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Investigating the adoption factors of new technologies: A case study of a milling innovation

Master's thesis in Management and Economics of Innovation

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SUMMARY

This paper aims to investigate how different factors can affect the adoption of new technology. Based on existing literature and previous research a framework for the adoption of technological innovations has been set up. The framework includes external, internal, and technological factors that might impact an adopter's decision when considering new technologies. Specifically, the considered factors are society, external institutions and market for the external part; internal institutions and risk, and path-dependency and resources & capabilities for the internal part; and ecosystem fit, relative advantage, maturity, and complementary services for the technological part of the factors.

The study focuses on a new milling technology and, through a qualitative study, investigates five cases in which this technology is being considered for adoption. Each case is focused on a different industry and revolves around a company that is operative in the respective industry. Data was collected through semi-structured interviews with (potential) adopters and the producer of the new technology. The adopters consider society and relative advantage as the most important factors and although these were positive in each adoption case, they affect the adoption decision in different ways. Relative advantage acts as a gatekeeper to the remaining factors and the society factor is an underlying force that pushes the adopter in a certain direction. In situations where adopters are explorative, the maturity of technology does not seem to have a large effect and they are more willing to take on risk. Several adoption factors cannot be viewed independently from the others when looking at how they affect the adoption decision. In the end, it is the sum of all factors that will ultimately decide the outcome of the adoption decision.
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Keywords: adoption, innovation, technology, factors

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1. Introduction

1.1 Background

The industrial mill is a century-old idea that has practically changed very little since its origination. Contrary to the old days, where a rope-attached donkey is powering the mill by walking in circles around it, nowadays the milling is done automatically. However, the basic concept of milling solid materials by grinding, crushing, or cutting has not changed. Presently, the two main drawbacks to the prevalent milling design are that it is an energy-intensive process that breaks materials apart and undesirably tends to break cell structures and material properties as well. A small Swedish company has, however, managed to overcome these problems through the development of a next-generation mill that is more sustainable and does not interfere with primary material features, from here on out referred to as “Technology X”.

An often returning topic that impacts both of these groups is sustainability. Sustainability is an important selling point for Technology X, as the required energy per litre of output is uncontestably low. Additionally, the capabilities of Technology X allow customers to go down new paths of sustainability with their products that haven’t been wandered before.
The quest for sustainability plays a large role in Swedish society and in the ecosystem of companies and ventures that go about their daily business. Economic and environmental sustainability gets strongly pushed from governmental levels (i.e. in education) and are hot topics that are included in companies’ codes of conduct and ethical policies (Olsson, 2018). While businesses try to meet the standards and requirements set by the government, they keep trying to improve their sustainability to seem more attractive to potential customers and suppliers. An increase in sustainability is often combined with technologies that are used in-house and environmentally friendly and therefore innovative ideas are commonly included in development efforts and (external) adoptions.

Technology X’s mill can be regarded as a novel technology that its developers are trying to get diffused in industries where separation and/or milling of material is important. These are industries such as whole foods, coffee, or the mining industry; industries that rely on breaking apart materials without damaging cell structures (e.g. protein extraction, grinding of coffee beans, etc.). A testimonial from an anonymous mining industry expert on the new milling technology: “I worked in the mining industry for a long time where traditional milling processes continue to limit production output. This new milling system will revolutionize all industries that require the liberation of materials into their parts. Nothing like this - at all - has ever come along until NOW”.

Each industry contains many companies that are in some way contributing to the economic landscape of the industry that it is situated in. The consensus among Technology X’s leadership is that such companies could be interested in using the new milling technology and start the new era of next-generation milling. From an adopter company’s perspective, the superiority in the performance of the new technology is a compelling reason to adopt, but there are many factors and conditions that either argue in favour or against adopting this technology (Parente & Prescott, 1994). Superior performance, though, is not necessarily the deciding factor in technology adoption. A famous example of this is the decision of choosing a keyboard layout. “QWERTY”, which had a 20-40% lower typing speed than the later introduced “DSK” layout used by Apple, came out as the preferred choice (David, 1985) and is still the most applied layout on most keyboards to this day. Several factors and conditions, apart from performance, play a vital role in the potential adoption of any new technology. A new milling technology with superior performance may therefore remain unadopted and an understanding of different factors is needed to support adoption.

Previous research has done extensive work on understanding developments on and the interplay between macro, meso, and micro levels of technology adoption, such as Bergek et al. (2018), Geels (2002; 2004), Schot & Geels (2008), Parente & Prescott (1994) and Hannan & McDowell, (1984). Also, technological adoption from the company’s point of view has been covered in various research (e.g. and Rogers (2003)). The goal of this research is to build upon previous publications and further narrow down how various factors influence the decision of adopting new technologies on the company level. Additionally, the research should be usable by technology developers to better understand what their clients (i.e. adopters) go through when presented with the choice of adopting new technology. Connections to and further developments on previous research will be made to shift the perspective from societal/industrial adoption factors to company-specific adoption factors, bridging the gap between both groups.

Additionally, a novel perspective will be offered to developers of new technologies to identify how their potential clients (i.e. adopting companies) are affected by and take into consideration various factors of adopting technology. Thus, hopefully, a contribution will be made to more successful launches of new technologies and the development of technology that uses society's resources more efficiently.

1.2 Aim and problem discussion

Adopting new technology is risky for the adopter because many unknowns (performance, maintenance, service level, etc.) come with the adoption and create uncertainty. Adopters deal with these uncertainties by setting criteria for themselves that new technologies have to fulfil to be adopted. Developers of new technology, in turn, are affected by adoption factors as well (Yu & Tao, 2009) and they cannot control every factor to fully satisfy an adopter.

The aim of this research is therefore to investigate how adoption factors affect an individual company's decision for adopting a milling innovation to better understand how new technology could be adopted in general. A framework that elaborates the interplay between adoption factors and that can be broadly applied to other companies that are in the position to adopt new technologies will be presented to further work towards uncovering adoption conditions for companies. Developers of new technologies could use this framework to understand what is being considered by companies when exploring the adoption possibilities of their technology.

Additionally, adoption factors do not solely affect the adoption decision, but one another as well. Also, a combination of factors will affect a decision in a different way than a single factor will do. The interplay of factors shows how factors are related, how they affect the adoption decision, and what connections can be drawn.

Based on this, the following research questions have been formulated:

How do different factors affect an adopter's decision on adopting a new milling technology?

How do these factors interplay with each other?

1.3 Limitations

The research is limited to companies/businesses/people that have already thought about adopting Technology X. They should have come in contact with the idea already and are not completely new to it. We will not be going deeply into the milling industry itself, but the focus will be more on different industries that are receptive to the outcome of the milling process; not the milling process itself. Examples of such industries are the tyre industry, manufacturing industry, recycling industry, and hemp industry. While many industries could fall inside the scope, we are specifically looking at companies within these industries that have an application for milling technology.

1.4 Disposition

This thesis report will have a structure that is similar to other scientific research reports and allows a clear flow of information from introduction to conclusion. The *introduction* has served to introduce the topic and related matters to the reader and offer a first look into the research. Following the introduction will be the *theoretical framework*, where relevant academic research regarding external, internal, and technological adoption factors are presented and discussed. Next, the *methodology* is presented and offers a thorough description of the chosen research process and strategy. In the fourth chapter, the *empirical findings* from the qualitative interviews will be discussed and interpreted and the subsequent *analysis* section will look at similarities and differences, adoption factors in detail, and technological questions. Finally, the *conclusion* will finalise the thesis as the research questions will be answered and some managerial implications will be offered. See Figure 1 for a process flow of the disposition.

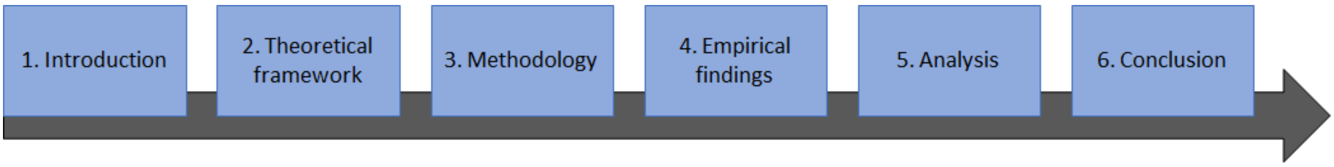

***Figure 1**: Thesis disposition*

2. Theoretical framework

The theory chapter is divided into three separate sections of factors that influence an adopter's decision on adopting new technology. The investigated literature covers the areas of transition theory, strategic management, and innovation strategies. From this literature, it can be concluded that adoption decisions are in broad terms influenced by *external*, *internal*, and *technological* factors. Often, they are intertwined and factors appear in different parts of the theoretical framework in different contexts. We describe the nature of each factor and how it relates to other topics mentioned.

The distinctions are made as follows: external are the conditions that are set by the industry, society, and factors that come outside of the company, also known as system levels in other literature. The main areas from which the covered external conditions flow are society, external institutions, and markets. The internal conditions are set by the company and are factors that come within the company and can be specific for the particular company. The factors for the internal conditions that will be covered are internal institutions and risk and path-dependency and resource & capabilities. The technological conditions are defined as technology-specific factors, which might vary in different contexts. They can be put into both external and internal settings and bridge them through technological aspects. The technological factors that will be covered are ecosystem fit, relative advantage, maturity and complementary services. The factors will be presented from a broad-to-narrow perspective, starting with the large external environment, followed by the smaller firm's internal environment, and ending with technology-specific factors. See Figure 2 for an overview of the factors.

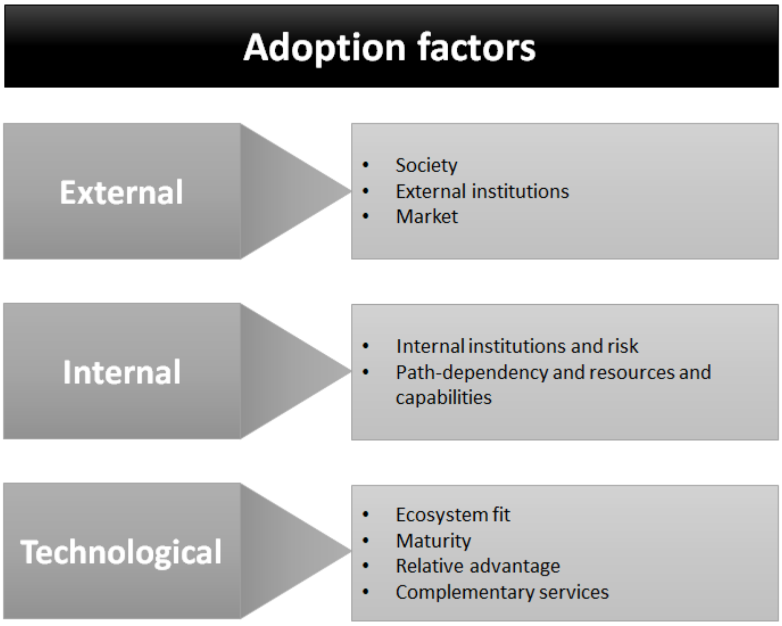

Figure 2*: Adoption factors*

2.1 External factors

External factors affect a company's operations and strategy from the outside. They flow from conditions set by the market, industry, and society. They provide a broader context from which a decision for adoption could emerge. External factors in this literature review are categorized as society, external institutions and market. These factors follow from the included articles that describe phenomena that fit inside one of these categories.

