supplier integration is increasingly early; supplier activities in the NPD process are shifting towards earlier steps according to the interviewees. As an OEM illustrates:

"Some suppliers really perform research for us, also in The Netherlands. Currently, it makes up about 10% of our total research, but we are ramping this up quickly because we simply want partners to take responsibility for their products." - OEM

Contract manufacturers indicate they have worked as mainly build-to-print companies in the past, but a large portion of their portfolio currently is made up of build-to-print-plus jobs as well. Although the proportional amount of build-to-spec jobs is small, there is an increase as well. As a matter of fact, some large contract manufacturers in the industry are developing or already have development and engineering departments so they can play a role as an engineering agency and CM in one.

Having presented the material from the interviews on these topics, this can now be further analyzed in chapter 5.

5 Results

This chapter evaluates the data from the interviews and secondary data. This is done step by step according to the concepts in the conceptual model. The propositions generated in chapter 2 are revisited and checked if they could be confirmed. Note that propositions that were omitted in the discussion could not be confirmed or denied because either there was not enough data, or the data was not sufficiently accurate. A complete overview of the outcomes of the propositions is provided in appendix H. Conclusively, several important insights are listed.

Chapter 5.1 presents findings on the concepts separately. This includes the contextual conditions and appropriability mechanisms. Chapter 5.2 provides an overview of concepts taken together; a helicopter view. Chapter 5.3 lists the most important insights of this study. Subchapter 5.3.1 presents those related to the appropriability framework and 5.3.2 those related to the supply chain.

5.1 Separate concepts

Institutional environment

The institutional environment for the main countries in which these companies have patents and formal IP is strong (appendix B). This means infringement can be effectively combatted and is discouraged in this climate. Formal IP, therefore, holds value and can be an effective appropriation mechanism. This was expected and is in line with P3 and P4.

The comment about the new procedure for challenging and invalidating patents in the US is only partially true. Though the challenging procedure is not new, an additional reexamination procedure for newly granted patents was introduced in 2012 with the Leahy–Smith America Invents Act, which the interviewee likely meant. In this reexamination, the challenger can potentially invalidate a patent at the US patent & trademark office without interference of the defendant. This has lowered licensing settlement sums but increased strength for patents that survive post-grant review.

Industry:

The most influential industry-specific factor is competitive intensity; its elements are discussed subsequently.

Entry barriers (capital investments, regulations, knowledge level) are high and products are anything but commodities. Furthermore, the industry concentration is currently relatively low after the economic crisis. There is slightly more competition the later the stages in the NPD process a company performs. An important note is that competition is diverging when it comes to capabilities or market area; companies report an increase in specialization and finding niches. Overall the competitive intensity is low to medium.

Two cases of infringement were reported, but these were not recent. Altogether it seems this is in line with P5; there is relatively little incentive for imitation at the moment. This also means P6 seems irrelevant. Technological complexity is high and makes imitation hard and in some cases impossible (P7). All in all, there is little incentive for imitation. It should be noted though that this is not synonymous with not having to protect IP. First of all, merely because competition with regards to products or technology is increasingly asymmetrical, does not mean declassifying IP will not spur the growth of potential newcomers or the introduction of competing products. Secondly, low competition does not mean there is no competition at all.

Firm (general):

Highly innovative firms generate more IP and this inherently provides more opportunities to market or license this IP. The innovativeness declines throughout the stages in the NPD process, where it is highest at the level of OEMs, slightly lower at that of the engineering agencies and lowest at the CMs. This is in line with the number of IPR applications and P9. Furthermore those firms with more experience in IP considered the value of IP higher than those who had little experience in IP, this is in line with P10.

Two examples of knowledge spillover were mentioned in the interviews, neither could be prevented by stricter measures. Although stricter and more measures generally improve protection against imitation, there is no impermeable security. After a certain point increasing security measures adds little to no benefits anymore, but only costs. Companies therefore use common sense to establish a level of security that seems right for them. So although stricter measures hinder imitation, in line with P11, it should be added that the relative effectiveness gradually decreases with the level of security. Furthermore trust is the main driver in preventing intentional knowledge spillovers in inter-firm cooperation within the supply chain. Companies who do not treat other firms' IP as confidential, risk severe reputation damage and ostracization.

It is a common misconception that large firms can enforce or defend their patents more easily than small firms. Although large firms can rely on traditional methods such as litigation and cross-licensing more easily because they have more resources, small firms can rely on other, more creative methods. For example leveraging the media in their favor (David versus Goliath) or buying the imitated products from the infringer for a small price. Small firms do not seem to realize these options are out there, yet. Although the interviewed companies' experiences align with P13, it is not necessarily true.

Small companies need to take fewer measures than large companies to reach a similar level of secrecy because smaller groups of people and activities are more manageable. This makes it more attractive for small companies to pursue secrecy, as in P14.

Firm (lead time advantages):

Many firms in the sample reported they are working with technology bordering the physically impossible. These firms are definitely technology leaders and those firms do happen to have lead time advantages. This part is in line with P15.

Technology:

In manufacturing tacit knowledge is prevalent and in conceptual stages of product development, knowledge is more codified. CMs indicate they struggle to make their skills and experience explicit. This is logical, in line with P17 and not something to worry about. Not enough was said about second-movers in relation to codified knowledge of technology to make claims about P18.

Complexity did not seem very decisive in going for either formal or informal appropriation mechanisms, the distinguishment between tacit and codified knowledge was much more profound in that. This is probably because for the companies in the sample the status-quo is highly complex and no comparison with low tech was made. Therefore P19 and 20 are irrelevant in this study. For process innovations, formal appropriation mechanisms are obsolete and secrecy is, in general, the smartest strategy (P21).

Supply chain:

As stated before, it is indeed clearly the case that most IP is generated in the early stages of the NPD process, during the research, development and engineering stages, in line with P23.
OEMs indicate they outsource more than before (P26). Research partners and engineering agencies are attracted to come up with new solutions in order to reduce technological uncertainty (P24). Unfortunately, OEMs handing over full responsibility for development of certain modules or products to engineering agencies, or even large contract manufacturers is far from perfect. OEMs expect their suppliers to take responsibility for a larger part of NPD more often. This means that manufacturers transition from build-to-print to build-to-print-plus suppliers, or from there to build-to-spec. Preferably, OEMs would like to see their suppliers to take full responsibility for an entire module. This goes slightly further than just build-to-spec. This is where there is a gap though; manufacturers do not have sufficient development/engineering capabilities yet. This diminishes the benefits of outsourcing because rework often has to be done. So, currently, the effects of supplier lock-in are very real (P25). Engineering firms could instead take this role. A problem here though seems to be a mismatch in compatibility between OEMs and traditional engineering firms. The engineering firms in our sample are small companies in comparison to OEMs, and their work focuses on very specific parts of a larger project. Apart from a capability gap & scale mismatch, OEMs want their suppliers to be healthy companies which are not fully dependent on them. This means that if they expect companies to fully take responsibility for a module, they must also have customers in other markets where they can use their technology in similar products. However, on very high-tech areas such modules are usually so specialized it is hard if not impossible to sell derivative products. Suppliers do indeed generate more IP as their development activities expand, but until suppliers can truly develop entire subproducts or modules on their own, OEMs will often get to own the IP.

Formal: patents

The use of patents in the sample is mainly defensive. The proprietary mechanism is used only with critical technology. Furthermore, potential revenue is lost by not actively trying to license out unused technology, the leveraging tactic. The biggest Dutch patent owner, Philips, uses many of its patents this way. Furthermore, smaller firms hardly search patent databases to see what competitors may be doing or to find out if there are advancements in technology.

Formal: other

Trademarks can be a great business tool in marketing and branding, but only one company actively uses trademarks this fashion. There may be lost potential here. Although the same could be said for design rights, supplying companies mainly produce sub-products or modules where physical design characteristics are not very important.

Complementary assets

Complementary assets are especially important when there is a weak appropriability regime (P2). This does not mean however that they are not important when this is strong; regardless whether companies decide to enforce their IP rights, they can leverage their assets to generate an advantage. These assets can vary greatly and are subjective to some extent.

From an outsider's perspective, it is of course hard to judge whether these are really specialized assets or just wishful thinking. One interviewee acknowledges this and states that companies must have a proven track record before they can claim they have mastered certain technological capabilities. Regardless, one thing is clear; every single company interviewed tries to differentiate itself from its competitor by trying to specialize in something(s) their competitors do not.

Informal: secrecy

Although all interviewed companies use NDA's in some way, for many interviewed companies this seems to be the only conscious measure to counter infringement on secrecy. Whereas NDA's provide legal protection from infringement of the other party, it does not provide protection from other parties who somehow gained access to this IP. This could happen as a result of leakage, company espionage or coincidentally developing a similar technology simultaneously. In these situations, companies can make a stronger case if they can clearly show they have identified certain IP to be kept secret and have taken measures to keep it secret. Although IT and security measures are in place and seem sufficiently safe, a clear identification of the IP that needs to be kept secret deserves more attention, especially for the smaller firms.

Informal: lead time advantages

Regarding lead time advantages, development speed seemed the most identifiable and decisive factor in establishing such advantages.Striving for a lead time advantage goes well with secrecy. After all, to maintain a lead it is important that competitors do not gain access to that knowledge that is crucial for staying ahead.

5.2 Summary of results

The institutional environment for the main countries in which the high-tech companies are active is strong. This means formal appropriation mechanisms can be employed and infringement can be combatted effectively if formal appropriation is pursued. Additionally, the competitive environment in the industry is relatively benign. As a consequence, the incentive to imitate innovating companies is relatively low since there is room to develop own technology and competition is based on non-price factors. Companies that perform large-scale R&D or are more innovative get more opportunities to put these in the market and capture value. These are typically OEMs.

However, any firm, once they get a technological lead, can effectively employ a lead time strategy as long as their development cycles stay sufficiently fast or if they can lock-in customers.

Firms that choose to employ secrecy instead can also be successful. They need to put security measures in place to restrict access to secret information. Also, for a stronger legal standing in case a leak or infringement occurs, this information needs to be well defined and actions to keep it secret need to be demonstrably sufficient. These latter two points need improvement, whilst the measures itself seem sufficient. Firms do not need to be overly strict though, as this will not provide any additional benefits since leakage is never fully preventable. Inherently, putting these measures into place is less resource-intensive for smaller firms than for larger firms.

Firms that choose to employ formal mechanisms and have more experience in this can leverage their experience for greater benefits than those firms without the experience. Larger firms usually have this advantage. However, this does not justify the misconception that patents are only a mechanism for large firms. There are creative ways by which small companies can enforce their patents as well.

The last main mechanism firms can use to capture value from their IP is by creating an advantage through complementary assets. This could be any asset that provides a distinct advantage over competitors, for example having superior customer innovation. The most common practice under CMs seems to be the specialization into certain technological capabilities or niches. As this diversification is still continuing, it is likely to (slightly) reduce reliance on other appropriability mechanisms as the technology becomes more isolated from competing technologies.

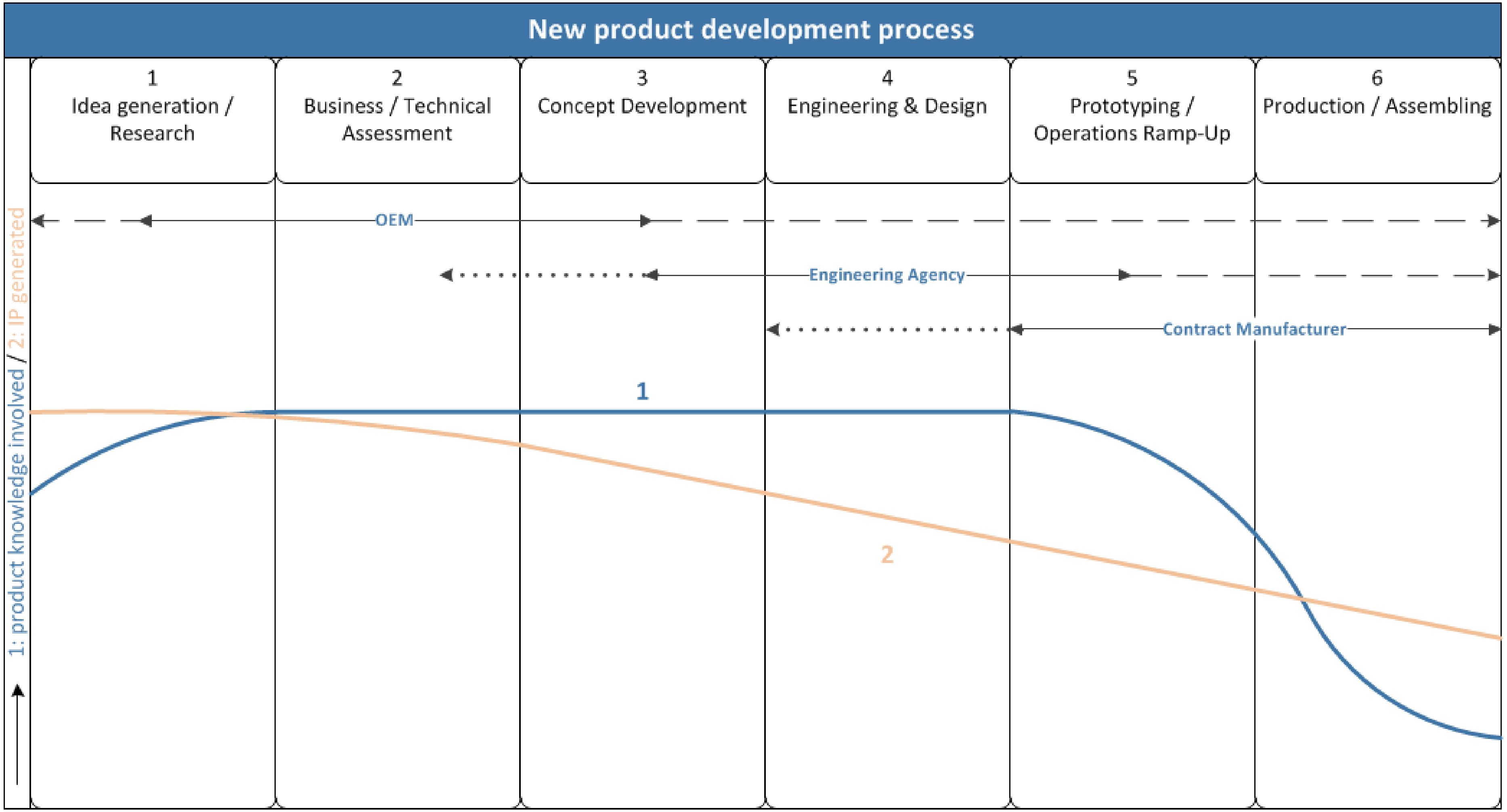
Most importantly of all, firms can choose multiple strategies at the same time and unconsciously do this already. This combination can be different for every technology or product of course.

When it comes to the difference in firm archetypes, there is a very clear distinction between product and process innovations and tacit and codified knowledge. Contract manufacturers typically deal with tacit knowledge and process innovations. These can be protected with informal mechanisms or by a focus on complementary assets. However, since process innovations are generally invisible to outsiders, they can easily be protected by secrecy. Engineering agencies typically deal with product innovations, which can be made explicit as codified knowledge. In addition to informal mechanisms, this knowledge can additionally be protected with formal mechanisms. OEMs deal with mainly product innovations, and to a lesser extent process innovations for they often do the final assembly or testing in-house. An illustration of the stages and the amount of product knowledge involved is depicted in figure 9.

Considering the dynamics of the supply chain and the NPD process, it is clear that most IP is generated in the early stages of the NPD process, also illustrated in figure 9. As OEMs outsource more, so they can focus more on their core activities to stay competitive, they expect their suppliers to step up and take more developmental and engineering responsibilities. This pulls engineering agencies and CMs closer to the front-end of the NPD process. However, engineering agencies and CMs are currently not yet ready to make this transition as their capabilities are not aligned yet with where the OEM wants them to be. CMs could use greater financial leeway to improve their technical capabilities. Engineering agencies usually do have sufficient technical capabilities, but often miss scale and continuity.

Currently, engineering agencies and contract manufacturers are usually hired by an OEM to work on a specific project (engineering agencies) or manufacture specific modules (CMs). For CMs, new IP created in this situation usually pertains to manufacturing processes and resides as experience in employees. For engineering agencies, new IP usually pertains to products and can be formalized. Because of asymmetrical bargaining power in favor of the OEMs, the OEMs claim ownership of that IP with the reason that they paid for the development. The OEMs state however that they often provide a license for use in non-competing markets and products. This is not always the case in the perception of the supplying company. Anyhow, in case they are granted, this license proves useless quite often, for the developed technology is too unique to use in other products or the license is too restrictive; non-competing markets and products are often interpreted very broadly by the licensor. This is one of the reasons that suppliers of OEMs currently stay behind in ownership of IPRs.

Both engineering agencies and CMs are starting to realize that if they want to expand their capabilities, they can actually create their own IP to capture value by designing their own products or modules and selling this as their own product. This shift towards productization will allow them to grow their capabilities as more independent and robust companies as long as they can manage their IP properly and continue to capture value from it. Over time, this will allow them to transform into companies that better align with the changing needs of the OEMs and strengthen the supply chain.



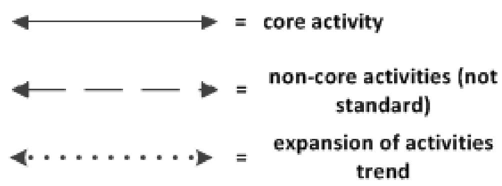


Figure 9: schematic representation of company activities, level of product knowledge and amount of IP generated throughout the NPD stages.

5.3 Insights

The main insights of the research are presented here. This is done by discussing two main topics. First, this is done in light of the appropriability framework and second by providing an overview of the supply chain.

5.3.1 Appropriability framework

Selection of appropriability mechanisms

Companies in the Dutch high-tech sector can use and do use all of the appropriability mechanisms to capture value from their IP. Zooming in, this differs per company. The main driver in the choice of appropriability mechanisms seems to be the firm archetype. The NPD processes a firm is involved in strongly influence the choice of the main mechanisms. The explanation for this is that the emphasis shifts from product knowledge towards process knowledge throughout the NPD process. Since product knowledge is closely tied to codified knowledge and process knowledge to tacit, this ultimately means that formal mechanisms are better suited for early NPD stages and companies involved in late stages should focus on informal mechanisms. Complementary assets remain valuable for all firm archetypes.

Efficacy of appropriability mechanisms

Untapped potential

The results show that some formal mechanisms are used more than others. Patents are mainly used defensively, trademarks are not highly regarded as a business tool and other rights such as industrial design rights seem non-existent. This begs the question whether firms fully value and utilize the potential of IPRs.

Legal protection of secrecy needs scrutiny

Secrecy is the most widespread mechanism and used by virtually all firms in the supply chain to a certain extent. Companies are satisfied with the measures they take to prevent both intentional and unintentional knowledge spillovers. Although this is justified for physical measures, companies seem to be insufficiently aware of the additional administrative precautions they need to take in order to have a good standing in case of litigation.

Complementary assets

The most universal complementary asset is a technical specialization and this is an ongoing trend. Most companies recognize this and can see its benefits. Some companies however, seem to focus merely on their technological capabilities as a complementary asset and forget to realize that there may be other assets they could try to use or obtain to gain additional advantages.

Experience with IP(R)

Smaller firms have less experience with IPRs than large firms. Some of these firms state they know their level of knowledge on IPRs and the procedures to apply for them is not at the level they would like it to be. An upside is that this knowledge does not need to be omnipresent in a small organization; other small companies in the sample show that one person or a small group of persons having experience with these matters proves sufficient.

Another related insight that becomes apparent is that the topic of IP does not play a large role in management practice for smaller or less experienced companies. For these companies, a strategic vision on IP often lacks; IP-related activities are done whenever they are required, but a pro-active stance or an evaluation of the current IP portfolio often lacks. Larger firms and OEMs tend to treat IP more on a strategic level. As most of the IP is generated at the front of NPD processes, it is also logical that IP plays a more important role for OEMs than the other firm archetypes. Nevertheless, as the trend is for other firm archetypes to also start handling earlier NPD tasks, it would suit them to treat the topic more pro-actively.

5.3.2 Supply chain

Locus of IP generation

The most IP is clearly generated in those companies which perform the early stages in NPD. Most notably these are the OEMs. The OEMs sell end-products to which certain technology is key. OEMs often develop the core technology themselves but outsource the development of the rest of the product. Jobs are then handed over subsequently down the supply chain where every company generates its own bits of IP. This means that in the supply chain, the driving force in the generation of IP stems from the OEMs and as the OEMs are the owners of the end-product, the bulk of the IP gravitates towards the OEMs.

Shift in locus; mismatch in expectations

Companies other than OEMs generate increasingly more IP. This is driven by two factors; the outsourcing trend of OEMs and the productization trend in engineering agencies and contract manufacturers. The former is driven by the OEMs' increasing focus on their core technologies and as a consequence, less on developing their products from head to toe themselves. The latter can be explained by an increasing desire to be less dependent on contracted jobs. Either way, companies upstream take on more responsibilities and start to perform activities earlier in the NPD process. This means they need to develop certain (technical) capabilities. This is where there is often a mismatch in expectations. OEMs tend to over expect and upstream companies tend to underperform. The development of certain capabilities does not go as fast as either company would like it to. This needs time to grow and companies need more realistic expectation planning. Additionally, contract manufacturers mention the speed of this growth is hindered financially because of the open-cost pricing.

Transfer of IP

When an OEM hires an engineering agency or a contract manufacturer, obviously there needs to be a transfer of some IP somewhere so these companies are able to start their work. The use of formal IP is characterized by the fact that the knowledge or the technology is more or less codified. Tangible technology and codified knowledge are transferred easily across partners, which does not hinder cooperation. The opposite could be said for informal mechanisms and the argument could be made that in those cases cooperation is hindered. However, as the IP seems to flow from the OEMs in the direction upstream towards the CMs, the IP flows from product innovations to process innovations and the IP takes the form of codified knowledge to tacit knowledge. However, this transformation of codified knowledge into tacit knowledge takes place for the most part after the job is handed down to the CM. Since the handed down information, a product(ion) documentation, is mainly codified, this does not seem to hinder cooperation.

Transfer of IP rights

As mentioned before, the ownership of IP lies with the company that outsourced development. OEMs state that licenses of IPRs are granted to companies contracted for development, but these licenses often prove to be useless because they are technically too specific to be useful or companies are restricted from operating in that market space, which is often interpreted very broadly. This limits companies involved in design and engineering, such as engineering agencies, in becoming more independent and strong suppliers for OEMs in the long term.

IP support

Some OEMs claim they provide support to their suppliers when it comes to IP related matters. They educate their suppliers on certain topics or help them out with specific problems. None of the suppliers in the sample mentioned receiving or knowing about such support with their OEM partners though. Some of these companies are suppliers to the OEMs in the sample though, so this could be a miscommunication issue or such support is limited to different (types of) partnerships. As small companies especially could improve their knowledge level on IP related matters, there is room to capture more value. This may also prove handy for (small) contract manufacturers, as they start to sell their own (sub)modules as products (productization). First because as they shift from process innovations to include product innovations too, they could use extra knowledge on formal IPRs. Second, because extra income will decrease reliance on external credit and make the success rate of these products higher.

6 Conclusion

This chapter aims to answer the main research question and the research subquestions as defined in the introduction. In order to answer the main research question of this thesis, this chapter first discusses the findings in relation to the subquestions. These subquestions are answered in 6.1 and follow the same order as in the introduction. After these, the main research question is answered in 6.2.

6.1 Answering the research subquestions

1. What appropriation mechanisms can be relevant for firms in the Dutch high-tech industry?

Appropriation is the concept that described the degree to which innovating firms can capture value generated when innovations are introduced (Ceccagnoli, 2009; Teece, 1986). The ownership of critical pieces of intellectual property is an important strategic source of competitive advantage (Granstrand, 2000). Hence, appropriability has become a synonym for the mechanisms that firms employ to prevent imitation by other companies. There are three categories of appropriation mechanisms (Cohen et al., 2000; Levin et al., 1987); formal mechanisms, informal mechanisms and the use of complementary assets.

Formal mechanisms:
Formal mechanisms are state granted exclusive rights to IP. The main formal mechanisms are patents. There are three patent strategies (Somaya, 2012). 1) Proprietary: protecting a key advantage by isolating it. 2) Defensive: providing freedom to operate by clearing the way. 3) Leveraging: using bargaining advantages to pursue direct and indirect profit opportunities.
Besides patents, there are various other IPRs. Trademarks serve as a symbol of identity and are mainly used as marketing and branding tools. Industrial design rights provide exclusionary rights to certain shapes and forms. There are several more IPRs which are not relevant for this research.