2.1.1 Society

The society factor has the potential to influence firms through culture and emerging trends. They generally do not have a direct effect on operations and competition but have an indirect impact through large-scale and slow changes in society. In literature, this is referred to as the landscape level (e.g. Rip & Kemp, 1998; Geels & Kemp, 2000; Geels, 2002), which is the largest - macro - level in the multi-level perspective.

The multi-level perspective (MLP) on technological transitions is a widely researched and applied framework that describes the nested hierarchy of three interdependent levels in a socio-technical system. The system is categorized in a macro, meso, and micro level, defining them as “landscape”, “regime”, and “niche” levels respectively. Rip & Kemp (1998) and Van den Ende & Kemp (1999) are among the earlier publications on this hierarchy in socio-technical systems, where they describe the interdependencies between the three levels. Geels & Kemp (2000) further develop this framework by describing technological transitions from a socio-technical perspective and Geels (2002) introduces the dynamic multi-level perspective on technological transitions. These sources define the macro-level, the landscape, as the collection of deep structural trends in society that define a set of heterogeneous factors. Examples of such structural trends range from low-impact to high-impact trends such as climate (change), war, financial paradigms, or fluctuations in oil prices (Geels & Schot, 2007). It draws on the explicit and implicit hardness of structures in systems in society, such as the structural properties of a building, but also society’s expectations of the nature of the said building. The landscape refers to technology-external factors and, while not impossible, it is hard to change and changes only slowly.

Landscapes are seen as something that we (society) can travel through and as something that we are part of (Rip & Kemp, 1998). They provide a mould that does not determine the nature of future actions but simply makes some actions easier to be carried out than others. Similar to a physical landscape of mountains and rivers, there are many theoretically possible ways through a landscape, but some are easier than others. Pressure from the landscape level comes in changes that are out of society’s hands or that gradually happen as a reaction to other developments. Landscape pressure can come from (1) solid environmental conditions that don’t change such as climate, (2) large and long-term changes such as the technology boom of the late 20th/early 21st century, or (3) rapid external shocks from other developments that affect important concepts of the landscape such as war (Geels & Schot, 2007). These pressures don’t directly act on lower levels (regimes and niches), but on actors in the system that perceive and translate them, which leads to their shockwaves to be eventually felt in the whole system. To summarise, landscape pressures go beyond surface pressures (e.g. pricing, competition, tax, etc.) and point to larger political, economic, and socio-cultural changes. They can differ in strength and tend to inflict change to lower levels (Smith et al., 2005).

2.1.2 External institutions

Underlying the landscape level is the technological regime on the meso level. The context of a technological regime is best described by Rip & Kemp (1998, p.340): “*A technological regime* *is the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems; all of them embedded in institutions and infrastructures*”. In the regime’s institutional environment, rules are made, set, and followed that steer every actor’s actions and decisions. Firms in a regime are bound by these rules and their adoption patterns are a consequence of them.

Transition literature uses regimes to describe socio-technical changes and while this paper does not necessarily look at socio-technical transitions, the MLP approach can however still be used to create an understanding of how higher-level influences and dynamics trickle down to the company level and set implicit conditions for the adoption of technology. A company that is part of a regime resides in the regime’s technological trajectory and profits of its stability created by the set rules. These rules are aimed at the “coordination and structuration of activities’’ and are part of external institutions (Geels, 2004). Bergek et al. (2018) refers to the rules in a regime as the external institutional environment and offers a broader conceptualization of regimes through the distinguishment of the institutional and task environment.

The external institutional environment has been acknowledged in previous research throughout the past three decades. This environment tends to put pressure on its actors, forcing them to follow similar paths in terms of actions, innovations, and methods (Teo et al., 2003; Geels, 2004; Bergek et al., 2018). The pressure on following existing paths deepens the paths in the regime, making other actors dependent on them as well. The path-dependency of such actors has a snowball effect on future decisions and actions in science, technology, and culture. Path-dependency is a phenomenon that exists due to the nature of external institutions and the rules that they set. Berkhout (2002) recognizes its existence and bundles various definitions of path dependency, which can be summarized in the following way: innovations are institutionally trapped by rules, expectations, and assumptions and their development takes place along the pathways that these set. Path-dependence gives stability to a system and new developments take place in small incremental steps (Geels, 2004). The thinking process of actors happens along such pathways as well. If incumbent actors are under the assumption that the solutions to certain problems can be found within the regime, they will keep their attention focused on existing technical trajectories and won’t be incentivized to invest in radical innovations (Dosi, 1982). Similarly, if they think that user preferences are satisfied, no change of product (e.g. to further increase user satisfaction) will take place (Christensen, 2013).

Paths are not just shaped by developments in a regime, but also by social and cultural pressures on the landscape level. If a certain agenda is pushed by society, a firm will be incentivized to follow this agenda to satisfy user and customer expectations. The shift to sustainable consumption and behaviour is a good example of affecting adopters. They are biased to select new technology that checks sustainable and environmental expectations and will be in harmony with goals set by them. Neo-institutional theory, NIT, suggests that many of a firm's actions are a reaction to social and cultural pressures from other organizations, thus being able to explain organizational behaviour that contrasts rational economic actions (Suddaby et al., 2013). The external institutional pressures that point organizations in the same direction are often viewed as irrational actions by firms that, against expectations, are not solely based on economic incentives.

NIT focuses on the effect of external institutional pressures on firms and uncovers that such firms often base decisions on legitimacy effects instead of performance effects, responding to the regimental construction of efficiency and effectiveness, instead of a rational construction of these. Specifically interesting in our case is if the new technology is compatible or incompatible with the social-cultural values and beliefs. Rogers (2003) brings up examples such as embeddedness in values and beliefs that hinder innovations. For example, American farmers place a strong value on increasing farm production rates. This has led to the slow adoption of innovative soil conservation methods because it limits production rates and is thus unpopular amongst farmers (Rogers, 2003).

2.1.3 Market

The market environment can be considered as a very specific subset of institutions and consists of the competitors, clients, customers, and suppliers of the focal firm. An institution, on the other hand, covers all rules, pressures, and actor relations in a regime. The market has a direct influence on a firm's (strategic) decisions and competitive picture. The market can accept or reject new technologies (Rogers, 2003), decide on the "fit" of innovation to the market environment (Holström & Stalder, 2001), impact technological trajectories of regimes (Geels

& Schot, 2007), which in their turn pressure individual firms, and provides the podium for actors to negotiate and emerge.

The market also can change external institutional rules, even though it is also impacted by those rules (Geels & Schot, 2007). Rules can either be indirectly changed by market preferences and product variations, or they can be directly changed where actors negotiate on rules in communities (Geels & Schot, 2007). The remainder of this section also looks at external institutions but investigates how these can be influenced/changed from the market's point of view. In the previous subsection, it was highlighted how external institutions affect actors and behaviour, while this section describes the changing of external institutions by these actors. It becomes clear that both parties can affect one another.

Organisational variety is the main driver of indirect rule changes and is defined by the selection environment of the firm. Users, customers, policy agents, etc. are part of the selection environment and their preferences and wishes drive a firm's investments, competencies, and strategic choices to make its products fit better to the users. Once a path towards strategic fit has been successfully created, it becomes an established method and becomes more dominant as other firms adopt similar practices. Thus, the market environment has successfully impacted the technological trajectory of a regime and its innovations (Geels & Schot, 2007). An adopter's perspective on innovations changes accordingly and provides an important factor for the decision.

New technologies that get introduced to the market level commonly occur in technological niches. Niches, on the micro-level, are small technological clusters that act as incubation rooms for new technologies. The development of new technologies happens either in the marketplace or in a protected area, where regular market conditions don't apply and the technology can slowly develop and adapt better to society's needs and views (Kemp et al., 2001). Protection is offered in ways of R&D programs, sponsoring, and lower external institutional influence. Niches provide a learning-by-doing experience because they demonstrate the viability of new technologies and set in motion new learning processes, which tends to lead to increased customer and actor support and gaining new financial support (Kemp et al., 2001). The new milling technology is a good example of niche technology that is gradually exposed to forces on the market.

To show the hardships of new technology adoptions, Christensen & Bower (1996) explain that current customers and markets guide the resource allocation of incumbent firms, which often leads to failure of investing in new radical innovations that are either unknown or missed by the market. Most radical innovations, however, were focused on niche segments and small markets which are of little importance to the balance sheet of big incumbent firms. The incumbent firms were guided to invest in current technology and incrementally improve it. Disruptive innovation theory discusses this phenomenon of incumbents vs. new entrants and their respective behaviours towards novel technologies.

2.2 Internal factors

This section will mostly focus on the conditions which arise from the company's perspective. Covering organisational behaviour towards change, path-dependency, and how current resources and capabilities affect companies choose to adopt.

2.2.1 Internal institutions and risk

Peng et al. (2009) introduce the institutional-based view, which, along with the resource-based and industry-based view, forms the three legs of strategic decision making by a firm. It has been brought forward to complement the resource-based and industry-based views in the aspect of bringing context to the decision. According to Peng et al. (2009), the institutions set the rules of the games in which companies are competing and it is vital to making good decisions leading to better performance. Informal rules consist of norms, ethics, and culture. If it is assumed that companies are rational, it becomes a potentially vital factor to understand how these internal conditions could affect strategic decisions to better understand the decision of adopting new technology. However, the concept of bounded rationality shows that humans do not always base decisions on reasoning, due to cognitive limitations, motivation, and being affected by emotions (Selten, 1990).