Informal mechanisms:
These strategies focus on preventing spillovers of own innovation efforts. This is done in two ways; secrecy or lead time advantages. Secrecy refers to a firm's efforts to protect the uniqueness of an innovation by withholding its technical details from public dissemination (Arundel, 2001; Winter, 2000). Lead time advantages result from the early timing of developing and introducing an innovation and staying ahead (Lieberman & Montgomery, 1988).

Complementary assets:
Complementary assets (and capabilities) relate to those assets (or activities) that are strategically needed for gaining competitive advantage and the successful commercialization of an innovation. The weaker the appropriability regime, the higher the reliance upon the complementary assets needs to be to achieve success (Teece; 1986).

Since the appropriability regime is strong in those countries the Dutch high-tech sector does business in, all mechanisms (including formal) can be utilized. A combination of multiple mechanisms can be used simultaneously. It is however impossible to use secrecy in combination with a formal method for the same innovation.

2. What are the determinants in the selection of (an) appropriation mechanism(s) by these firms?

The determinants for the appropriability mechanisms are also referred to as the contextual conditions. The main four groups are the institutional environment, industry, firm and technology.

Institutional environment:
The institutional environment refers to the strength and availability of legal protection (Lanjouw & Schankerman, 2001). When this is weak, it makes less sense to choose informal mechanisms since they rely on strong legislation. This is not the case for Dutch high-tech companies; informal and formal measures can be effective, as well as the use of complementary assets. The efficacy of these mechanisms however depends on the other contextual conditions.

Industry:
The industry factors that influence the choice of appropriation mechanisms are the degree of competitive intensity, the number of capable competitors and barriers to imitation. Mainly the competitive intensity proved to be of relevance. The competitive intensity is relatively low at the moment, which is beneficial for current businesses.

Firm:
Firm-factors include innovativeness, ability to manage IP processes, and firm size. Highly innovative companies get broader opportunities to capture value with formal appropriation mechanisms than less innovative companies. The same goes for companies who are more experienced in managing IP processes. When it comes to secrecy, increasing strictness and measures is effective up to a certain degree; knowledge spillovers cannot be prevented entirely because no security is impermeable. Secrecy is a lot less costly than formal measures and is therefore a preferred mechanism for many small companies. Another reason to turn to secrecy is that small firms wrongfully believe they cannot effectively defend or enforce formal IPRs, mainly patents, in litigation against larger companies with more capital. When it comes to establishing lead time advantages, companies need to be technology leaders to attain that lead. Once this is established, development speed becomes crucial to maintain the lead.

Technology:
The nature of knowledge that pertains to the technology is important, as well as whether the innovation is a product or a process. These are typically strongly connected. Tacit knowledge plays a major role in process innovations. These cannot be captured well by formal mechanisms but can be protected by the other mechanisms, especially secrecy. Codified knowledge is related to product innovations and its value can be captured by using all mechanisms.

3. Does this vary between firm archetypes within the Dutch high-tech supply chain?

The three firm archetypes identified in this research are the OEM, the engineering agency, and the contract manufacturer (CM). The OEM is a company that sells an end-product and is typically at the end of a supply chain. Typically performs steps 1, 2 and 3 in the NPD process (figure 4). The engineering agency is a company that develops and engineers a (sub)product or module for an OEM. Typically performs steps 3, 4 and 5 in the NPD process. The contract manufacturer is a company that manufactures end-products or modules for an OEM. Typically performs step 5 and 6 in the NPD process.

The CM typically deals with process innovations and tacit knowledge. Although the CM traditionally does not introduce innovations to the marketplace, it can still try to gain lead time advantages on its internal processes. Process innovations are the easiest innovations to keep secret, so CMs also use secrecy. Lastly, it can rely on complementary assets; many CMs specialize in certain types of manufacturing capabilities. Examples include the production of large vacuum chambers or high precision manufacturing. To protect IP owned by their clients, the CM uses secrecy by default unless their client allows otherwise.

The engineering agency mostly deals with product innovations and codified knowledge. In case they design a product or module for themselves, they can decide to protect it with any mechanisms possible. To protect IP owned by their clients (OEMs), the engineering agency uses secrecy by default unless their client allows otherwise.

OEMs deal with mainly product innovations, and to a lesser extent process innovations for they often do the final assembly or testing in-house. So these companies use a variety of the formerly mentioned mechanisms.

As the trend is that companies take more responsibility and expand their businesses to also include other steps in the NPD process, their exposure to a different kind of knowledge will also grow. As CMs take on more engineering or even development jobs, they will also get to deal with product innovations. Likewise, if engineering agencies decide to expand their businesses to also include manufacturing, they will also get to deal with process innovations more and employ those mechanisms that fit with that technology.

6.2 Answering the main research question

How do suppliers in the Dutch high-tech sector protect their intellectual property and capture value from their innovations?

A large chunk of IP created within the supply chain originates from the producers of the end-products, the OEMs. In the quest to stay competitive, OEMs innovate and come up with new products, which drives the generation of IP in the supply chain. In the new product development process, as the OEM performs activities such as applied R&D, new technologies and ideas for products are generated and inventions are made. As these things crystallize and become more tangible throughout the NPD process , they eventually turn into new innovations. But before it comes to that, part of the development is handed down to engineering agencies, who are contracted to design and engineer certain (non-core) parts of the product. Eventually, this is handed down to a manufacturer, who makes the final adjustments to the design and produces (part of) the innovation.

During this process, OEMs mainly deal with codifiable knowledge. The IP it generates can therefore be protected by any of the three main appropriation mechanism categories, including patents. Engineering agencies deal with mainly codifiable knowledge as well, so when they create IP they could also protect this with patents. However, when they are contracted to work for an OEM, which is more often than not, the OEM usually contractually obliges them to forfeit the IP. Then the case of contract manufacturers; they do not really use patents because they mainly deal with tacit knowledge and process innovations, which is inherently hard to formalize.

When companies in the Dutch high-tech sector patent, they mainly do so for defensive purposes; companies want freedom to operate. Furthermore they would only patent if the technology is otherwise verifiable; by means of reverse engineering for example. Using patents only defensively leads to thinking that there is lost potential by not adopting other patent strategies in order to gain some economic benefits. The same can be said for the use of other formal mechanisms; notably trademarks and industrial design rights. There are several reasons why this happens. A first reason is that many companies are unfamiliar with the strategic use of IP and value capture mechanisms. This is a matter of attention and consciousness. Furthermore, SMEs have to cope with their day-to-day activities and constraints related to firm size. Moreover, large companies (and smaller ones as well) stated they simply want to focus on their core business. Finally, small companies have an unreasonable fear of losing litigation against large companies when they would own patents. This fear is unjustified because there are many other ways to settle, furthermore owning multiple patents can decrease risks by being able to cross-license.

Onto the informal mechanisms. Secrecy is used throughout the supply chain and is especially useful to protect IP of CMs, since that pertains mainly to process innovations. Process innovations are often easy to protect because they are generally not visible in the end-product. Moreover, access to production plants is usually restricted. Besides using secrecy to protect proprietary IP, companies are also deemed to stay confidential when handling information or IP of other companies they work with.

Secrecy has been working quite well for Dutch high-tech companies so far, however, knowledge spillovers (leakage of information) will happen eventually and have happened. In cases of misappropriation, companies can still defend their innovation in court, provided they have taken careful measures. Physical measures taken seem appropriate, but a few simple administrative measures could use improvement. Secrecy also goes well with going for lead time advantages. The idea here is that if a spillover occurs, it should not matter much for the company is already working on a superior technology or product. The drivers to choose for secrecy are that it gets easier to manage the smaller the company is, and that it is generally a lot less costly than getting and maintaining patents.

Pursuing lead time advantages is something many companies do. The drivers behind choosing this as the dominant strategy are technological leadership and fast development cycles. Not only are these drivers, they are also requirements to stay ahead. Companies in this research attributed the success of this strategy not just to being a technology leader or being fast themselves, they also credited this to having a well-integrated supply chain combined with informal company cultures. This makes cooperating fast and free of hassle.

Complementary assets are also utilized by virtually all companies in the sample. The main form of complementary asset is a technological specialization. This is different to technology leadership. Companies seem to position their product in the market into certain areas where competition is low. In other words, companies choose a 'technological niche', and over time these niches overlap less and less with those of competitors. This is good news for those companies, but it is likely made possible by several competitors going bankrupt during the economic crisis around 2009.Anyhow, for many companies it seems that a technological specialization is the biggest, or only complementary asset. This leads to thinking again that there is untapped potential here. Companies should not become fixated on just their technological capabilities, but should also look outwards to identify other complementary assets that would be beneficial to them.
Overall, the emphasis lies on informal mechanisms; secrecy, lead time advantage and increased specialization technologically. This means that firms prefer to choose mechanisms that align well with the core business, as opposed to protective mechanisms. A likely reason for this is that currently the competitive intensity is low, so there is relatively little fear for imitation by competitors.

Unfortunately, there are several dynamics that pose challenges. First of all, OEMs focus increasingly more on their core business in order to stay competitive. This makes them outsource greater parts of their product development. Naturally, they want strong partners that can do that job. However, many suppliers are not ready for this yet. Engineering agencies often lack scale and CMs need more time and incentives to transition from build-to-print(-plus) to build-to-spec or even build-to-roadmap suppliers. As responsibilities and capabilities shift, several changes will happen in regards to IP as well. For example, CMs will get to handle codifiable knowledge and may need to update their security measures to prevent knowledge spillovers. They may also want to familiarize themselves with formal mechanisms in case they need to apply for a patent. Although OEMs currently claim most of the IP when other companies design or develop (sub)modules on their behalf, they will eventually need to allow their (key) suppliers to build their own IP portfolio. This will make the aforementioned transition easier for them, as they can use the newfound IP position to attract new customers, better personnel, grow as a business and strengthen the supply chain as a whole.

Meanwhile, engineering agencies and CMs are exploring how to transform their current work into their own product to sell as a complete package to their clients. This shift towards productization will also grow their capabilities. However, doing this on their own will be slow since there are greater time, cost and scale restraints. Therefore, to keep the Dutch high-tech supply chain as great as these companies claim it to be, they will need to keep working together to facilitate each other's growth.

7 Discussion

The goal of this chapter is to evaluate the results of this study, as well as the study itself. By comparing the results as in chapter 5 and 6 to findings in previous research, we gain a deeper understanding of the subject matter. The study itself is also scrutinized; its limitations are presented, as well as possibilities for future research. Furthermore, the findings of this study are translated into managerial implications.

Chapter 7.1 presents the discussion of the results from chapters 5 and 6 in regards to previous research. Chapter 7.2 gives a list of managerial implications for various stakeholders in the Dutch high-tech sectors. In 7.3 the limitations of this study are discussed and 7.4 presents ideas for future research that could follow from this study.

7.1 Discussion

This thesis investigated how companies in the Dutch high-tech sector utilize their IP to capture value from their innovations. It contributes to the knowledge in the field of strategic management, which is fundamentally interested in describing why firms differ in their investment choices and subsequent performance (Rumelt et al., 1994).

Previous work has had a profound impact on technology strategy research but had several limitations (James et al., 2013). One, the majority of work in this area emphasizes the use and relative effectiveness of patents (versus secrecy) as a mechanism for capturing value from innovation whereas too little is known about other value capture mechanisms. Two, the field lacks the unbundling of the characteristics of institutions, industries, firms, and individual technologies that affect the selection of particular value capture mechanisms. Three, many of these concepts are approached as independent concepts with binary relations; e.g. combinations of various mechanisms remain relatively unexplored and firms are regarded as standalone entities. Four, the field is dominated by quantitative research whilst qualitative work is needed to explain results in a refined way.

This study recognized these issues and tried to make a valuable contribution in the following ways. First of all, by treating IP as a broad source of value, it transcended the traditional perspective on value capture mechanisms being dichotomous (patents versus secrecy) and included other value capture mechanisms as well. Lead time advantages were treated as a second informal mechanism besides secrecy, formalized IPRs other than patents were considered and finally, complementary assets were included as well. Second, an effort was made to provide depth by exploring context-specific factors which have an effect on the selection or efficacy of specific value capture mechanisms. Third, by looking at the dynamics in the supply chain, results are more nuanced and role-specific as firms were not regarded detached from their environment or seen as interchangeable. Finally, it may be clear this study is explorative and mainly qualitative in nature in order to provide both theoretical and practical insights.

When looking at the broader context in research, this study included elements of both the resource-based view and the knowledge-based view of the firm.

The resource-based view sees knowledge as a generic resource which to some extent can provide a competitive advantage if it is expressed in skills and utilized strategically (Barney, 1991). In a nutshell, it regards resources itself as the most important factor to explain firm performance. In the context of this study, such resources could be regarded as patents, proprietary technologies or key relationships within the supply chain.

The knowledge-based view considers knowledge to be the most strategic resource of the firm (Dierickx & Cool, 1989). Scholars of this view claim that knowledge-based resources are hard to imitate, are socially complex, immobile and heterogeneous. These resources are mostly intangible and immobile. A strong element of this view that relates to our research is the notion that knowledge is mostly tacit and hard to transfer. Therefore, important elements of this view in the context of this study include the focus on developing capabilities to stay ahead of imitators (lead time advantages) or by preventing knowledge spillovers (secrecy).

Zooming in on the research subject, the results of this study are compared to findings in previous research. This way, differences or similarities can be identified which can provide additional depth or ideas for future research. This is done in the same order as the discussion of the results.

Institutional environment

The findings about the institutional environment are in line with previous research (Lanjouw & Schankerman, 2001; Cohen et al., 2002; James et al., 2013). One could argue that the fact that most of the firms in this study only used formal mechanisms in countries where the efficacy of legal instruments is high could be purely coincidental. However, companies indicated they did take this into consideration when choosing to employ formal mechanisms or not, acknowledging that the weaker the protection, the less likely companies are to employ formal mechanisms as a value capture strategy (James et al., 2013).

Industry

This thesis found that when it comes to industry factors, competitive intensity played an important role. A distinction between competitors and capable competitors was also made in literature, the latter kind having great R&D skills and being innovative (Hill, 1992). However, in our study, this distinction was hard to notice; when companies in our sample would list competitors, they would only consider companies on a similar level of capability. Altogether, imitation in the industry is hard due to high levels of technical complexity of the innovations and in other cases the costs of reverse engineering being too high to prove profitable. It is possible that this pertains to the high-tech sector specifically, contrary to general findings.

Firm

Considering firm characteristics, it is reasoned in literature that the more innovative a company is, the more IP it generates and the more it can resolve litigations by engaging in cross-licensing (Lanjouw & Schankerman, 2004; Aggarwal & Hsu, 2009). Therefore, such companies are more inclined to use formal mechanisms. This thesis found that in general, the innovativeness of companies gradually decreases the further upstream you go in the supply chain. So, although the reasoning in literature is true, it needs to be expanded by including also the notion that the nature of the NPD process has an inherent preference for firms performing the earlier stages to be more innovative.

When it comes to the ability to manage IP processes and experience, literature says that firms with more IP can better identify infringement (James et al., 2013; Somaya et al., 2007). This sounds very logical but is extremely hard to test in practice. Not finding any infringers for a company with little experience in IP, does not mean that this firm is bad in finding infringers, it could also mean there simply is no infringement. Regarding this experience in the light of secrecy, this study's results add a small contribution to spillover prevention. Managers feel there is a boundary to the effectiveness of measures to prevent spillovers. This goes beyond the simplistic notion that secrecy is managed either well or not (Mansfield, 1985).

Firm size has effects on appropriability consistent with previous work on a few aspects. Smaller firms did patent less than larger firms in this research. Reasons they gave included being less experienced with IP and fear of losing litigations to large companies with more resources, in line with previous research (James et al., 2013; Somaya et al., 2007). The Netherlands Patent Office, however, has seen multiple cases though where small companies were doing great in litigations versus large firms by using new or creative approaches. Although technically these cases were not part of the study, I have a strong feeling that the current perceptions in research on this are somewhat outdated. At the very least this area deserves more investigation. Findings of firm size related to secrecy were in line with current knowledge; secrecy is relatively easy and low-cost for small firms and therefore attractive (Lanjouw & Schankerman, 2004).

Technology

Some unexpected differences between the results in this thesis and that in previous research could be observed. First of all, in the results of this study, there was a clear distribution between process and product innovations across the supply chain. This is contrary to earlier research where this would be attributed to being firm or technology dependent (Langlois, 2001).

Surprisingly, technology being highly complex did not have as big as an effect on the selection between formal and informal mechanisms as expected. Previous research claims that highly complex products have more patentable elements and because of this, patenting (and other formal IPRs) is less suited than for lower complexity products. Although two companies did claim they would rather file for patents with broad technical applications than with niche applications, there was no indication this was a strong prerequisite. An obvious limitation is that all companies in the sample were high-tech and there was no comparison with other companies, in that regard this finding is somewhat subjective.

Supply chain

Besides those already described, there were no large differences between previous research and this study. Trends happening in this research field were clearly also seen in practice; OEMs outsource more to suppliers and suppliers are expanding their new product development activities (Schraven, 2015; KPMG, 2015). An issue that was not mentioned in the literature used was the capability gap between OEMs and their suppliers. Some extra depth was provided in this study as to the causes of this misalignment; mismanagement of expectations and for CMs specifically: open-cost pricing.

Patents

An observation that really stuck out was that companies used patents mainly defensively. Companies in this study did not use the leveraging strategy, unlike a big OEM like Philips does. There may be several causes for this. First of all, most of the technology these firms use may be too specific for other firms or market to hold value (Somaya, 2012). In such cases, proprietary patents seem useless (Lippman & Rumelt, 2003; Rumelt, 1984). Also, there would be little interest from companies to buy licenses (Reitzig et al., 2007). Another possible explanation is that these companies are highly technology-driven and as a result simply conduct their business by focusing their resources on developing a superior product and not so much on utilizing patents for any other reason than to provide the minimum amount of protection needed. This conscious decision is not described in literature. Finally, there was an indication that for some firms, technology simply moved too fast to stay relevant in the long term. This varies across industries, according to Cohen et al., (2000).

Other IPR

Since the use of trademarks is not that well researched in literature, it is hard to put the marginal use of trademarks in the results of this study into a broader context.

Complementary assets:

Whereas complementary assets in traditional research are often regarded in terms of business capabilities or departments (Teece, 1986), complementary assets in this study pertained mostly to a specialization in certain technological capabilities. This is a difference between this study and previous work (Hurmelinna et al., 2007; Stuart, 2001), but it is a feature that defines the high-tech sector and therefore may not be that relevant in other sectors.

Informal: secrecy & lead time advantages

The antecedents and omnipresence of secrecy fit well with findings of current research (Arundel, 2001; Winter, 2000). Secrecy is relatively easy and inexpensive to implement and it is also the first mechanism to resort to before a decision is made on choosing for a different appropriability mechanism. The findings on technology leadership and the impact of fast development cycles to stay ahead of competition are also in line with literature (Lieberman & Montgomery, 1998). The slight emphasis for companies to choose these informal mechanisms is in line with comparative research closest to the high-tech industry; mid-tech industry (Agostini et al., 2015).

7.2 Managerial implications

In this paragraph, based on the results, managerial implications are presented. These are discussed per stakeholder as indicated by the title.

7.2.1 Companies in general

Appropriation mechanisms - selection

First of all, the study suggests that in the selection of suitable appropriation mechanisms in order to capture value from IP, managers should look at the contextual conditions that apply to their specific situation. There are several influential factors. First of all, their company archetype, or more specifically what stages of the NPD process the company performs. Codified knowledge seems to be prevalent early in the NPD process and process knowledge mainly at the late stages. This is a big differentiator between informal and formal strategies. Second, if companies choose a formal strategy, they should first evaluate if the institutional environment is one of a strong efficacy of legal instruments. If not, then formal strategies hold little value in those countries. Third, companies considering a lead time advantage should carefully evaluate if they have sufficient innovative capacity and development speed to stay a technology leader in the long term. Fourth, all companies can leverage complementary assets to capture even more value. These are different for every company, but the most prevalent type in the Dutch high-tech sector is a specialized technical capability which competitors do not have access to. Lastly, managers should not forget to consider multiple mechanisms used simultaneously.

Appropriation mechanisms – points of attention

First of all, companies in the sample that use patents mainly use them defensively. Companies are advised to carefully reevaluate their patent portfolio and see if there is any lost potential by skipping the leveraging or proprietary strategies. For example, companies owning patents could license out one or more to companies in non-competing markets or patents protecting technology they no longer use. A similar thing can be said for the use of trademarks as a business tool.

Second, companies are advised to reevaluate their precautions taken when it comes to secrecy; most companies have taken perfectly fine physical measures (restricted databases, locations, etc.) but forget to take steps in specifying or defining what information they want to protect.

Third, companies are advised to carefully evaluate what complementary assets are within their reach. Many companies seem to over-focus on technical capabilities.

7.2.2 Small companies

For many small companies, their IP strategy is not scrutinized. IP seems to be a somewhat subconscious topic. Small companies are advised to, at the very least, make an effort to take a critical look at what IP they generate and how this is or can be utilized. Ideally, this is evaluated periodically. The seemingly inactive stance on IP can be partially blamed on inexperience with IP. It does not take many resources to attain basic level knowledge or experience on the topic of IP though.

Small companies are relatively more frightened to apply for a patent than large companies because they fear they cannot win litigations or pay for going to court. There are other ways to settle and create a win-win situation. For example, instead of resorting to litigation when company A found out company B was producing its patented products, company A bought company B's production equipment inexpensively. This way, company B was able to invest the money in a different product, and company A took over the clientele of company B for that product. Involving the media often leads to great results as well when dealing with unreasonable companies. There are more of such methods. Small companies are advised to look into this.

Furthermore, unlike formal mechanisms, costs of informal mechanisms seem to be proportional to firm size. This means that small firms can engage in secrecy, or go for lead time advantages at relatively low investments.

7.2.3 Contract manufacturers – late stage NPD

Out of the three company archetypes, CMs deal with almost exclusively process technology, which means knowledge is often tacit and resides within people. CMs are therefore advised to consider informal mechanisms in particular. They are also advised to continue to expand their capabilities from production towards engineering. As one company already does, making an integral module to be sold to not one but multiple clients instead, allows it to practice new capabilities. At the same time, this provides an exit from the open-cost pricing as they can sell a product that is their own and does not need a justification of costs made towards other companies.

7.2.4 Engineering agencies – middle stage NPD

The engineering agency archetype deals predominantly with products and to a lesser degree, processes. This means they could use any appropriability mechanism that fits the contextual conditions. As OEMs increase their outsourcing, engineering agencies can expect greater responsibilities in future projects. However, OEMs will want their partners to be reliable and risk-free. So, engineering agencies are advised to continue to develop their capabilities, but also their independency. As many already do, spending non-contracted time developing their own products (modules) is a valid strategy for that.

7.2.5 OEMS – early stage NPD

OEMs, in general, have sufficient knowledge of IP, treat it on a strategic level and in general know how to deal with IP well. There are a few points of attention for OEMs however.

First of all, OEMs expect their suppliers to take on a greater responsibility when it comes to NPD and the technical capabilities. This is reasonable, however, OEMs seem to underestimate the time and resources this change needs on the suppliers' side. OEMs need to setup greater incentives for their suppliers to support them in making this transition. Meanwhile, there is a need for more realistic expectation management on both sides.

Second, OEMs claim to give licenses to engineering agencies when they design for the OEMs. If they are granted they often hold little to no value as they often cannot be used effectively since the license is too restricted market wise or the technology is too specific to be used for different applications. This makes it hard for suppliers to build their own IP portfolio and ultimately hinders them in becoming independent and more capable partners. After all, OEMs select their suppliers on the basis of their capabilities and technologies. Allowing more leniency with the restrictions on licenses or helping these firms find more valuable uses for them will help bridge the capability gap.

Third, OEMs claim to support (small) suppliers with their questions about IP. This is not something that was heard from the suppliers. If this is a genuine policy, it needs to be promoted more.

7.2.6 The Netherlands Patent Office

The Netherlands Patent Office can expect relatively more IP to be generated from non-OEM type companies as a consequence of the outsourcing trends of the OEMs and increasing productization by those suppliers. Overall it is expected that patent applications will still grow over the years.
From the discussion and results so far, the following is a list of challenges companies face where The Netherlands Patent Office can help with its education services:

1. Average knowledge and awareness level of IP is low (for small firms especially)
2. Administrative measures concerning secrecy need improvement
3. Non-basic strategies or uses of patents, trademarks and other IPRs are largely unknown
4. Licensing or ownership of IP in partnerships needs to be more effective and beneficial for both parties

Before considering how these issues could be tackled, one should first look at the current educative activities. These primarily consist of consultations and conducting workshops. Additionally, there are flyers and other informative documents available on the website. The consultations are one-hour meetings between an advisor from The Netherlands Patent Office and company employees or private individuals. The workshops are held by these advisors several times a month and are catered to small groups of people from various companies. Subjects of these conversations and workshops range from basic topics such as 'what type of IP right is suited to what situation' to more advanced topics such as 'how do I apply for a patent' or 'how do I search effectively in patent databases'.