Culture can be defined in a myriad of ways and is not a phenomenon that is isolated to companies, but one can find it anywhere from a family, sports team, group of friends to a nation. Shani et al. (2009) bring forth a summary of different definitions and defines it as a system of values and beliefs that is shared by all or almost all members of a social group. In organisational culture literature, the focus is mainly put on leaders of an organisation and how to manage it (Willcoxson & Millett, 2000), but the definition of culture fits on different levels and could theoretically be on the national level, family level, or team level. Rogers (2003) describes that the factor compatibility is one of the important factors for an innovation to diffuse, compatibility in sense of the innovation to fit into the beliefs, values, and social systems. Hofstede (2001) focuses on a national level and distinguishes cultures based on different characteristics to better understand their behaviours. One characteristic that Hofstede uses is uncertainty avoidance. If someone has a high uncertainty avoidance, one likes to have predictable everyday life which often is filled with rules, norms, and no abrupt changes; opposite to low uncertainty avoidance. Uncertainty avoidance has then been used in different research as a measure of risk tolerance, which will be most relevant in adopting new technology. Thus, although the initial characteristics have aimed to be for a national level, we argue that at an organisational level it would still be applicable in the definition of culture, and the concept of risk tolerance, willingness to change could potentially be important to understand an adopter's decision. Locket & littler (1997) showed that risk-averse households were less likely to adopt direct banking. Early adopters coined by Rogers (2003) are more risk-tolerant. Further, Aurigemma & Mattson (2018) concluded that risk-aversion is affecting adoption. However, they also could conclude that risk is not perceived as homogenous. For example, customers perceive the risk of new technologies which are similar to old ones as lower. Rogers (2003) argued that the individual's characteristics affect the adoption and those individuals who are reluctant to change and generally sceptical to new ideas will lag adopting the innovation, and on the other side of the coin people who show a positive attitude towards new ideas and display leadership will naturally be more willing to adopt early. The perception of risk and the characteristics of the adopters to tolerate risk can be used to understand the adopters' decision. Further, the informal institutions and characteristics of the adopters and the behaviours that come with it, display the potential of being one of the main factors which affect the adoption decision.

2.2.2 Path-dependency and resources & capabilities

In a more organisational context on intangible operations, Sydow et al. (2009) describe that there are many different definitions of path-dependency and they are not very well explicitly stated. Sydow et al. (2009) define the core of the phenomena of self-reinforcing mechanisms that lead to organisational lock-in. Sydow et al. (2009) state that organisations, due to their social character, have more complex lock-ins, but they might not be as extreme. As previously mentioned, self-enforcing dynamics are all about bringing forth preferred actions, which then get deeply rooted in the organisation. A positive loopback that reinforces the behaviour, which ultimately leads to actions without actual explanations and answers, is achieved when questioning if "this is the way we always have done it". Intangible resources and capabilities are to be taken into account as potential factors hindering or pushing the adoption.

Arthur (1989) was one of the first to model path-dependency and did it in the context of competing technologies. He argued that increasing returns of economies of scale and learning curve would lead to technical lock-in effects, which would exclude new competing technology even if it is superior in some aspects. This will affect the current resources and capabilities an adopter has and the view of their future. One famous example is David (1985) who investigated the keyboard layout, "QWERTY", which hasn't changed till today, even though rivals have surfaced with better performance. David argued, like Arthur, that this was due to economies of scale, but also technical interrelatedness (fit into a system) and quasi-irreversibility of investments (investments specific to the technology). The latter two are related to company incentives of avoiding switching costs of changing from old to new technology. Technical interrelatedness in a system could be relevant in both external and internal views. Internally it is how it would fit with other internal processes and general resources and capabilities that the company possesses. The technological section covers a link and a broader perspective of fit into the ecosystem. The quasi-irreversibility of investments could be in knowledge, plants, or other processes which would make the incentives to change technology decrease, there are also the resources and capabilities which the company might lack which is necessary for the new technology. Further, Weiss et al. (1994) could, based on quantitative research with empirical data, conclude that a greater switching cost will reduce the probability of early adoption. Christensen (2013) explains, in his famous management book "The innovator's dilemma", that companies are locked into established processes and capabilities. The creative destruction that new radical technology can inflict lowers the incentives to invest and according to Schumpeter (1934) is why innovations mostly come from entrepreneurs, outside the current system. Thus, the current resources and capabilities that the company currently possesses matter in the decision and could be an important factor when studying the cases of the new milling technology.

2.3 Technological factors

The last group of factors focuses on the technology itself and its properties that could potentially influence an adopter’s decision.

2.3.1 Ecosystem fit

In contrast to the external and internal fit, which has been covered in the previous sections, this section is dedicated to the whole picture of the ecosystem in which the technology will be implemented. Although the technology might fit with external standards and internal processes, other aspects have to be concerned, such as the suppliers. The simple fact of the connection between internal-systems with the technology and external might not fit. The current fit into the ecosystem of integration of external and internal parts could potentially be one of the main factors in the study. The performance of the new technology is one of the most important features and plays a big role in societal acceptance of technology. However, performance is not the only and often not even the most important factor, so it does not draw the whole picture. While the standalone value of technology is the isolated technological value itself, it is not the entirety of value for a user. Pianura (2012) showed that the standalone value of new technology is limited to the systems and subsidies to complement the technology could prove to be pivotal in the adoption of technology. This is also the case when looking at the new entrants’ and incumbent firms’ performance when a new technology enters. Adner (2006) is in similar ways investigating innovations and focuses on the whole picture and not only on the internal levels. He proposes that adoption in the value-chain is also very important for an innovation to be successfully adopted, which is called the integration risk of innovation. He defines the integration risk of the innovation as the risk that occurs when actors in the value chain accept innovations and handle new output, input, or maintenance. The technology should fit the value chain and the integration risk for the innovation should be low for it to be successfully adopted (Adner, 2006). Further, Adner (2006) also proposes that there might be complementary innovations that have to succeed during the adoption stage, which is adding to the risks. Depending on which ecosystem the technology is being implemented in, the adoption conditions will vary and are important to take into consideration when either adopting or trying to get it to be adopted.

2.3.2 Maturity

Turnheim & Nykvist (2019) set up key conditions in their study to assess the feasibility of potential pathways of a transition in a sector. Factors to be assed are maturity and momentum of options. They argue that it is important to consider the readiness of the technology and commercial availability at a given time. In our case, this is applicable, and to draw upon what previously has been discussed about risk; a more mature technology will be less risky. The track record of the new technology can be used to examine if it has been delivered in a specific context. This may vary through the different cases and although the fundamental technology will remain, the contextual maturity may vary and it could potentially be the main factor to be considered.

2.3.3 Relative advantage

Although performance has been argued to not be the sole factor of adoption, it is still a factor that has to be considered. In this study, the same technology will be studied in different contexts and the standalone value of the increased performance in these will most likely differ. These different effects are the reason that current performance will be compared to the old performance of the technology. The risk-reward ratio will most likely differ in the context and was explained more in the internal conditions. Additionally, Rogers (2003) describes one factor that determines the diffusion of technology as a relative advantage. This is not solely the objective view of relative advantage, but it is whether an individual perceives innovation as advantageous. A company, however, has the obligation of explaining the actions to stakeholders. Actions will still be influenced to a large extent by subjectivity and the perceived reward could potentially be the main factor. Venkatesh et al. (2003) formulated a unified model based on eight previous models on determinants of technological adoption with empirical data. They found that the most important factor determining adoption is the performance expectancy a user believes it has.

2.3.4 Complementary services

In industries all over services are increasing and off-the-shelf products with no strings attached are becoming less general and more specific. Manyika et al. (2012) of McKinsey argue that the lines between services and products in manufacturing are blurring more and more and the mindset of separating them is outdated. The increase of smart products and integrated services has great potential to change industries fundamentally (Porter & Heppleman, 2013). The value does not only come from the new technology itself but the services around it as well. Grönroos & Svensson (2008) describe the provider to be a facilitator of value and not the creator. The customer is the creator of value; the value that they can create, enabled by the product/service, is important. Thus, the complementary services which the provider may offer can provide value in different forms. For example, operational services, data gathering and analysis, warranties, knowledge, and so on, which will increase the value for the customers in terms of risk diversity, operational efficiency, safety, etc. This factor is offered in combination with the new technology itself and could be an important factor for adopters when they decide to adopt.

2.4 Framework

The literature analysis on the topics of external, internal, and technological factors provides a list of factors and shows how these are connected. We propose that the connection between the three-factor "umbrellas" can be illustrated as seen in Figure 3. The adoption conditions that adopters sets for the adoption of new technology depend on several factors that together create the conditions in which technology is to be adopted.

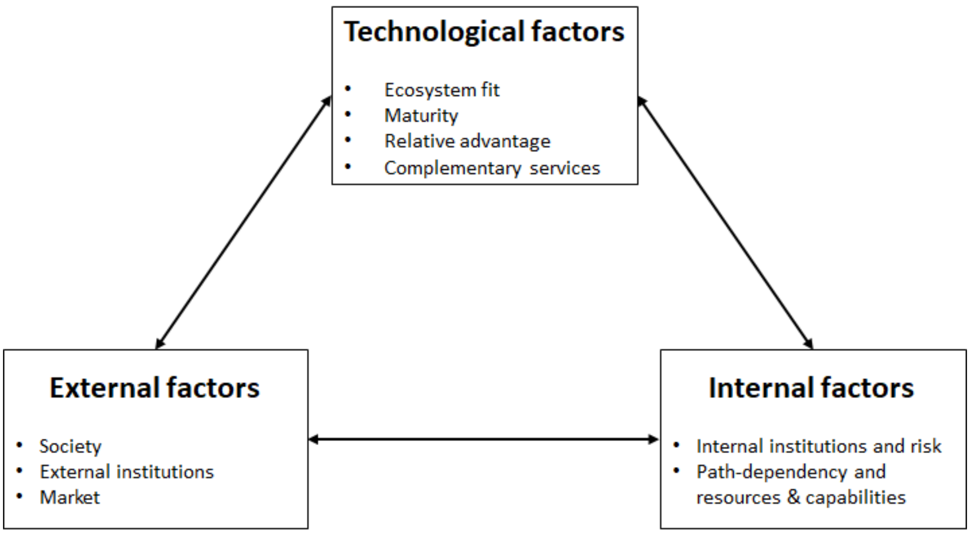

Figure 3*: Overview of adoption factors*

Technological, internal, and external factors are the "umbrella" factors that other related factors are grouped into. See **Table 1** for an extension on the adoption factors.