Suggestions on how The Netherlands Patent Office can adjust its activities to address the four issues above follow below.

1: Average knowledge and awareness level of IP is low (for small firms especially)

Both the consultations and the workshops are inbound work; requests to participate are made on the companies' or individuals' behalf. So, currently, companies that are aware they need help on IP related matters come to seek advice and those that are not aware but could still benefit from it, do not come. Although the advisors are sometimes invited to speak at seminars or other large meetings, their time is consumed mostly by consultations. Therefore it is safe to say that there is still a large group of companies that are not being reached right now. Making a shift towards doing more outbound work instead of inbound work will contribute to solving the first problem.

Shifting towards a more outbound work approach could be done by contacting umbrella organizations (trade associations, supply chain organizations, etc.) and asking them for the advisor to speak at seminars or other type of meetings. Alternatively, they could be contacted to sound out about the knowledge level of their members or other IP related issues and contact those companies that need help. These could then be invited to workshops or lectures, on a larger scale, catered to their needs. To free up time for this, companies that scheduled consultations with a similar subject would be referred to these lectures or workshops instead. This means the consultations would be reserved for companies or individuals with very specific questions and less so about general or trivial IP issues. Another option to free up time is to shorten the consultation sessions, but to do this it boils down to the same; companies need only come to these consultations well prepared. To distinguish between companies that can be referred to a workshop or lecture and companies that actually need a consultation, prospects can be asked a few simple questions regarding their reason for a consultation and their current level of knowledge.

2: Administrative measures concerning secrecy needs improvement

Many companies are still not aware that secrecy is not just a preventive measure, but also enjoys some degree of legal protection if this information was gained by a competitor using improper means. This basically boils down to companies having to prove in court that they have taken reasonable precautions to keep this information secret. Many companies do invest in physical measures such as restricting building access, database access and so on. However, companies often forget or do not realize, to perform certain administrative actions, which serve as proof in litigations. One example is that secret information needs to be marked as confidential specifically (e.g. saving it on a secure hard drive does not imply all the information pertains to trade secrets). Another is identifying who has access to what trade secrets and putting this on paper.

The Netherlands Patent Office has no workshop on how to organize secrecy. Instead, it has recently created a leaflet on doing this, addressing the aforementioned issues. Since secrecy is used more than any other mechanism, for the high-tech sector at least, it is advised to also emphasize how to improve secrecy in those workshops and consultations where the subject plays a role. Actively promoting the leaflet in those cases will also contribute.

3: Non-basic strategies or uses of patents, trademarks and other IPRs are largely unknown

The Netherlands Patent Office teaches most companies on the traditional ways to use patents and approaches these as if there is mainly a need to protect information. However, patent and patent data can be used for many more purposes than just protection. Even though many companies still use patents the traditional way (defensively) and The Netherlands Patent Office is right in directing most of its attention to this, there will also be companies who could benefit from different approaches on how to use a patent or patent data. For example, there is no guide on how to chart a patent landscape. Another example is that there is little attention to encouraging companies to patent technology to license out, or find licensees for 'old' technology the company no longer uses, the so-called 'Rembrandt in the attic - syndrome'. Information on these other uses does not need to be extensive; it is about creating awareness of using IP on a more strategic level. Companies who get interested in certain uses will set out to find more information on this themselves.

The simplest solution to create such awareness is by making a leaflet about it and using it during certain workshops and consultations. The leaflet would mention the mechanisms, briefly list the various ways it can be used and possibly contain a reference for more information. This does not go just for patents, it also goes for other IPRs such as trademarks and industrial design rights. Of course, the non-formal value capture mechanisms cannot be omitted either. The mechanisms listed in the framework of figure 2 or 7 could be a starting point for such a leaflet.

4: Licensing or ownership of IP in partnerships needs to be more effective and beneficial for both parties

The Netherlands Patent Office offers a workshop on how to deal with IP when working together with one or more companies. It offers practical guidelines for organizing such cooperations when it comes to sharing information, ownership of IPRs, what to put in contracts and so on. When it comes to the distribution of newly created IP, companies generally tend to get ownership of the part that is closest to their core technology. So when both companies work on different aspects of a product, this distribution offers little problems. As an example, take the Senseo coffee machine; Philips claimed the part of new IP pertaining to the machine, and Douwe Egberts got the part pertaining to the coffee pads. In reality, this was a little more complex, but it is a clear example of how such a division can be relatively easy to make whilst still being beneficial to both. It gets harder when both companies have similar competences and technologies, or when one company is hired to design something for another company. Both companies would want to claim similar IP. The first option is to have joint ownership of the IP. However, from the interviews it became clear that companies, in general, are opposed to this because having 'a boat with two captains' causes issues. When that option is out the window, it comes down to the bargaining power of the parties involved. Large companies generally have a greater bargaining power than small companies, and this is not something a workshop or lecture can improve. However, something that can be done, is to educate companies on the long-term effects of such decisions.

From the results and discussion in chapter 5 and 7, it follows that to increase capabilities of engineering agencies and CMs in order to close the capability gap with OEMs, it would help if they would be able to build an IP portfolio around their technology. Currently, OEMs claim most of that IP in such cooperations. So the challenge is to educate both OEMs and other companies on that issue. Since it is mostly SME's that come to seek help from The Netherlands Patent Office and not so much the larger companies such as many OEMs, The Netherlands Patent Office would need to actively reach out to those larger companies. This could be done efficiently by reaching out to umbrella organizations, similar to the solution of the first challenge. By making such efforts, general awareness and knowledge on mutually beneficial IP ownership decisions can spread.

7.3 Limitations

First of all, this study is limited in the amount of data gathered, therefore others are invited to repeat a similar study and validate the results. Triangulation was used wherever possible but secondary data was merely limited to firm size, the amount of patents and trademarks owned by companies and finally, secondary data from literature. Although this poses some pressure on construct validity, the information provided by interviewees could still be compared to those of others within the same stratification criterion.

This study is also limited by the research setting. This research only pertains to Dutch high-tech companies. It would be interesting to see how these concepts vary across different types of industries or across different nations. Furthermore, although the sample was very diverse on all other criteria, there were no small OEMs in the sample of our research. Gathering data from small OEMs could provide additional insights and increase external validity.

There were a limited number of managers we spoke to. Although all were high-level managers, there was some variety in their professional background. Some had a background in IP, others in a technical field, some in business. It was great to see this variety of perspectives, but at the same time, this allowed some conversation to go a bit deeper about a specific topic than the other. Likewise, some managers could not give answers to certain questions. That is why for several propositions, not enough data was available.

A more important limitation related to the respondents is that these managers represented an entire company, which means the data may be vulnerable to some degree of response bias. Future research may therefore need to talk to multiple managers of the same company to have possibly more reliable data. Nevertheless in the interviews precautions were taken to obtain the most objective data possible. For example, by ensuring the data would be treated confidentially respondents were not limited to withholding information. Secondly, the fluidity of a semi-structured interview did not force the interviewee to pause and store valuable thoughts as can happen in fully structured interviews.

Finally, since the theoretical direction of this research was new; a cross-over between appropriability and supply chains, there may be contingencies or other concepts that play a role in this field which were missed. However, the literature research covered a great width of topics across both fields. And ultimately, it is the nature of science to come up with better theories if the possibility arises.

7.4 Future research

This thesis investigated how companies in the Dutch high-tech sector utilize their IP to capture value from their innovations. It contributes to the knowledge in the field of strategic management by providing mainly qualitative insights on the research topics. Qualitative insights are lacking on these topics and are needed in order to explain quantitative findings by providing in-depth insights. Future research that is qualitative in nature will prove to be useful.

Regarding the research position, this study incorporated elements from both the resource-based view as well as the knowledge-based view. Elements of both fit surprisingly well together. A holistic approach could aid in accelerating the field forward to a less fragmented and more unified state.

Considering concepts and topics, the following recommendations can be made.

The first and most obvious recommendation for future research is to repeat this study as a means of validation. As a study that zoomed in on a particular supply chain, this study managed to identify several firm archetypes. This provided practical relevance and it is something that I would highly recommend for future studies. Perhaps these archetypes can be unbundled in more refined ones and companies can start to benchmark their practice to that of other firms of the same type. Going one step further, it would be great if a blueprint could be created that shows such firm types how they could best spend their resources when deciding how to capture the most value from their IP.

This study incorporated many different characteristics to try and unravel which would be relevant for the Dutch high-tech sector. One could zoom in on those factors that proved most important in this study and provide more depth in future research. Alternatively, one could zoom in on those factors for which was not enough data in this research; the factors in the unconfirmed propositions.

Lastly, it would be very interesting to see research like this study superposed on a different geographical or industrial setting. This way, scholars could compare findings across countries or businesses, spot the differences and come up with practically relevant improvements.

Appendices

Appendix A: propositions list

Complementary assets

P1: The more tacit the nature of knowledge of an innovation, and the better the efficacy of legal instruments is, the stronger is the appropriability regime and vice versa.

P2: The stronger the appropriability regime, the less reliant a company needs to be on its (co-) specialized complementary assets to profit from innovations and vice versa.

Institutional environment

P3: the weaker the institutional environment, the more competitors tend to infringe upon an innovator's patents and the higher the innovator's associated costs (identification & litigation)

P4: the weaker the institutional environment, the less an innovator is inclined to employ formal appropriation mechanisms and the more he's inclined to employ informal appropriation mechanisms

Industry

P5: the higher the competitive intensity within an industry, the higher the incentive for competitors to imitate the focal firm's innovation. An industry with a high competitive intensity is characterized by; (a) a low industry concentration, (b) high exit barriers, (c) low entry barriers, (d) low product demand and where (e) the product is a commodity

P6: the higher a competitor's R&D skills, the more capable it is and the quicker it can imitate the focal firm's innovation.

P7: the higher the technological complexity of an innovation, the less competitors are able to successfully exploit an imitated innovation in the marketplace

P8: the higher the organizational complexity of an innovation, the less competitors are able to successfully exploit an imitated innovation in the marketplace

Firm (general)

P9: the larger the scale & scope of a firm's R&D activities, the higher the (relative) value it can capture with, and the more it is inclined to employ formal appropriation mechanisms

P10: the more experienced a firm is at managing its intellectual property, the higher the (relative) value it can capture with, and the more it is inclined to employ formal appropriation mechanisms

P11: the stricter a firm is in preventing unintended knowledge spillovers (maintaining secrecy), the more likely it is to protect its innovation from imitation

P12: the stricter a firm is in preventing unintended knowledge spillover (maintaining secrecy), the more likely it inhibits future innovation

P13: the larger the firm, the higher the (relative) value it can capture with, and the more it is inclined to employ formal appropriation mechanisms

P14: the smaller the firm, the higher the propensity to pursue secrecy as the dominant appropriability mechanism

Firm (lead time advantages)

P15: the higher a firm's degree of technological leadership, the ability to preempt scarce assets and buyer switching costs, the larger the propensity for firms to pursue lead time advantages as the dominant appropriability mechanism

P16: the higher a firm's absorptive capacity, the less negative spillover effects and the higher the benefits of pursuing lead time advantages

Technology

P17: the more tacit the nature of knowledge or the less codified it is, the less suited formal appropriation mechanisms are and the more informal mechanisms are

P18: the more codified the nature of knowledge is, the less the benefits of pursuing lead time advantages

P19: the more complex a technology, the smaller the propensity for firms to pursue formal appropriation strategies as the dominant appropriability mechanism

P20: the more complex a technology, the larger the propensity for firms to pursue secrecy as the dominant appropriability mechanism

P21: for process innovations secrecy is more effective than product innovations

P22: the more critical assets a firm has, the higher the benefits of pursuing lead time advantages

Supply chain

P23: the earlier a firm's involvement in NPD activities, the more likely it is to generate IP

P24: the earlier a supplier is integrated into a firm's new product development process, the more technological uncertainty can be mitigated

P25: the earlier a supplier is integrated into a firm's new product development process, the higher the risks of supplier lock-in

P26: OEMS increasingly outsource development activities in NPD processes to suppliers; supplier integration in the NPD process is increasingly early

P27: suppliers generate increasingly more IP as their development activities are increasingly early in the NPD process

Appendix B: institutional environment strength

Park-index score

The Ginarte-Park index is an index of patent rights that was developed for 110 countries for 1960–1990, broken down into 5 years intervals (Ginarte & Park, 1997). It is the unweighted sum of five separate scores for: coverage (inventions that are patentable); membership in international treaties; duration of protection; enforcement mechanisms; and restrictions (for example, compulsory licensing in the event that a patented invention is not sufficiently exploited) (Ginarte & Park, 1997). The index was designed to provide an indicator of the strength of patent protection, not the quality of patent systems. The Ginarte-Park index, however, is out of date. Park (2008) therefore updated the index to 2005 and however still about 10 yours out of date, it is now the most recent version of the index. This version also included more countries (such as China and the East European countries). These were originally excluded because laws protecting industrial property were either non-existent or based on a different system, such as inventor certificates (Park, 2008).

Several observations from the updated index are noteworthy and may be relevant for the thesis. First, one can see that the Netherlands scores consistently very high, as most of the western countries do. Second, the United States have the highest score overall. Third, large upcoming economies such as that of China and India have shown to greatly improve their scores over the course of 10 years which indicates a growing importance of the patent system in their country. On the other hand, the other two BRIC-countries, Russia and Brasil have mediocre scores that did not seem to improve over the last 5 years of the index. The scores of this index can be found in tables A & B. Note that this index only pertains to patents and no other forms of intellectual property.

Global competitiveness index

The World Economic Forum's Global Competitiveness Index ranks countries' (economic) competitiveness on the basis of 12 pillars which consist of several indicators each (World Economic Forum, 2015). Many of these indicators are derived from an executive survey and can therefore be seen as a user review. In three of the 12 pillars, intellectual property plays a role. In the first pillar 'institutions' and in the last pillar 'innovation', executives are asked how well in their country intellectual property is protected. This can therefore be seen as a measure of the quality of protection. In the eleventh pillar called 'business sophistication', there is also a score for the amount of patents filed through the PCT procedure. Although this also pertains to intellectual property, it does not tell us about the quality of protection, because the amount of patents filed through the PCT procedure is largely dependent on the geographic location of the market.

When looking at the scores (which range from 1 to 7), one can observe the following. First, western countries score high, with Finland topping the chart (6.3), the Netherlands occupying place 8 (6.0) and the United States taking place 15 (5.8). China has a mediocre score of 4 and the other BRIC countries have a mediocre or low score as well (Brazil 3.7; Russia 3.0; India 4.2).

The World Economic Forum highlights the macroeconomic importance of having proper intellectual property protection by paraphrasing from De Soto (1990); no nation can have a strong market economy without adequate participation in a framework that enforces legal ownership of property and records economic activity, because they are the prerequisites to obtaining credit, selling properties, and seeking legal remedies to conflicts in court.

World Intellectual Property Indicators

James et al. (2013) also mention the World Intellectual Property Indicators report as a measure of intellectual property protection. However, this merely includes a tally of the number of intellectual property applications in various countries. More precisely, it shows how many patents, trademarks, industrial designs, and plant varieties were applied for. Based on this report, it is hard to determine how strong intellectual property protection is within these countries because many factors are at play. First of all, these countries differ greatly in population, in prices for the application and finally, people will file applications only in countries where they deem protection necessary, or in other words, where their market or competition is located. Nevertheless, a logical assumption is that people only file for intellectual property in those countries where they regard the protection as adequate. This means that countries with many applications most likely also offer good protection.

Important observations are that the patent & trademark applications are still growing fast yearly, however the industrial design applications have declined since 2013 (World Intellectual Property Organization, 2015). China is the biggest driver of these trends and counts the most patent & trademark applications. Europe, the US and South Korea also recorded strong growth of patent applications. Japan and India saw a strong growth of the amount of trademark applications, followed by the US. The Netherlands has a prominent place at number 9 for patent applications and 18 for trademarks.

Table 1 (*Continued*)

	Average 1960–1990[b]	1995	2000	2005
United States	4.14	4.88	4.88	4.88
Uruguay	1.54	2.07	3.27	3.39
Venezuela	0.92	2.82	3.32	3.32
Vietnam	1.38	2.90	2.90	3.03
Zaire (Dem Rep Congo)	1.49	1.58	1.78	2.23
Zambia	1.54	1.62	1.74	1.94
Zimbabwe	1.61	2.28	2.60	2.60
Mean	1.80	2.58	3.05	3.34
Standard deviation	0.80	1.09	1.00	0.89
Coefficient of variation	0.45	0.42	0.33	0.27
Skewness	0.09	0.14	-0.07	-0.43

Table B: Park index scores U-S continued

Index of patent rights 1960–2005[a]

	Average 1960–1990[b]	1995	2000	2005
Algeria	2.74	2.74	3.07	3.07
Angola	0.00	0.88	1.08	1.20
Argentina	1.60	2.73	3.98	3.98
Australia	2.35	4.17	4.17	4.17
Austria	2.96	4.21	4.33	4.33
Bangladesh	1.34	1.87	1.87	1.87
Belgium	3.39	4.54	4.67	4.67
Benin	1.64	1.78	2.10	2.93
Bolivia	1.38	2.37	3.43	3.43
Botswana	1.59	2.08	3.32	3.52
Brazil	1.22	1.48	3.59	3.59
Bulgaria	1.83	3.23	4.42	4.54
Burkina Faso	1.62	1.98	2.10	2.93
Burma (Myanmar)	0.00	0.20	0.20	0.20
Burundi	1.98	2.15	2.15	2.15
Cameroon	1.74	2.10	2.23	3.06
Canada	3.00	4.34	4.67	4.67
Central African Republic	1.74	1.98	2.10	2.93
Chad	1.61	1.78	2.10	2.93
Chile	2.04	3.91	4.28	4.28
China	1.33	2.12	3.09	4.08
Colombia	1.05	2.74	3.59	3.72
Congo	1.74	1.90	2.23	3.06
Costa Rica	1.07	1.56	2.89	2.89
Cyprus	2.52	2.78	3.48	3.48
Czech Republic		2.96	3.21	4.33
Denmark	2.88	4.54	4.67	4.67
Dominican Republic	2.12	2.32	2.45	2.82
Ecuador	1.16	2.04	3.73	3.73
Egypt	1.41	1.73	1.86	2.77
El Salvador	1.71	3.23	3.36	3.48
Ethiopia	0.00	0.00	2.00	2.13
Fiji	2.20	2.20	2.40	2.40
Finland	2.64	4.42	4.54	4.67
France	3.29	4.54	4.67	4.67
Gabon	1.74	2.10	2.23	3.06
Germany	3.24	4.17	4.50	4.50
Ghana	1.47	2.83	3.15	3.35
Greece	2.40	3.47	3.97	4.30
Grenada	1.67	1.76	2.48	3.02
Guatemala	0.77	1.08	1.28	3.15
Guyana	0.82	1.13	1.33	1.78
Haiti	2.58	2.58	2.90	2.90
Honduras	1.25	1.90	2.86	2.98
Hong Kong	2.44	2.90	3.81	3.81
Hungary	2.20	4.04	4.04	4.50
Iceland	1.67	2.68	3.38	3.51
India	1.03	1.23	2.27	3.76
Indonesia	0.00	1.56	2.47	2.77
Iran	1.91	1.91	1.91	1.91
Iraq	1.95	2.12	2.12	1.78
Ireland	2.15	4.14	4.67	4.67
Israel	2.76	3.14	4.13	4.13
Italy	3.16	4.33	4.67	4.67
Ivory coast	1.64	1.90	2.36	3.06
Jamaica	2.66	2.86	3.06	3.36
Japan	2.93	4.42	4.67	4.67

Table 1 (*Continued*)

	Average 1960–1990[b]	1995	2000	2005
Jordan	0.66	1.08	3.03	3.43
Kenya	1.55	2.43	2.88	3.22
Korea (South)	2.55	3.89	4.13	4.33
Liberia	1.78	2.11	2.11	2.11
Lithuania		2.69	3.48	4.00
Luxembourg	2.16	3.89	4.14	4.14
Madagascar	1.05	1.85	2.31	2.31
Malawi	1.35	2.03	2.15	2.15
Malaysia	1.70	2.70	3.03	3.48
Mali	1.78	1.98	2.10	2.93
Malta	1.34	1.60	3.18	3.48
Mauritania	1.70	1.98	2.43	3.27
Mauritius	1.62	1.93	1.93	2.57
Mexico	1.19	3.14	3.68	3.88
Morocco	1.58	1.78	3.06	3.52
Mozambique	0.00	0.00	1.06	2.52
Nepal	1.79	1.79	1.79	2.19
Netherlands	3.43	4.54	4.67	4.67
New Zealand	2.67	4.01	4.01	4.01
Nicaragua	0.92	1.12	2.16	2.97
Niger	1.64	1.78	2.10	2.93
Nigeria	2.50	2.86	2.86	3.18
Norway	2.75	3.88	4.00	4.17
Pakistan	1.09	1.38	2.20	2.40
Panama	1.34	1.46	3.64	3.64
Papua New Guinea	0.00	0.00	1.40	1.60
Paraguay	1.13	1.53	2.39	2.89
Peru	0.59	2.73	3.32	3.32
Philippines	2.19	2.56	3.98	4.18
Poland	1.38	3.46	3.92	4.21
Portugal	1.48	3.35	4.01	4.38
Romania	1.50	3.52	3.72	4.17
Russian Federation		3.48	3.68	3.68
Rwanda	1.94	1.95	2.28	2.28
Saudi Arabia	1.83	1.83	1.83	2.98
Senegal	1.70	1.98	2.10	2.93
Sierra Leone	2.38	2.45	2.98	2.98
Singapore	1.64	3.88	4.01	4.21
Slovak Republic		2.96	2.76	4.21
Somalia	2.00	2.00	2.13	2.13
South Africa	2.94	3.39	4.25	4.25
Spain	2.74	4.21	4.33	4.33
Sri Lanka	2.27	2.98	3.11	3.11
Sudan	2.61	2.61	2.61	2.61
Swaziland	1.36	1.98	2.43	2.43
Sweden	2.86	4.42	4.54	4.54
Switzerland	3.04	4.21	4.33	4.33
Syria	1.68	1.87	1.99	2.19
Taiwan	1.26	3.17	3.29	3.74
Tanzania	1.84	2.32	2.64	2.64
Thailand	0.95	2.41	2.53	2.66
Togo	1.60	1.98	2.10	2.93
Trinidad and Tobago	1.78	2.33	3.63	3.75
Tunisia	1.45	1.65	2.32	3.25
Turkey	1.16	2.65	4.01	4.01
Uganda	1.77	2.85	2.98	2.98
Ukraine		3.68	3.68	3.68
United Kingdom	3.20	4.54	4.54	4.54

Table A: Park index scores A-U

Appendix C: appropriability effectiveness scores

In figures C and D, effectiveness scores for various appropriability mechanisms are listed per industry, from Cohen et al. (2000).