***Table 1**: Adoption factors*

Type	Factor	Example
External	Society	Environmental trends, financial climate
	External institutions	Regulations, standards, industry norms
	Market	Market expectations of product, resources allocations, norms of customers, and beliefs
Internal	Internal institutions and risk	Organisational culture, Adopter characteristics, perceptions of risk, norms, beliefs
	Path-dependency and resources & capabilities	Current processes and systems, perception of the cost of switching, new investments, capital restrictions, previous commitment to different technologies
Technological	Ecosystem fit	Fit with suppliers/partners/buyers current processes and systems, fit with complementary systems such as after-services or addons.
	Maturity	Proof of concept, data of past performances in efficiency, wear, cost, etc.
	Relative advantage	The perceived advantage/disadvantage the technology has, objective performance, opening up for other opportunities, the market position being first
	Complementary services	Warranties, after-services, on-call support, financial options, business models, customer supports

3. Methodology

In this report, research is presented on adoption conditions for companies concerning a new milling technology. This implicitly requires that perspectives from different actors are needed to be considered to be able to draw righteous and objective conclusions. To gain knowledge and understand what conditions may be important, a literature review was done before gathering empirical data. The approach to the empirical data analysis is from a qualitative research perspective where the data gathering was primarily done in the form of semi-structured interviews. The interviews were done on several cases of companies that have adopted or considered adopting the new radical milling technology. Then, the cases were (cross-)analysed and in the end, a conclusion was formulated.

3.1 Research design

This research has been qualitative. According to Bryman (2003), a qualitative approach reveals many different emphases and would allow the data to be viewed from different perspectives, which is needed to fulfil the purpose of this study. The empirical evidence was based on several qualitative case studies in different contexts. A qualitative research approach is highly suited to gain a deep understanding of phenomena and according to Yin (2003) qualitative case studies are preferred when trying to understand why and how something is occurring or not.
Additionally, Berkwits & Inui (1998) argue that a qualitative approach, as opposed to a quantitative approach, captures expressive information, such as beliefs, values, feelings, and motivations for underlying behaviours. The subjective aspect of a company's decision to adopt or not is important to understand. Further, Black (1994) explains that a qualitative approach is excellent when seeking answers to questions formulated as "what …". Lowhorn (2007) explains that "*It is a subjective way to look at life as it is lived and an attempt to explain the studied behaviour.*", trying to understand why a behaviour is occurring. Thus, the chosen qualitative approach will fulfil the purpose of this study which is to understand how adoption factors affect an individual company's decision for adopting a milling innovation and how these factors affect this decision.

The choice of cases was limited to companies that have considered adopting Technology X, which has either failed, succeeded, or is still in process. These companies have all been (potential) clients of the mill developers at a certain point in time. Making contact with these companies has been dependent on the ability and willingness of the producer of Technology X to connect them to the authors. The choice of cases was therefore limited and not every potential client has been interviewed. The cases are all focused on the same technology, but within different contexts (e.g. industrial differences such as the rubber industry or waste-management industry), which implicates different adoption environments. Further, this study has been performed in collaboration with the company that has developed Technology X. Below follows a short description of the cases that have been covered.

Technology X was developed from ideas that came up during the development of silent submarine engines. The development of the technology to fit milling started in the late 1990s and the first commercial product was sold in 2003. Currently, there are three mills active in the world. Further, there are 25 potential customers which have either accepted to adopt or in the process of adopting it, the order stock of Technology X with these clients goes up to 5000 units combined. The study has been covering five cases, including companies that have adopted, failed to adopt or are in the process of adopting it.

Case (1): The first case focuses on a Swedish company in the recycling of tyres/rubber industry, where Technology X was adopted in 2012 and was used for about two years, only to be discarded later on.

Case (2): The second case is about a Swedish company in the hemp industry that is in the process of adopting Technology X. The first contact was made in 2019. This is a very small client for the producer of Technology X and is not their main focus, which might have some effect on how HP perceives their experience.

Case (3): The third case is on a soil management and quality company from the United Kingdom. The first contact was made in 2014 and the company soon after adopted the technology and in 2020 upgraded their mill to the next generation of Technology X. Further, the product will not be disclosed in this case due to the request by the company.

Case (4): number four focuses on a large international manufacturing firm. The industry in which this company is operating and the product it is producing will remain undisclosed, due to a request from the company that wishes their competitors not to find out about their new operations. The first contact with Technology X was in 2018 and it was just recently adopted on a first-test project.

Case (5): The final case is on a general recycling and waste management company in Sweden. The company was first in contact with Technology X in mid of 2020 and is currently in the process of negotiation of the adoption.

In all cases but (2) and partly (1), the purpose of adopting Technology X has been to approach something new or something that doesn't require any substitution of older technology. This could have a potential effect on the bias of our data, especially factors such as maturity, resources, and capabilities that will have a lower impact in these cases.

3.2 Data collection and Analysis

To gain an understanding of the importance of each factor and an insight into previously done research, a literature review has been done in the early stages of the process.
The following topics, amongst others, have been looked into: socio-technical transitions, innovation adoption, technological change, organisational behaviour, disruptive innovations, path-dependency, strategic management, and resources and capabilities theory. The search through literature was done by using combinations of words such as “innovation”, ”new technology”, “performance”, “adoption” and “transition” in Google Scholar and the Chalmers library search engine. Additionally, previous literature materials from Chalmers courses have been consulted as well. A multi-level classification of adoption factors could be deduced from the literature. The factors to be considered are displayed in Table 2.

The primary data on each case has been collected through semi-structured interviews. The developer of the new technology and an independent sales consultant have been interviewed as well. A separate interview guide has been used for these two interviewees, see Appendix A. This has increased the validity of the data since there are different actors in the same case. Transcripts from each interview were made to further increase the transparency of the study and was a part of the analysis. The thesis was written in collaboration with the company which develops the new milling technology (Technology X); disclosure of the relationship is needed for transparency reasons.

One interview was conducted with every company in each case. In the interview, the general theme of the thesis, the expectations for the interview and questions regarding adoption, external, internal and technological perspective has been covered. See Appendix B for the interview template that has been sent to every interviewee beforehand. The two additional experts have also been interviewed once each. Every interview took between 40 and 90 minutes, depending on the answers and explanations of the interviewees. The same template of questions was used for the five case interviewees, while another template was used for the two experts that was more focused on general parts. See Appendix A for the questionnaire for the experts. Finally, each interview was recorded and subsequently transcribed. During the interview, notes were taken as well for quick access and refreshing the memory. A summary of the interviews is shown in Table 2.

Case (1): The interviewee was the head of the R&D apartment and will be referred to as RT. Another interview within this case has been conducted with an external innovation consultant, TC, who purchased the first mill with Technology X and used it in cooperation with the Swedish tyre recycling company.

Case (2): The CEO, referred to as HP, was interviewed in this case. This is a very small client for the producer of Technology X and is not their main focus, which might have some effect on how HP perceives their experience.

Case (3): The CEO, SQ, was interviewed in this case. SQ is personally very involved in the adoption process. An e-mail with more detailed follow-up questions has been sent to and answered by SQ after the initial interview.

Case (4): LI, the interviewee in this case, is the sustainability manager of the company and responsible for the Nordic countries and has been one of the frontrunners of introducing Technology X to the company. The person has been in the company for over 20 years and was previously the technological manager.

Case (5): A business development manager, RW, has participated in the interview and sheds light on the possibilities that Technology X brings to the table.

Producer interviews: The first additional interview was done with the chairman of the board of Technology X who qualifies as the technology expert on the milling technology, TE. They share their insights and views on Technology X, the adoption, and dealing with customers. The second additional interview has been conducted with an independent sales consultant, IC, who connects Technology X with potential client companies and scouts the market horizon and networks for companies that could benefit from the adoption of Technology X. The innovation consultant's independence is based on the fact that they work for themselves, but they are receiving a commission of 3% on the sale of a Technology X mill to a customer, which incentivizes them to the selling/leasing/etc. of these mills.

Table 2*: an overview of cases, interviewees, and abbreviations*

Case	Position of interviewee	Referred to as	Important to know
(1) Recycling tyres /rubber	Head of R&D	RW	RW wanted to use the mill for an innovative recycling process
(1) Recycling tyres /rubber	External innovation consultant, a previous stakeholder in the company	RT	Purchased the first mill of Technology X and used it in cooperation with the Swedish tyre recycling company.
(2) Hemp	Chief executive officer	HP	This is a very small client for the producer of Technology X and is not their main focus, which might have some effect on how HP perceives their experience.
(3) Soil quality /management	Chief executive officer	SQ	SQ is personally very involved in the adoption process
(4) Large international manufacturing firm	Sustainability manager in Nordic countries	LI	LI has been in the company for over 20 years and was previously the technological manager.
(5) General recycling and waste management	Business development manager	RW	Technology X should ideally be used as a substitution for obsolete technology and improve sustainability
Technology X	Chairman of the board / Technology expert/founder	TE	Have been there since the beginning and helps clients on the technological side and has knowledge through many different cases
Technology X	Independent sales consultant	IC	Connects Technology X with potential client companies and scouts the market horizon and networks for companies that could benefit from the adoption of Technology X

The analysis of the data has been divided into three main areas (external, internal, technology) to try to understand which factors are relevant and try to explain why adoption occurred or not through the literature that has been chosen. The analysis process can be summarised by Figure

4 and it is more of an agile approach and an iterative process. The start is at the theoretical level to grasp the landscape and know where and what to look for in the data collection. Then, data is collected. During the interviews, notes were taken to highlight the sections or factors that would potentially be of most interest in the particular case. After the interviews, transcriptions were made. These transcriptions and the interview notes were analysed and informally discussed by the authors. Timestamps in the recording of the interview were highlighted where the interviewee, either explicitly or implicitly, describes a factor that is being considered in this study. Further, these highlighted sections are then focused on and trying to analyse it with the "theoretical lens" to try to understand the situation. As the factors are not easily quantifiable, there will be a certain subjectivity when interpreting the data. To understand how the factors have been fulfilled, the analysis will first consider every case separately and in the second part compare, look for similarities and connect lines between cases. Also, other interesting findings of the interviews were used to extend the theory and add parts that affect the adoption process as well. At the end of this process, a complete revelation of the theory was done to see if anything had to be changed, added, or removed to be able to fulfil our aim of the research, as inspired by Altmann (2020, 05-14). Additionally, if necessary, additional data was collected through e.g. follow-up questions through email.