TABLE 1

Effectiveness of Appropriability Mechanisms for Product Innovations:
Mean Percentage of Product Innovations for which Mechanism Considered Effective[1]

Industry	N	Secrecy	Patents	Other Legal	Lead Time	Complementary Sales/Svc	Complementary Mfg.
		Mean percentage of innovations					
1500:Food	89	58.54	18.26	21.18	53.37	39.83	51.18
1700:Textiles	23	63.70	20.00	25.87	58.26	55.22	58.26
2100:Paper	31	55.00	36.94	26.45	47.10	40.00	39.84
2200:Printing/Publishing	12	32.50	12.08	21.67	48.33	66.25	60.42
2320:Petroleum	15	62.00	33.33	6.33	48.67	40.33	35.67
2400:Chemicals, nec	65	52.77	37.46	21.62	48.62	44.92	41.31
2411:Basic Chemicals	35	48.00	38.86	11.57	38.29	45.86	44.71
2413:Plastic Resins	27	55.93	32.96	18.15	38.33	44.63	46.11
2423:Drugs	49	53.57	50.20	20.82	50.10	33.37	49.39
2429:Miscellaneous Chemicals	29	70.69	39.66	25.52	55.52	55.17	48.97
2500:Rubber/Plastic	35	56.86	32.71	10.14	40.86	34.29	37.71
2600:Mineral Products	18	46.11	21.11	12.22	39.72	37.78	40.00
2610:Glass	6	46.67	30.83	11.67	50.00	62.50	70.00
2695:Concrete, Cement, Lime	10	45.00	30.00	17.50	38.00	45.50	40.00
2700:Metal, nec	6	65.83	20.00	5.00	50.83	58.33	61.67
2710:Steel	10	37.00	22.00	11.50	61.50	34.50	42.00
2800:Metal Products	44	43.07	39.43	18.18	48.18	37.05	40.11
2910:General Purpose Machinery, nec	74	49.19	38.78	20.88	52.23	41.15	43.65
2920:Special Purpose Machinery, nec	64	45.08	48.83	23.05	59.69	46.33	51.09
2922:Machine Tools	10	61.50	36.00	9.00	61.00	43.00	34.50
3010:Computers	25	44.20	41.00	27.20	61.40	40.20	38.00
3100:Electrical Equipment	22	39.09	34.55	15.00	33.41	32.27	31.82
3110:Motor/Generator	22	50.91	25.23	19.09	48.86	47.27	45.23
3210:Electronic Components	26	34.04	21.35	20.19	45.58	50.00	51.15
3211:Semiconductors and Related Equipment	18	60.00	26.67	22.50	53.33	42.22	47.50
3220:Communications Equipment	34	47.21	25.74	20.15	65.59	42.06	41.18
3230:TV/Radio	8	50.00	38.75	35.63	53.75	24.38	38.75
3311:Medical Equipment	67	50.97	54.70	29.03	58.06	52.31	49.25
3312:Precision Instruments	35	47.29	25.86	20.86	54.14	49.57	45.57
3314:Search/Navigational Equipment	38	48.95	28.68	24.08	46.84	32.89	40.53
3410:Car/Truck	9	42.22	38.89	19.44	65.56	41.67	42.22
3430:Autoparts	30	50.83	44.35	15.65	64.35	44.84	53.06
3530:Aerospace	48	55.10	32.92	16.15	58.02	34.58	46.88
3600:Other Manufacturing	84	49.29	33.81	26.61	63.51	42.56	45.30
ALL	1118	51.00	34.83	20.71	52.76	42.74	45.61
	(s.e.)	(0.96)	(0.94)	(0.73)	(0.92)	(0.91)	(0.88)

[1] Response categories were: less than 10%, 10-40%, 41-60%, 61-90%, and greater than 90%. Means were computed using category midpoints.

Figure C: Appropriability mechanisms for product innovations. (Cohen et al., 2000)

TABLE 2

Effectiveness of Appropriability Mechanisms for Process Innovations:
Mean Percentage of Process Innovations for which Mechanism Considered Effective[1]

Industry	N	Secrecy	Patents	Other Legal	Lead Time	Complementary Sales/Svc	Complementary Mfg.
		Mean percentage of innovation					
1500:Food	89	55.84	16.40	15.00	41.91	29.78	46.52
1700:Textiles	23	60.65	25.22	24.35	48.70	44.35	53.91
2100:Paper	31	58.87	27.58	19.35	34.52	20.65	34.03
2200:Printing/Publishing	11	20.45	8.64	10.91	33.64	50.91	63.64
2320:Petroleum	15	57.33	36.67	6.33	32.00	27.67	31.33
2400:Chemicals, nec	63	53.65	20.40	12.86	27.14	28.41	42.30
2411:Basic Chemicals	35	58.43	29.71	11.71	25.71	26.71	40.14
2413:Plastic Resins	27	62.96	21.30	7.22	23.70	25.19	34.26
2423:Drugs	48	68.13	36.15	16.04	35.52	25.21	44.17
2429:Miscellaneous Chemicals	28	76.25	27.32	15.71	33.93	40.36	54.46
2500:Rubber/Plastic	35	59.14	19.86	11.43	35.86	23.00	37.43
2600:Mineral Products	18	48.89	23.33	11.11	28.61	27.50	46.94
2610:Glass	6	58.33	30.83	18.33	31.67	42.50	50.00
2695:Concrete, Cement, Lime	10	54.00	18.50	15.50	26.50	31.50	33.50
2700:Metal, nec	6	65.83	31.67	12.50	66.67	46.67	50.00
2710:Steel	10	41.00	15.50	11.50	42.00	25.00	42.00
2800:Metal Products	42	46.19	22.50	15.36	39.05	35.36	47.38
2910:General Purpose Machinery, nec	69	37.54	23.62	16.30	34.86	28.33	40.00
2920:Special Purpose Machinery, nec	63	41.83	28.57	16.03	44.92	35.48	41.27
2922:Machine Tools	10	48.00	18.00	9.50	43.00	34.00	39.00
3010:Computers	20	42.50	30.25	16.75	39.75	23.50	35.50
3100:Electrical Equipment	22	31.59	19.09	6.82	19.09	11.82	18.86
3110:Motor/Generator	21	42.62	22.14	17.86	44.52	31.67	39.29
3210:Electronic Components	26	46.54	15.19	15.00	42.69	42.31	55.77
3211:Semiconductors and Related Equipment	18	57.50	23.33	8.33	47.78	32.22	42.50
3220:Communications Equipment	33	35.30	14.70	13.94	43.03	33.64	40.61
3230:TV/Radio	8	47.50	18.75	18.75	38.75	32.50	46.88
3311:Medical Equipment	66	49.24	34.02	22.27	45.15	32.12	49.55
3312:Precision Instruments	31	43.55	16.77	15.81	35.48	32.74	40.81
3314:Search/Navigational Equipment	37	43.65	13.24	16.35	39.05	31.89	42.97
3410:Car/Truck	9	34.44	21.67	17.22	34.44	26.67	41.11
3430:Autoparts	31	56.45	24.35	15.16	50.16	36.94	55.97
3530:Aerospace	47	49.26	21.38	13.30	42.23	28.40	44.89
3600:Other Manufacturing	79	51.65	23.42	20.76	44.56	31.39	38.29
ALL	1087	50.59	23.30	15.39	38.43	30.73	43.00
	(s.e.)	(1.03)	(0.83)	(0.63)	(0.96)	(0.88)	(0.95)

[1] Response categories were: less than 10%, 10-40%, 41-60%, 61-90%, and greater than 90%. Means were computed using category midpoints.

Figure D: Appropriability mechanisms for process innovations. (Cohen et al., 2000)

Appendix D: research methodology steps

Table C shows the methodology for qualitative research and marks the steps performed in this thesis.

		Steps	Performed in this study:
1	Determining:	Research goal and research question(s)	✓
2		Necessary information and search method	✓
3		Type of research	✓
4		Research design	✓
5		Scope of the research	✓
6		Data collection criteria; themes, propositions, reliability & validity	✓
7	Performing data collection:	Literature review	✓
8		Interviews	✓
9		Observations	✗
10	Synthesis:	Data preparation	✓
11		Data analysis	✓
12		Reporting	✓

Table C: Steps in research methodology. Adapted from: Baarde, De Goede & Teunissen (2005)

Appendix E: literature search

The goal of a search plan is to determine criteria to ensure relevance of the information. This was done by making a selection of search constructs, databases and limiting the results by several factors such as journal impact factors, the authority of authors and the age of the results.

The online database Web of Science was used to find literature. This is a database containing a vast amount of literature on exact as well as social sciences. Furthermore, it is easy to perform filtering, navigate to forward or backward cited articles and lastly provides a good overview of journal scores.

It was decided not to limit the initial search query for dates of publication, in order to identify the most important articles by sorting them by the amount of citations. The abstracts of the top 10 to 20 results for each search query were read and a selection was then made to thoroughly read these articles. By doing so, basic knowledge was gained of the concepts and themes in the literature that were relevant and irrelevant to our research. This helped shape next, more specific search queries. Before long, several key articles and authors were identified. This allowed the snowballing method to take effect, reading cited literature tracking back and forward. The resulting list of literature comprised of articles mainly from journals with a high impact factor, for example, listed in ABS's Academic Journal Quality Guide (2010). To make sure that this did not exclude state of the art knowledge, we did not exclude literature from articles in journals that did not have a high impact factor if they were sufficiently recent (<5 years old).

Appendix F: interview protocol

This document was used during the interviews and presents the structure of the interview, a topic list, general questions and sample questions to support the topic list. Lastly, the hand-out that was provided to the interviewees is also included.

The structure briefly mentions the (administrative) steps to conduct the interview. The topic list was used to make sure every topic was discussed. The general questions were always asked. The list of sample questions was there to support the interviewer. Obviously, follow-up questions (how/what/why) were asked during the interview but are not listed there. Usually the interview started on topic A2 (see topic list) to subsequently move down to topics B, C, D and E. However, the interviews allowed for flexibility (hence semi-structured interviews).

Structure of the interview

1. Introduction (self – colleague – research – interview setup – clarifying anonymity – asking permission for recording)
2. Giving the handout with information
3. Start of the interview (and the recording)
4. Wrap-up (stop recording – summarizing the follow-up procedures – exchange of contact information – thanking the interviewee)
5. Follow-up (sending of transcript / thesis or adjustments)

Topic (check)list:

A Exogenous conditions:
A1 Institutional Environment
A2 Industry
A3 Firm
A4 Technology

B Appropriability Mechanisms
B1 Patents
B2 Secrecy
B3 Trademarks / Other
B4 Lead time
B5 Complementary Assets

C Outcomes:
C1 Intermediate / Ultimate

D Relations & supply chain
D1 Open innovation
D2 Supplier involvement / NPD process

E IP effectiveness / expertise
E1 Effectiveness of IP
E2 Level of IP expertise
E3 Supporting organizations
E4 Government / The Netherlands Patent Office

General questions:

1. What is your position (/ job)?

2. How many employees does your company have? How many at this location?

3. Can you tell me what industries the company is involved in?

4. How would you classify your company type?

5. Would you classify your company as an OEM, supplier, engineering agency or perhaps something else?

6. What kind of activities does your company perform in the development of both your own or your customer's innovations? (R&D - Design & Engineering - Prototyping & Industrialization - Component production - System integration - Sales & Service - Other)

(7.) Is your company a tier 1, 2 or 3 supplier?

8. Are your customers mainly OEMs or suppliers or other companies?

9. Can you name a few customers (companies) and suppliers?

Sample questions (topic list):

A1: Institutional environment
In what countries or regions do you hold your IP rights?

Are you able to enforce or defend your IP in those regions?

Is the judicial/legislative system effective there?

Does your IP hold value in those regions?

Has this changed over time? (present, future)

A2: Industry:
Can you describe the dynamics in your industry? (Clients, products, suppliers)

How is the competition in your industry? (Scale, intensity, form, geography)

Do new companies often enter the market? Do companies often cease to exist in your industry?

How would you say you compete with your competitors? If you stay ahead of your competitors, how do you do this?

How do you differentiate your products from your competitors?

What is the degree of specialization technologically in regards to your competitors?

Do you work together with other companies? (Whom, company type, what parts, how)

How do you organize your partnerships/relations/cooperations with these other parties?

A3 Firm:
How innovative is your company? (Examples/manifestation, form, self-rating)

How often do you introduce new innovations or products to the market/customers? Would you say this is fast / slow (in relation to competitors/partners)?

Does your company perform R&D activities? (Budget, % revenue, partners)

Do you value your firm size as a strength? (Which, obstacles)

How well do you find your company able to transform new knowledge/technology into new innovations? (organizational complexity)

A4 Technology
Is there a dominant technology for your innovations in the marketplace/industry?

Does the technology change a lot over time? (Dominant design, frequency, effects, 'tech race')

What is the degree of complexity of the technology in your products?

How much do your products rely on technology or knowledge from other parties in the industry?

Is the knowledge pertaining to your innovations easily transferable? Where does this knowledge originate / where is it 'stored'? (tacit/codified, people/documents)

Does your company specialize itself technologically or is it a broad integrator of technologies?

What kind of technology does your company deal with? (Which, strength)

B: IP Introduction
How does your company gain knowledge for the development of your products?

How important is this knowledge the company?

How is this knowledge utilized?

How much of this knowledge is captured in intellectual property?

Is IP treated consciously / strategically in your company?

What kind of IP does your company own?

B1 Patents
Does your company have patents? (why, why not, geography, amount, technology, product type)

To what extent can you enforce or defend your patents? (institutional environment, reverse-engineering)

Do you have enough expertise regarding application procedures, litigations, etc.?

Do you have enough resources to enforce, file and manage your portfolio?

How essential are those patents? (importance)

How are these patents used strategically? What are the intended goals / advantages?

Do you use public patent databases as a source of information?

Do you use patents to generate rents from licensing?

Do you use patents to ensure freedom to operate?

Do you own any technology that is patented that you consider critical to current innovations or innovation development?

B2 Secrecy

Does the company use secrecy?

How is secrecy organized within your company and in cooperation with different companies?

How effective/essential is this to your company/innovations?

What measures did you take to ensure secrecy?

Does secrecy hinder learning or cooperation in your company?