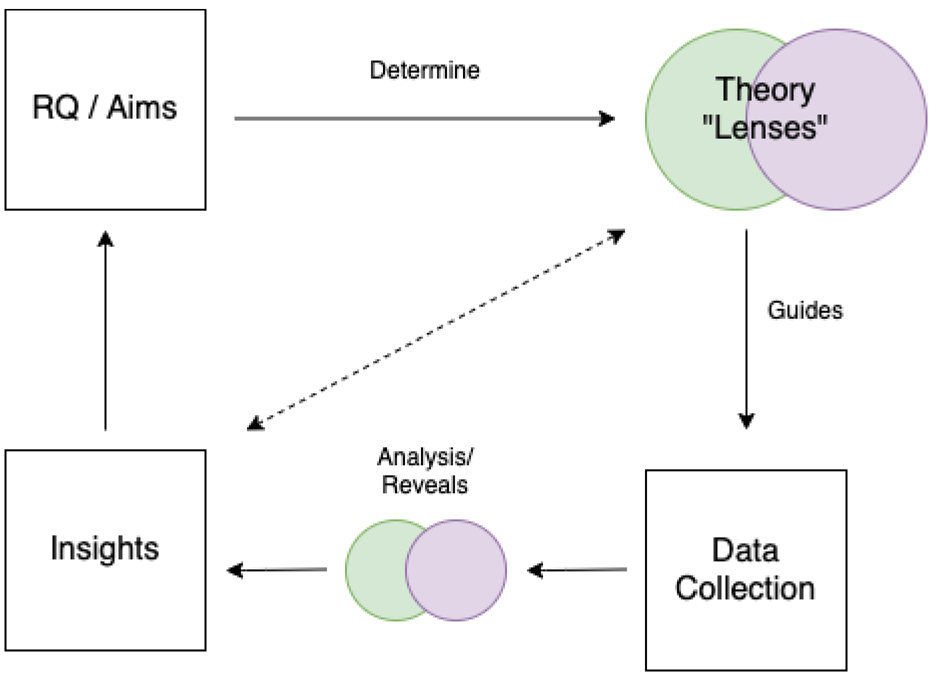

***Figure 4**: Overview of the research process*

3.3 Method discussion

Several processes and choices in the method are open to discussion as to why exactly a certain approach has been taken. The sections where such a discussion would be appropriate are highlighted here and comments on how weaknesses were mitigated are provided.

The focus of the study is on Technology X and thus the company that develops it plays an important role in the design of the research. As the aim of the study requires to closely look at (potential) adopters of Technology X, every client that the developers have been in contact with becomes interesting and can contribute to the depth of research. To find out who these clients are and how to contact them, though, the developers have to be willing to share this information, as they are the only party that knows about every client that has considered adopting Technology X (as they have to provide the technology themselves eventually). Therefore, the data collection has been very dependent on the willingness/ability of the developers to share (ex-)client information. The developers could therefore have been selective of the cases that they provide and there is a possibility that the analysis based on the available information has been drawn to a certain direction. To mitigate the effect of potential selectiveness, two out of five cases have been acquired through an independent sales consultant and one case through an early adopter of Technology X. Both parties do not directly work for the developers, although the sales consultant works with them to connect potential clients. The parties will have different stakes and views than the developers of Technology X, which allowed the connection to different clients that did not surface directly when in contact with the developers.

When looking at the cases themselves, there is always one interviewed person per case who has in some way been (partly) responsible for the decision on adopting Technology X. There is a risk that one individual is not the sole decision-maker or does not understand or see the whole picture when it comes to adopting Technology X, so there could be a certain bias in the answers to the interview questions. Some factors, for example, might have played a smaller role for the interviewee than for another individual in the same company in a different role. To mitigate this bias, every factor has been mentioned in each interview to at least "force" the interviewee to think about it. Therefore, on every factor, an explanation has been given on what role it played and why - also if the interviewee thought that it wasn't important in their adoption case.

In the interviewee with the technology producers, every factor has been mentioned from the interviewers' side as well to see if the producers thought about it and to get a larger understanding of their train of thoughts on their client's adoption process.

Continuing, the research was started on the biased idea that in every case the adopters were trying to substitute older technology with Technology X. It was found, however, that in every case the potential adopters were trying something new with Technology X - not substituting old technology - in terms of sustainability, performance, and discovering new applications. This is something that can only be highlighted at the end of the data collection phase and is something that has been observed, rather than a requirement for every case.

The research and data collection have been conducted by two students. To keep a structured interview process, it was decided that one student would lead the interview while the other one took notes and assisted with checking all questions and touching every subject. Additionally, it was decided that one student would always contact - and stay in contact with - the interviewees, so that a direct and undisturbed line of communication with interviewees could be established.

Finally, the results of this study are generalizable within a certain degree of innovation studies. The context of the study was limited to a unique innovation that can be applied in several new manners that previously was unheard of. The application of Technology X has been in developed countries within companies/businesses that had resources to facilitate some kind of adoption. The findings of this research can be used in similar cases where a new, high-tech technology revolutionizes the way of working for applicable companies/businesses.

4. Empirical findings

In this section, a summary of the findings from the interviews of the cases will be covered. The first two presented interviews are with the technology producer and the independent innovation consultant, respectively. The latter five sections will cover each case and the findings from the interviews are presented there.

4.1 Technology Overview

Technology X was developed from ideas that came up during the development of silent submarine engines. The development of the technology to fit milling started in the late 1990s and the first commercial product was sold in 2003. Currently, there are three mills active in the world. Further, there are 25 potential customers which have either accepted to adopt or in the process of adopting it, the order stock of Technology X with these clients goes up to 5000 units combined. The study has been covering five cases, including companies that have adopted, failed to adopt, or are in the process of adopting it.

The technology expert, “TE”, is the chairman of the board of the company behind Technology X and is the most technologically experienced person on board. TE has also been very included in the process of attracting customers. TE has been working on Technology X for about 20-15 years and has developed it on different continents in the world. Currently, Technology X is being further developed and promoted in Sweden. This mill is different from the classical mill, which operates with steel balls and grinders, managing to keep particle properties unchanged while still drastically reducing the size of the material. A jet mill is another type of mill that is highly specialized, very expensive to buy and operate, and can work with a lower volume than Technology X. The large difference in performance between both mills is that Technology X could practically work with most materials - depending on the way that it is put in the mill -, is inexpensive to operate and is unique in its milling properties and output.

According to TE, customers tend to be positively surprised about the output quality and are very eager to send many different kinds of materials through the mill for extensive testing. During the testing phase, the uniqueness of the mill becomes clear and most customers are fully convinced of Technology X’s superior performance after the first set of tests. The uniqueness of what Technology X can output is one of the things that TE regards as the biggest reason why companies adopt, it gives them something that they didn't have before and could give both opportunities and potential advantages. However, while Technology X is relatively inexpensive to operate (when measured in cost per milled litre), the initial investments are rather high and tend to scare potential customers away a bit. This is the point where TE has to try to make a case of superior milling technology and offer reminders of the sustainability that comes with Technology X.

Sustainability in this regard is another very positive factor that is created with Technology X. Direct sustainability is achieved due to the low energy demand and the low wear and tear of the particles of the mill. Indirect sustainability is created through the application of the mill and the opening up of new possibilities for different materials. TE notes that Technology X can isolate specific substances from materials that can be applied in completely new ways. An example is the extraction of pure protein from peas, which can be mixed with other food substances to create vegetarian/vegan meat replacement products or vastly increase the shelf life of conservatives. While this is an example specific to the food industry, it is up to the customer to isolate specific materials that can greatly contribute to a more sustainable society.

The independent innovation consultant, IC, has met the developers of Technology X through a mutually known third party. Interest in the milling technology behind Technology X was aroused through the IC's previous knowledge of the food industry where they saw several application fields for Technology X. Generally, the IC introduces interested parties to the milling technology, its possibilities, pricing, and some core technical specifications. For more in-depth technological questions and explanations the main developer of the mill is invited to a meeting where all three parties exchange information and primary needs. A good point that the IC always mentions to potential adopters is the sustainability of the mill as the mill guarantees environmental sustainability to a large degree. While the mill's energy use is relatively high, it manages to process more material than previous techniques and thus the used energy per milled piece of material is a lot higher. Pressure on the environment will thus be less and there is an interesting cost incentive to the customer as well.

The IC describes the first step in the adoption process as a testing phase, where a potential customer can send some to-be-operated-on materials to the developers who then mill the material. If the required substances have been successfully liberated - or if the output has the expected qualities - the adoption process is usually taken to the next level. This first testing phase is pretty broad and serves as the first “wow-moment” to the adopter. According to the IC, Technology X is such an innovative improvement on the general milling technology that customers either do not know what to expect, or their expectations have been exceeded. On a technological aspect, Technology X manages to impress many interested parties and opens up new ways of processing material. However, for a process to continue after the initial tests of performance, the performance has to reach its previous performance at least for it to move forward.

However, the IC has pointed out several times that a mill is usually part of a production process and that new mills are required to fit in that existing process. To every client, it is important that they can fit new technology in their current processes, or that there is a way to make it fit (better). A misfit generally requires a large investment in additional machines that can work both with the material and with Technology X. A specific example that IC mentioned was a recent decision by a potential client to not adopt Technology X because it could not work with the raw materials that were just extracted. The material had to be processed abroad in the US and Denmark first before it could be processed in the mill. This proved to be a too cost-intensive process for it to be profitable. To fit the mill better into the existing ecosystem of market standards and existing machines, IC stated that the developers are working on pre-processing techniques that can prepare the material in a way that it can be used in the mill, such as sorting machines or conveyor belts. Gradually, Technology X is ramping up from serving small business and material sizes to more substantial material sizes.

When it comes to financials, the developers and IC prefer to offer Technology X as a service, where a customer pays a monthly fee based on the processed material. Such fees are determined during the testing phase, where it is looked at how much material is processed, how successfully, and how fast. Cost packages are tailored to the client so that financial limits will not be the deciding factor for adoption, if within reasonable limits.

4.2 Recycling tyres/rubber industry

The rubber industry is an international industry that is interested in recycling tyres. Black carbon, amongst oil, carbon, steel, and gasses, can be extracted from tyres and gives the tyre rubber its tear-resistance and flexibility. Without black carbon, tyres wouldn’t be as nearly effective as they are today. A tyre is about 30% black carbon.

The company has one full-scale plant operating in Sweden and around 25 employees. According to RT, the industry is rather slow-paced, as it has taken about 20 years to start up a plant that extracts materials from tyres. The industry is characterised by heavy environmental regulations and standards that require plants and technologies to earn various certificates. RT’s company’s plant is in the final stages of acquiring every certificate, which has taken about 20 years. RT’s customers set very strict specifications and requirements based on these regulations.

RT came in contact with Technology X when looking for a mill that could reduce milled particle size below 20 microns. Technology X was able to produce material under five microns during the initial test phase, which allowed it to skip a few steps in RT’s testing process. The wear and up-time reliability of the mill were two other very important criteria that were still unclear for Technology X after testing, as it had no ISO or other certifications or adhered to other accepted standards. RT decided to adopt anyway and was promised that an updated version of Technology X, with improved wear and up-time numbers, was to be delivered. The first version quickly proved that it was susceptible to high levels of wear, vibrations, and many other smaller problems. This led to a long-lasting back and forth with the developers of Technology X, as at that time extensive on-site service, good customer support, and continuous contact wasn’t taken care of. Finally, after 1,5-2 years, RT decided to exchange Technology X for another type of mill that had proved itself on the market and backed by large multinationals.

RT stated that they would have continued to use Technology X if complementary services would have been much better. A change back to the newest current version of Technology X is, however, out of the question as RT has invested a lot of the company’s resources and time in their current technology.

The external innovation consultant acted as the bridging factor between Technology X and the Swedish tyre company. “TC”, the consultant, established early contacts with the developers of Technology X and purchased the first fully developed mill, and used it in the tyre company to try to increase the recycling rate of old tyres. This was about 20 years ago. TC saw the environmental trends forcing the tyre industry into a more sustainable corner and creating some real incentives to try and recycle the black carbon in these tyres. Regulations dictated that tyres were not allowed to be stored as complete tyres and that they had to be shredded, ideally recycled, and used again. A simple mill would have covered the shredding part, but not the recycling part. TC discovered that Technology X was able to liberate black carbon at a rate that had never been seen before and saw the potential behind Technology X. As black carbon is a precious material for which high prices are bid when offered in pure form, there was a good reason to pursue the recycling efforts of tyres anyway.

As the tyre industry is very slow-moving and 20 years ago wasn't as complete as it is today, TC saw that the company was not very locked into its processes and techniques. This offered a good chance to introduce a unique technology that later turned out to be rather slow on the output level in comparison to other machines in the company's plant. Along the same lines as RT, TC stated that eventually, Technology X underperformed too much on levels of speed, which eventually outweighed the technological performance and the mill was replaced for an alternative.

4.3 Hemp industry

The Swedish hemp industry is a small industry that is not as fully developed as in other countries such as the U.S., Canada, and France. The processing of industrial hemp focuses on the whole plant where every bit between the root and the stem is being taken into account. The interviewee is the owner of a Swedish hemp processing company HP and is looking to extend the range of operations that it carries out on the hemp plant. Bales of hemp consist, amongst other things, of shives and fibres, mixed that have a broad range of applications when separated. The Swedish hemp industry is operational in the part of the processing chain after shives and fibres have been separated and in the case of shives only with a considerable low percentage of dust. Technology X has already proven that it can reduce the dust in pure shives to a percentage below the required maximum. This is a promising outlook, as only a few other technologies in Sweden have been able to produce similar low dust percentages when processing shives.

Unpacking bales and fully separating and processing fibres and shives are part of the upstream processing steps of the hemp industry. The physical properties of Technology X don't allow a smooth fit to the upstream, but HP is currently collaborating with the developers of Technology X to find out it can isolate fibres and shives to skip one step. While there are already technologies that can achieve this, these are generally used overseas and not sustainable, the latter being a non-negotiable requirement for the Swedish hemp industry. If Technology X would be able to deliver on the isolation of critical materials, HP sees a possibility to alter harvesting methods to provide hemp in a way that is compliant with Technology X, though requiring another investment and the acceptance to change old industrial habits.

HP is thought to be the first hemp processing company in Sweden that has had trial runs with Technology X and is convinced that a shift in the hemp industry is on the horizon due to this technology. For HP it would be a large investment sum in the event of potential adoption of Technology X, so it desires to complete many test runs with different kinds of materials to exactly know what Technology X is capable of. The technology will be deployed for the long term and many Swedish actors in the hemp industry would benefit from the outputs of Technology X, that is if it passes all the prior tests. Also, traceability, various accepted certifications, low use of energy, and after-market services are important criteria for potential adoption, although underlying to performance. HP, as of the time of writing, has not adopted Technology X but is in the midst of its decision process.

4.4 Soil management/quality

Companies in the soil management/quality industry help increase the quality and sustainability of soil for land managers in all different areas, such as farming or golf courses. The company that has been interviewed is operating for 80% in the UK and 20% internationally. The founder and CEO, “SQ”, has been interviewed and founded his company in 2018 and currently employs ten people.

SQ had been in contact with Technology X before founding the company. It left such a great impression that SQ took the following five years to develop a product that could extract great potential from Technology X. This was a product and service that hadn’t been introduced before and proved to be crucial to SQ’s business, further to remain undisclosed. SQ is very excited in a visionary way about Technology X and talked about the endless possibilities that it potentially has. The founding of SQ’s business comes hand in hand with the technology and according to SQ the passion that is involved with Technology X will bring it to great applicable heights. A quote from SQ: “*Passion is everything, isn’t it, gentlemen, you know, and I’m very passionate about this because I really know it could change mankind. Okay. Yes. There’s going to change* *the game even more. I need the amount of resources. We will be able to recapture alone, start to stop wasting if this thing were rolled out and there were 10,000 of these across the planet right now doing that 12 sectors that we could easily identify. We'd be looking at savings in the multiple trillions of dollars per year for the planet. I mean, it's just ridiculous growth.*" (12:49).

Further, SQ revealed that apart from the offered opportunities, there were more factors behind his adoption of Technology X. Environmental regulations, pressure to become more sustainable, and EU-wide goals are underlying trends that favour the application of Technology X and helped SQ's company greatly. The United Nations Sustainable Development Goals (UNSDG) were specifically named as being key drivers to pursue Technology X. Across the UK's recycling and processing industries there remain strong concerns for high-performing and efficient mills. Technology X can help to realize SQ's vision, fitting in the culture of doing things. The risks that innovations carry with them, though, weren't ignored, as there was no proof of concept or standards that fit with other systems, such as ISO certificates, board certificates, etc. SQ highlights that for Technology X to break through, a streamlined package has to be delivered. Pragmatic support methods such as very personal customer service is a must. When discussing the future of the technology in the industry, it is very possible that many will adopt it and, according to SQ, around 70% of all mills in the world could be replaced by Technology X.

4.5 Large international manufacturing firm

The industry is global and consists of a few very large actors and the market is high-volume. The product is an everyday product that everyone comes in contact with each day. The company is actively manufacturing, developing, and selling the product. The company operates internally and is one of the biggest manufacturers of this product in the world, with 34 production sites and 25000 employees in 100 countries. A agreed, the product and industry will not be disclosed as the company fears that competitors will take advantage of the information.

The initial contact LI made with Technology X was at a sustainability conference where TE was presenting Technology X around the year 2018. LI saw an opportunity to be able to liberate a particular material, which then is to be recycled into their current products, something that has previously not been able to be done in a great manner. The direct motivation of the potential adoption of Technology X was to improve waste management and recycling. Three years after the initial contact there is a first agreement struck between the company and the producers of Technology X and a first project is underway.

The industry itself is very slow-moving and to a large extent the market as well. LI mentions that the environmental regulations of the industry and in Sweden are very far behind other industries, so the industry is not pushed towards sustainability and recycling. The market and customers do not value sustainability aspects such as recycling. Customers are not willing to pay a premium price for a recycled product. LI explains that some competitors get away with "planting some trees" to offset their pollution, which the customers seem to buy. LI argues for more regulations that would push the industry towards action, describing the Swedish reduction law in the diesel industry as effective regulation. At the current stage, a large investment towards increased recycling products is not justifiable from an economic aspect.

However, LI has taken the initiative to be more sustainable by setting up various goals. For example, 30% of their products should consist of recycled materials by 2030. Currently, they are at 12%. Their vision is to become a fully circular company. LI explains that at first the recycling and circularity of processes was a lot about making the processes more efficient and saving money but that has shifted and is now more about contributing to a sustainable climate. LI was asked if a project like this was to be initiated for about 20 years, the answer was that It would be very unlikely. LI also explains that they see this investment and the focus on sustainability as a strategic decision and as a preparation for the future and regulations to come.

LI would argue that the company is a classic production company that is focusing on production and efficiency and is not very flexible, which can be seen in some R&D efforts. However, he argues that there is a great business climate and an entrepreneurial mindset in the Nordics that is suited for these types of new technologies. This project would have been much harder in France and impossible in Germany. The informality and lack of bureaucracy in this project were very helpful.

According to LI, performance is the deciding factor. If the technology would not work as expected, it would not have been adopted. The current project is not full-scale, and if the technology is to be implemented full-scale it is not to substitute a current process but establish a new one. One of the primary benefits of Technology X is its flexibility and if a full-scale investment is to take place it would be used for several different materials. This would entail investments around the technology, and it would have to fit with other solutions such as logistics. If a logistic solution would not have been found, they would not be able to move forward.

4.6 General recycling and waste management

In this section, a recycling and waste management service company is covered that provides solutions for companies that cannot take care of their waste. The company is active in Sweden, Denmark, Norway, and Estonia and handles 6.3 million tons of material of different waste each year. It is a large company with annual revenue of 6.4 billion SEK, 2300 employees, and about 60-65 waste handling sites in Sweden, varying in size and expertise.

The initial contact was in person and a former employee told RW to look into Technology X. The material that RW receives to recycle is highly mixed and has to be separated before the recycling process, or it goes to waste. This led to a discussion with the producer of Technology X, since one of their key advantages is to liberate materials. An initial test was conducted and showed great potential. A material that had previously always been put in a landfill was managed to be recycled. Based on this success, there is currently an ongoing process of taking the collaboration further.

The industry is very slow-moving and RW would characterize the business and branch as very conservative. They have done the same thing in the last 20 years. However, there are strong trends that are affecting the industry. The EU is, under pressure from climate change, going green, and regulations in Swedish society are pushing towards circular economy strategies. The new regulations have led to change. Waste ordinance laws have been established in Sweden and have gone into effect in 2020, demanding that companies that produce waste are responsible for that waste. Further, if RW takes the waste and there is a possibility to recycle it they have to do it. This has pushed new investments in technology. Further, the market and customers are also pressuring towards a change since they want to lower their CO_2 footprint. This has led to increased competition among the players in the industry and RW mentions that they need new technology to stay competitive. However, when it comes to material handling processes, innovative sustainable recycling is expensive and the customer will have to pay. As the customers' main concern is financially motivated, they will not go with more expensive options, even though they might be more sustainable. As no company wants to take the first step in this, RW feels that someone just has to step up and that the others will soon follow after.

The new goal of the company is to be climate-positive by 2030. In general, RW would characterize the company as rather reluctant to change, although there are a few people that drive the changes. The implementation of Technology X would require some new processes and knowledge, but RW does not see a big challenge and thinks that it is not hard to handle. RW describes that they didn’t see any larger risks and was quite confident that it would work.