Did knowledge ever leak out? How did you get to know this?

Does your company ever disclose information intentionally to block competitors from patenting?

B3 Trademarks/ other

Does the company have other IP rights? Which?

What is their use? Is the use of a certain IP right linked to certain uses / technologies?

What is the goal of owning each type of IP right? (business tool, etc.)

Which kind of IP rights are most valuable to your company?

Did you ever consider other IP rights? (list)

B4 Lead time advantage

Does your company try to stay ahead of your competitors technology wise? (reason, advantages)

Is your company a follower or a leader? What are its effects?

Does your company try to imitate products or technologies or do you try to develop these yourselves?

What are the most important factors in trying to stay ahead of your competitors?

How hard is it to stay ahead of your competitors? What are the difficulties and how do you tackle these?

Does your company own unique technological capabilities? Are they transferable?

Is there any uncertainty beforehand about what technology or products will be successful in the market? (investment / lock-in risk)

How fast is new technology (typically) developed in your market?

B5 Complementary assets

Does your company possess any assets which you consider to be critical to the success of your innovations? Are these related to technology or technological capabilities/skills?

Do you excel in certain business-related areas (e.g. marketing, service, customer integration)?

How important do you consider these complementary assets?

Are there any such assets the company does not possess but could really use? Are there any plans to attain them? How are they attained?

C1 Intermediate / Ultimate

Why do you own [IP rights]? Why do you employ [mechnanism]?

What kind of advantage do you want to achieve by using the above?

Why is that important to your company?

Do you consider entering new markets by using that IP?

Do you want to increase current market share by using that IP?

Do you want to stay ahead of your competitors technologically?

D1 Open innovation:

Do you cooperate with partners within the supply chain?

In what areas do you cooperate in the supply chain?

Is there any cooperation with competitors?

When developing a new product or innovation, how is knowledge exchange organized in these cooperations? What kind of knowledge is exchanged and how is it transferred?

Is there any knowledge that is kept proprietary?

Is new IP generated in development projects? Is this formalized? How is the ownership decided?

Are there any problems in any of the above? What role does IP play in this?

D2 Supplier involvement / NPD process

What kind of activities do you perform in new product development?

What kind of activities does your client / supplier perform in new product development?

(Suppliers) Do you develop any own products for yourself and sell them to your clients? Or are you often hired (project-basis) for development?

Is there any shift in any of the above?

How committed are you to your clients/suppliers? Is this long or short-term?

Are there any problems in any of the above? What are its causes? Is this related to IP?

E1 Effectiveness

How big a role does IP play in your company? (present, future)

Do you consider your knowledge to be protected or utilized sufficiently well

Have you ever noticed that your technology/knowledge was used by competitors?

Are your innovations imitated?

Do you feel that clients or suppliers treat your knowledge or IP confidentially? What are the consequences if this is not the case?

E2 Expertise

Who is responsible for the IP policy/strategy in your company?

Does your company have sufficient knowledge about IP in your company? Do your employees have sufficient knowledge?

Would a greater knowledge about IP and related topics be advantageous to your company?

How and where do you find extra expertise on IP if you need this?

Do you offer or receive assistance from partners (in-/outside of supply chain)?

E3 Supporting organizations

Are you a member of any supporting/branch organizations or do you cooperate with such organizations? (E.g. Brainport Industries, HighTechNL, HTSM roadmap, BOM, etc.)

Is there support or help available within these organizations in regards to IP strategy/procedures? (which, degree, future)

E4 Government / The Netherlands Patent Office

Is there support from the government available on IP?

Are you familiar with The Netherlands Patent Office? Do you know they also provide workshops and other information related to IP to help companies?

What should the role of the government be in supporting innovation (IP specific)?

How / where do you think NL Patent Office can best target or reach companies to provide their services?

Hand-Out

Research title

Capturing value from intellectual property in the Dutch high-tech supply chain

Introduction

You are invited to participate in this study. Your participation is greatly appreciated and I would like to ask your permission to use the results of this interview. Before giving permission I would like to inform you what your participation entails.

Purpose and background of the research

To ensure the continuation of a company, intellectual property (IP) plays a major role. Knowledge of intellectual property can be used to gain competitive advantages. To maintain such an advantage, it is important that a company protects its intellectual property (appropriability). In addition to protecting intellectual property, the company can use it in a way that creates value (value capture). The purpose of this study is to identify related strategies used by Dutch companies in the high-tech industry, the largest 'top sector' in The Netherlands. Certain factors or conditions involved may also be taken into account in the selection of those strategies. The results of this study can lead to important insights because;
i) they can identify possible strengths or weaknesses in the IP policy of businesses or government.
ii) The Netherlands Patent Office can improve her educational activities to fit the need of the industry accordingly. The Netherlands Patent Office is the government body responsible for carrying out the patenting policies in the Netherlands and also has an advisory role regarding intellectual property in order to strengthen Dutch companies.

The research is part of my thesis for the Master of Innovation Management at Eindhoven University of Technology.

What does the research mean for you?

An interview is conducted that will last about 60 to 90 minutes. Based on a number of concepts I will ask you some questions about your business. There are no right or wrong answers, but of course you are asked to answer these questions truthfully.

During the interview, an audio recording is made. This is so the interview can be transcribed. Also, I might take notes. After the recordings are transcribed, the audio file and the notes are destroyed. The transcript is sent to you so you can check it for accuracy.

Confidentiality

Your information will be treated confidentially. The data will be anonymized so they are not traceable to you personally, to your company, or to any parts thereof. Furthermore I and my mentors at The Netherlands Patent Office and the TU/e are bound to secrecy.

Voluntary participation

You allow or disallow free participation in this study. Even if you give permission, you can withdraw from the study at any time.

Documents

As mentioned earlier you will receive a transcript of the recording so you can check it for accuracy. Also, I will send you a draft of my thesis. This will probably happen in late February. If you find a mistake and something is traceable to you or your company, please indicate this and I can adjust it in the final version, which is published in the library of the University of Technology Eindhoven. If I have not received your commentary after two weeks, I assume that the document is approved by you.

More information

If you have questions about the interview, please address them to Jeroen Musch (researcher), at [phone number] or [email-address]. Observations and comments or tips are greatly appreciated as well.

Appendix G: coding scheme

The coding scheme in table D is the initial one based on literature alone. The labels are arranged hierarchically based on topics. A maximum of 5 levels is used. This means that for instance, a level 4 label represents a feature or an aspect of a level 3 label. The deepest level of hierarchy is used as an actual label in the interview. The labels could then be sorted later on in the results based on a specific topic. Labels that did not fit a topic directly or those that would fit multiple topics were labeled under the level 1 label of 'Other'.

Hierarchy Level				
1	**2**	**3**	**4**	**5**
Contextual conditions		Firm	Size	
			Organizational complexity	
			Knowledge spillover prevention	
			Technology leadership	
			Absorptive capacity	
			R&D	Scale / Scope
				Experience / Capability
		Industry	Competitive intensity	Industry concentration
				Exit barriers
				Entry barriers
				Product demand
				Commodity (degree)
			Competitor R&D	Experience / Capability
				Intensity
	Appropriability Regime	Institutional Environment	Efficacy of legal instruments	
		Technology	Tacit / Codified	
			Complexity	
			Product	
			Process	

Appropriability mechanisms	Formal	Patents	Defensive
			Proprietary
			Leveraging
		Trademarks	
		Design rights	
		Other	
	Informal	Lead time advantages	Critical Assets
			Buyer switching costs
		Secrecy	
		Complementary assets	Generic
			Specialized
			Co-specialized

Outcomes (performance)	Intermediate	Market entry
		Incentive to innovate
		Extent of knowledge spillover
	Ultimate	Competitive advantage
		Economic performance
		Profits

Supply chain	NPD process	Stages	Idea Generation
			Feasibility Assessment
			Concept Development
			Engineering / Design
			Prototyping / Testing / Ramp-up
			Production
			Servicing
		Supplier integration	White Box
			Gray Box
			Black Box
			Build-to-print

			Build-to-print plus
			Build-to-spec/req
			Build-to-roadmap
	Company roles	OEM	
		ODM	
		OMM	
		CM	
		EA	

Other	Imitation	Success
		Intensity
	Litigation	Costs
		Intensity
	Knowledge spillover	

Table D: coding scheme

Appendix H: proposition outcomes

The propositions as defined in chapter 2 were revisited in chapter 5. This resulted in a number of confirmed, refuted and unconfirmed propositions as listed below. A letter in front of the proposition denotes whether the proposition was confirmed (c), refuted (r) or unconfirmed (u). Refuted propositions are found to be not true. Unconfirmed means there was no or not enough data in our study to confirm or refute it.

Complementary assets:

(c) P1: The more tacit the nature of knowledge of an innovation, and the better the efficacy of legal instruments is, the stronger is the appropriability regime and vice versa.

(c) P2: The stronger the appropriability regime, the less reliant a company needs to be on its (co-) specialized complementary assets to profit from innovations and vice versa.

Institutional environment:

(c) P3: the weaker the institutional environment, the more competitors tend to infringe upon an innovator's patents and the higher the innovator's associated costs (identification & litigation)

(c) P4: the weaker the institutional environment, the less an innovator is inclined to employ formal appropriation mechanisms and the more he's inclined to employ informal appropriation mechanisms

Industry:

(c) P5: the higher the competitive intensity within an industry, the higher the incentive for competitors to imitate the focal firm's innovation. An industry with a high competitive intensity is characterized by; (a) a low industry concentration, (b) high exit barriers, (c) low entry barriers, (d) low product demand and where (e) the product is a commodity

(r) P6: the higher a competitor's R&D skills, the more capable it is and the quicker it can imitate the focal firm's innovation.

(c) P7: the higher the technological complexity of an innovation, the less competitors are able to successfully exploit an imitated innovation in the marketplace

(u) P8: the higher the organizational complexity of an innovation, the less competitors are able to successfully exploit an imitated innovation in the marketplace

Firm (general):

(c) P9: the larger the scale & scope of a firm's R&D activities, the higher the (relative) value it can capture with, and the more it is inclined to employ formal appropriation mechanisms

(c) P10: the more experienced a firm is at managing its intellectual property, the higher the (relative) value it can capture with, and the more it is inclined to employ formal appropriation mechanisms

(c) P11: the stricter a firm is in preventing unintended knowledge spillovers (maintaining secrecy), the more likely it is to protect its innovation from imitation

**Note: the relative effectiveness of protection decreases gradually with strictness*

(u) P12: the stricter a firm is in preventing unintended knowledge spillover (maintaining secrecy), the more likely it inhibits future innovation

(u) P13: the larger the firm, the higher the (relative) value it can capture with, and the more it is inclined to employ formal appropriation mechanisms

(c) P14: the smaller the firm, the higher the propensity to pursue secrecy as the dominant appropriability mechanism

Firm (lead time advantages):

(c/u) P15: the higher a firm's degree of technological leadership, the ability to preempt scarce assets and buyer switching costs, the larger the propensity for firms to pursue lead time advantages as the dominant appropriability mechanism

**Note: true for technological leadership, not enough data for buyer switching costs and preemption of scarce assets*

(u) P16: the higher a firm's absorptive capacity, the less negative spillover effects and the higher the benefits of pursuing lead time advantages

Technology:

(c) P17: the more tacit the nature of knowledge or the less codified it is, the less suited formal appropriation mechanisms are and the more informal mechanisms are

(u) P18: the more codified the nature of knowledge is, the less the benefits of pursuing lead time advantages

(u) P19: the more complex a technology, the smaller the propensity for firms to pursue formal appropriation strategies as the dominant appropriability mechanism

**Note: there was no comparison with low- or mid-tech companies/technologies*

(u) P20: the more complex a technology, the larger the propensity for firms to pursue secrecy as the dominant appropriability mechanism

**Note: there was no comparison with low- or mid-tech companies/technologies*

(c) P21: for process innovations secrecy is more effective than product innovations

(u) P22: the more critical assets a firm has, the higher the benefits of pursuing lead time advantages

Supply chain:

(c) P23: the earlier a firm's involvement in NPD activities, the more likely it is to generate IP

(c) P24: the earlier a supplier is integrated into a firm's new product development process, the more technological uncertainty can be mitigated

(c) P25: the earlier a supplier is integrated into a firm's new product development process, the higher the risks of supplier lock-in

(c) P26: OEMS increasingly outsource development activities in NPD processes to suppliers; supplier integration in the NPD process is increasingly early

(c) P27: suppliers generate increasingly more IP as their development activities are increasingly early in the NPD process

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