The performance of Technology X was great, and it provides an interesting financial benefit. Currently, the costs for putting processed materials in landfills are about 1200 SEK/ton. If they manage to recycle the material, however, they could sell the material for 500 SEK/ton, which leads to a financial incentive of an increase of almost 2000 SEK/ton. RW mentions that Technology X has to bring a lot of value and outperform the current processes significantly. In this case, no technology can perform as well as Technology X. A problem related to Technology, though, is that there is high uncertainty in terms of payment. It is unknown what payment model the producers of Technology X will use and the adoption costs are unknown. This makes the evaluation of cost versus reward very hard and is currently the main issue that prevents larger investments in Technology X. Further, RW can see the industry adopting more new technology that pushes in this direction. Especially the initial projects will take time, though, but once they are up and running following investments should go quicker.

5. Analysis

In the first section of the analysis, each case will be looked at separately. The adoption factors that have been introduced in the theoretical framework will return here and it will be looked at if they appear in a case, how they influence the decision for adopting, and how it relates to the case in general.

The second part of the analysis will be a discussion where cases are compared and where an in-depth analysis of each occurring factor will take place. Comments will be made on the perceived importance and effect of each factor and their applicability across the cases.

5.1 Analysis of factors per case

The analysis will be conducted per case and a sub-division of sectors across the external, internal, and technological points of view will be presented. Factors that belong to these three groups and that occur in a case will be marked in **bold**.

5.1.1 Recycling tyres/rubber industry

External

The **society factor** is affecting the whole industry in terms of environmental pressure and climate support. The landscape pressures have already partially affected **external institutions**, as many regulations, standards, and certificate requirements were already put in place. This, however, focused more on the production of tyres and the disposal of used tyres and acted as barriers to further environmental harm by these actions, rather than supporting the adoption of new technologies. Rather, it acted as a hindrance to new approaches and slowed down innovation processes to protect the environment. The industry is rather conservative and slow-moving - evidenced by the 27 years that RT needed to get their plant fully up and running. The regime is therefore strong and actors are very path-dependent (Geels, 2004), which makes the diffusion of innovations more difficult. Societal pressures are, however, forcing the industry to work more towards sustainability and especially innovate in the area of recycling. This opened a door for Technology X and helped to break in the regime, potentially destabilising it with other, similarly working, technologies (Smith et al., 2005).

The **market** was not specified as having a positive or negative impact on the decision of adopting Technology X. The market was only exposed to a selective range of technologies that were accepted by the regime and followed by external institutional pressures. As RT's company had just been founded when the adoption of Technology X was considered, it acted as a niche-level player in the tyre regime (Geels & Kemp, 2000). It brought Technology X to the surface of the regime, but was largely protected from **market** influences through R&D funding and allowed Technology X to slowly develop.

Internal

The **internal institutions and risk**, in this case, are a positive effect of adopting the technology. The culture and mindset of the company are very entrepreneurial and, as early adopters, very risk-tolerant (Rogers, 2003). The company was aware of the risk and had to deal with uncertainties in terms of performance and specifications. However, in line with theory (Locket & Littler, 1997; Aurigemma & Mattson, 2018), RT's company resided in an explorative phase that allowed larger risk and higher uncertainty.

The **path-dependency and resources & capabilities** factor at an initial stage was a positive effect of adoption. The resources and capabilities that the company possessed were very limited and it created a condition that allowed them to be flexible and could start building production processes from the bottom up. There were no established lock-in effects or barriers either. The initial situation is what Schumpeter (1934) described as the introduction of an innovation by an external party and introducing it to the regime. Technology X, however, did not manage to live up to expectations after adoption and RT replaced it with another technology. The complementary services of Technology X were lacking or non-existing, which proved to be too big of an issue to ignore and led to the demise of Technology X in the tyre industry. Once Technology X was replaced, the lock-in effects by replacing technology were huge and the switching costs of once again using an updated version of Technology X too high.

Technological

The **maturity** of Technology X was almost non-existent in pre-adoption and the readiness of the technology (Turnheim & Nykvist, 2019) was very low and increased the risk that comes with adoption. The lack of certificates and proof of concept in the material to be processed was a big uncertainty that hurt the adoption. **Relative advantage,** however, is considered by RT to still offset the risk in a pre-adoption stage. They perceived the opportunities as larger than the risk and this would be a positive factor (Rogers, 2003). However, the risks after the adoption were realised to be more than they first perceived, and the rewards not as great as the first tests showed, but still showed potential to continue the business. Further, one of the most important factors, in this case, is complementary services. The lack of or insufficient complementary services led to scrapping Technology X, even though investments in knowledge and processes were already made. The producers of Technology X were not able to provide full-time services, such as maintenance on site. Although the raw performance of Technology X was satisfactory, it did not outweigh the questionable reliability and difficulties with maintenance. RT values **complementary services** since their next choice of technology was more focused on complementary services and went with a big international producer that could provide this. This shows that a producer's task of facilitating value for its customers doesn't stop at purchase, since they do not create the value but rather facilitate it (Grönroos & Svensson, 2008). The **ecosystem fit** was not discussed in this case per se. This is most likely what was discussed in the external part, that they are not currently in the system and their operations are rather isolated except that the **market** did demand a certain requirement.

This case highlights the importance of the internal context. The internal context was very different in their first explorative phase and their current situation, where the lock-in effects resulted in too high of a switching cost to consider a switch back to Technology X. Further, while the **relative advantage** was an important factor and was satisfied as well, the **complementary services** showed to be the make it or break it factor.

5.1.2 Hemp industry

The interview with the owner of the hemp processing company (HP) uncovered that the major factors that affect their adoption of Technology X are **society** as part of the external section, **path-dependency and resources & capabilities** of the internal section and **ecosystem fit** and **complementary services** as part of the technological section. While other factors have also surfaced in the interview, the section below will highlight why the four above-mentioned factors are prevalent.

External

Society's views and expectations were fueling the consideration and adoption process of Technology X. HP had been looking to extend their up- and downstream operations and consider some practical examples that were used abroad for such operations. While these examples could have been copied by HP and applied in Sweden, Swedish societal views on sustainability have led to HP disregarding this. The sustainability push in society, by politics and throughout many Swedish industries steers many companies towards a more sustainable trajectory. The indirect pressure of society's sustainability expectations (Rip & Kemp, 1998; Geels & Kemp, 2000; Geels, 2002) pushes HP to trace purchased material, process it in environmentally sustainable ways, and convince the external environment of their green intervention.

Further, the mould that Swedish **society** has created for sustainability (Rip & Kemp, 1998) created a considerable barrier towards vertical integration of not just HP, but the entire Swedish hemp industry. HP stated that the Swedish hemp industry is considerably lagging on the global level and that the push for environmental sustainability, both in the large and long-term change of society's perception (Geels & Schot, 2007) and **external institutional** sense in sustainability regulations and standards (Geels, 2004; Bergek, 2018), in Sweden has increased the difficulty of conducting the same operations, but sustainably. This, however, will put Sweden in the lead of sustainable hemp once innovations such as Technology X can be widely applied and diffused. Expectations, rules, and regulations provide an important acceptance case for Technology X. Through its lower energy demand per milled kilogram and long life expectancy it has overtaken traditional mills on the sustainability front. This puts it on the radar of companies and industries that want to innovate and produce sustainably and offers an interesting trade-off against the initial investment sum, which will be further looked into in the internal factors.

Finally, it becomes evident how the **society** factor has impacted the adoption case for Technology X by HP. While the push for sustainability has taken place on the larger political-economic and socio-cultural level, its effects are gradually being translated downwards in the MLP and can now be felt on the industrial level and individual companies such as HP carry it onward (Smith et al., 2005). The need for adopting sustainable technologies is pushed by society's view on a company's operations and forces them to develop their business along with those views. The Swedish hemp **market** has set standards for hemp products in terms of consistency and size and is actively looking for sustainable methods that can provide such products. The market hasn't, however, specifically accepted or declined technologies that create suitable products (Rogers, 2003), as their focus is on the product outcome and not the technology that has created it. Technology X is, within the hemp industry, too new for the broad market to know about and as such, no reaction has been seen yet on the market horizon.

Internal

The **resources & capabilities** of HP are fairly limited because the Swedish hemp industry is small and profits per company are therefore marginalized. HP stated that their limited budget has not made them the most financially interesting client for Technology X, which led to a delay of the testing phase of the different kinds of hemp-related materials. Additionally, the decision of adopting Technology X leads to the need for a considerable primary investment sum and HP has to break out of its established processes and capabilities (Christensen, 2013). HP is locked in by existing contracts with abroad suppliers that provide them with the specific materials that are needed to provide their customers with the requested output. Switching to Technology X brings a degree of uncertainty regarding these input specifications, the closing of existing supply lines and network effects, and requires a substantial amount of capital for HP.

Internal **risk** plays a small role for HP in comparison to other factors. The risk that is currently taken is very overseeable as the requirement stands that many test runs should be finished first before any kind of adoption can take place. HP sees a long timeline towards adoption and thus does not have the imminent pressure of any large risks that might balance the effect of positive factors. HP's culture, or the **internal institutions**, is based on the will of being sustainable and innovating towards sustainability. Technology X is a natural step in HP's process as it delivers on the sustainability aspect and is technically unique in its way worldwide. HP's appearance of being a curious entrepreneur helps to open doors and see possibilities where other players in the Swedish hemp industry either don't see them or feel the need to pursue them.

The **path-dependency and resources & capabilities** of HP have locked them into their current established processes. These processes are a proven way of conducting business across the Swedish hemp industry and mainly exist because no better alternative is more sustainable. In line with Schumpeter (1937), innovations such as Technology X keep hemp actors from innovating themselves and allow outside entrepreneurs to enter the hemp system. It takes an early investor from inside the industry to demonstrate the use case for Technology X. Technology X manages to convince HP on technological aspects, which will be analysed in the next section. International supply lines push the costs for the hemp industry and complicate the delivery processes. Due to strict material standards import costs are relatively not much lower, but no extra processing is needed once the requested material has arrived. All in all, the adoption of Technology X opens up many possibilities, but also many uncertainties. HP wants to complete many different materials tests before it decides to use Technology X and in general, it can be stated that the **path-dependency and resources & capabilities** requirements are worth it if Technology X manages to deliver on all other fronts.

Technological

These other fronts can be grouped under **ecosystem fit** and **complementary services**. The fit to the ecosystem is a big point of concern for HP as hemp bales need preprocessing before they can be milled. Unpacking bales, separating shives and fibres, and conveying material into the mill are important steps that are time-sensitive and cannot be skipped. HP is currently supplied with material that considers these steps and allows for a smooth process. Adoption of Technology X would require some bale opening process, a complete pre-separation of fibres and shivers, and the use of some conveyor unit that can feed the mill. The stand-alone value of Technology X is limited regarding such complementary processes and weakens the overall adoption case for Technology X (Pianura, 2012). The hemp's ecosystem is large enough that it cannot be ignored and that HP has requested Technology X to look for ways to innovate more into their existing value chain. As the testing phase is not rounded off yet, the older way of conducting business fits better to HP's complementary assets and still poses a threat to Technology X's adoption (Adner, 2006). The **ecosystem fit** is, therefore, a strong factor that affects a potential adoption negatively. In industries with important and many complementary assets, such as the hemp industry, it is an insurmountable barrier that can only be overcome if Technology X can provide (parts of) the most important complementary assets. Without this provision, more capital would be needed to provide new assets with the same old functions and heavily impact the production process of hemp in a negative way.

The **relative advantage** has been shortly mentioned by HP that if Technology X can steadily perform in line with previous tests, it will be large enough to consider other factors and push the adoption decision in a positive direction. Technology X has already proven that it can deliver on the sustainability part and perform better in that aspect than has been seen abroad.

HP does not solely require a product that can process the hemp but needs after-market services, financial options, and customer support as well. The integration of such **complementary services** with the product itself (Manyika et al., 2012) is an interesting but vital possibility for HP to ensure successful long-term use of Technology X. Different financial options, such as outright buying, leasing, renting, or using term payments create great flexibility for HP's limited budget and creates the financial possibility of actually adopting Technology X. As the adoption case would apply to the long-term, HP needs Technology X to function error-free for a long time. As faults can show up anytime, quick mechanical assistance from the developers, active customer support, and short lines of communication will bring them closer to seriously consider Technology X. **Complementary services** enable HP to create the value of hemp themselves, while the developers of Technology X will just be the facilitators (Grönroos & Svensson, 2008) to the value creation process of HP.

The **society** factor has a fundamental effect on the decisions and is pushing certain behaviour or actions, which in this case resulted in looking into Technology X. Further, the **relative advantage** of the technology is satisfying and unique, although not convincing enough by itself. Rather, the **complementary services** combined with the **ecosystem fit** will have a large effect on the final adoption decision.

5.1.3 Soil management/quality

SQ is a classic example of a very passionate entrepreneur that highlights every positive side of innovation and envisions the most extraordinary applications for it. The **relative advantage** of Technology X, therefore, plays a huge role for SQ and he has been very elaborate on this advantage to anyone that can find a use for Technology X. Additionally, the **internal institutions and risk** factor has been prominent in this adoption case, due to the characteristics of the adopter. Finally, the **landscape pressures** confirmed SQ's feelings on riding the sustainability wave and going down the path of adoption of new and unique innovations.

External

Legislation and policies have been a dominant driver of the change that SQ has undergone. The United Nations Sustainable Development Goals (UNSDG) were described as a key driver for SQ to pursue the adoption of Technology X. The **society** factor acts as an outer force that creates a mould through which SQ can develop themselves. While legislation and policies dictate how technology currently is to be developed, it also acts as a blueprint for future developments in the soil sector. The clear message from the EU - and citizens in the EU - that green production is the new way to go forces businesses to look into the future and anticipate how this call is to be implemented. SQ, therefore, saw enough reason to pursue Technology X from a present point of view and definitely from the point of view of the future. Additionally, society's perspective on sustainable consumerism and wanting to know how certain products have been produced further solidify the need for sustainable production. A company's image to this 'crowd' and solid credibility is what keeps them in business.

External Institutional pressures have barely been mentioned and it seems that SQ is mainly driven by **society** factors. The **market**, however, is very fragmented and the soil 'industry' is pressured by different underlying industries that are supplied by companies such as SQ's. While the EU is pushing for the centralisation of soil data and no consistent policies are present in the soil industry, it forces SQ to be proactive and continuously align its sales message with the newest legislation. This is a clear sign that the **market** reacts actively to forms of societal pressure and requires its actors to be up to date on the newest legislation and environmental policies.

Internal

SQ does not mind taking on some **risk** when adopting new technologies. They have already adopted and used Technology X and knew that in their industry this technology was completely new and unknown by any competitors or customers. It is a fair question to raise why this adopter had such a large risk tolerance. SQ is an early adopter and they traditionally are more risk-tolerant than later adopters (Rogers, 2003). Rogers (2003), continued, underlines that the individual characteristics of an actor affect the adoption and that people who are open to change are less reluctant to integrate an innovation. SQ is led by inner motivation and emotions and in combination with cognitive limitations does not necessarily base his decision on rational reasoning, but rather on emotional reasons and out of love for the novelty (Selten, 1990).

SQ's **risk tolerance** is fueled by the **internal institutional** environment consisting of norms, ethics, and culture. It can be argued that SQ's company has a culture of being open towards innovations, taking risks, and thinking outside the box. It is carried by most people in the organisation (Willcoxson & Millett, 2000) and steers towards a general acceptance of uncertainty and learning to deal with it. Norms and ethics are well rooted in SQ's internal institutional environment, but the impression is created that the CEO is an eager risk-taker that likes to dream big and spread Technology X not only in his organisation but if possible anywhere on the globe.

Technological

SQ's openness to risk is strongly backed by his perceived **relative advantage** of Technology X. SQ underlines his complete trust in Technology X and the advantage that it provides to his industry and many wider applications as well. The gained advantage by Technology X was large enough to catapult SQ to a market-leading position where he could afford to think of applications outside the line of his industry. The importance of **relative advantage** is described by Rogers (2003) and showcased by SQ. The actual advantage, or performance, of Technology X, is not of the utmost importance. It is SQ's complete belief and conviction that Technology X is one of the most outstanding innovations of the previous decade(s). Relative advantage has the appearance of being such a strong factor that even if other factors influence the final adoption decision negatively, it will still lead potential adopters to take a positive decision. The interview with the independent innovation consultant ("IC") underlines this, as they make sure that, before discussing anything else, the client is aware of the abilities of Technology X, how it could benefit the client's organisation and how the conducting of business will be much easier after implementation of the mill in their production lines. IC manages to convince clients of the relative advantage that the mill creates and uses it as a foundation to work on other adoption factors.

The **relative advantage** plays a large role and specifically the performance expectancy which SQ see as huge potential and growth possibilities, further Technology X brings something unique allowing SQ to build a product that is first in the world. Additionally in this case the characteristic of the adopter is probably the most important factor in collaboration in the **relative advantage**. The **internal institutions and risk** are what sticks out in this case, SQ sees the risk but compared to the gain and his vision it is neglectable and his attitude towards the technology plays a huge part.

5.1.4 Large international manufacturing firm

External

In this case, there is an overall trend of increased environmental awareness, related to the **society** factor. The landscape is changing slowly (Rip & Keller, 1998) and changes are coming from society, not within the industry itself. The company operates internationally all over the globe and the pressure on the industry has not resulted in any changes yet. However, in the Nordics, the effects are felt stronger on a local level. It has influenced the internal part of the company and changed its vision. As Geels & Schot (2007) describe, it affects the actors in the network in a way to create larger changes that could have a deeper impact in the end. This is a key factor in this case because LI mentions that 20 years ago when environmental awareness wasn't as active as it is today, this project would not have continued.

The **society** factor has not led to any **external institutional** changes which have affected the adoption negatively. At the current stage, the rules of the regime are lagging behind other industries and current regulations do not favour environmental awareness, which is LI's goal of adopting Technology X. The regime can be seen as very stable and slow-paced and there is a lack of forces pointing toward environmental actions, thus there is no pressure on actors to become more sustainable (Geels 2004). There are no other competitors that have started to take action towards a more environmental recycling process, which could also be evident to the industry stability and path-dependency on the ways that they have always done things (Geels, 2004). The strategic decision would then be, according to Peng et al. (2009) and NIT, not to pursue a venture with Technology X, in contrast to LI's final decision. The **market** does not value the additional cost of a recycled product and is guiding the current companies in the industry to neglect innovation. There are no incentives to adopt Technology X based on market responses, as customers are not willing to pay for it, which would lead to lower margins. This is what Christensen & Bower (1996) describe when stating that big companies get locked in by current demand on the market and focus current resource allocation on current processes and products. Further, there is no external institutional pressure and no pressure for the market to change at the current stage.

Internal

The **internal institutions and risk** had a positive effect on the adoption of Technology X. The visions of the company have been affected by societal factors since there is a clear goal to improve recycling. In line with Peng et al. (2009), LI's current actions are irrational from the internal institutional point of view. However, as LI mentions, this is a strategic decision to prepare for the future when, as expected, new regulations and policies will be introduced when the s**ociety** factor eventually breaks through, making LI's decision rational in the end. Environmental awareness has been embedded in the company and it can be seen on a deeper level, as the motivation for recycling and circular economy changed from efficiency to doing it for the climate. It has sparked a purpose for the company as its employees and beliefs are affecting the behaviours (Shane et al., 2009). In this perspective, the actions "fit" with the internal institutions and pressured this action. Further, the context of informality in the Nordics and business climate with the entrepreneurial mindset both get rid of bureaucracy. The characteristics of those in charge of the project were more positive to new ideas to change and entail a positive effect for the adoption (Rogers, 2003). These factors are important since LI mentions that if this happened in another context such as in France or Germany it would be almost impossible. The current investment that is being made is not that significant for the company and the risk perceived for this is very low.

The **path-dependency and resources & capabilities** are not a factor that is very much involved at the current stage. They are currently investigating to integrate something new instead of substituting a current method, allowing this factor to act more as a blank-space and not be influenced negatively by the lock-in effects that can arise from established processes (David, 1985)

Technological

Technological fit is not very relevant in the current small project, but it will become relevant for a larger project. LI mentioned that Technology X has to fit in a logistic solution and if it is not able to do so they won't further invest in it. In line with Adner's (2006) integration risk, Technology X has to fit the current operations in the system to make it viable. Although the standalone value (Pianura, 2012) is great, it is still limited in relation to what it can bring with the systems in place already. The **relative advantage** and the performance of Technology X is still the most vital factor according to LI, although the risk at this stage is not very high. It will be greater when a full investment is needed, which would likely be around 100 million

Swedish kronor. The performance decides if Technology X will even be considered and the flexibility of Technology X is key. Depending on how many processes it will be able to do, it would increase the potential rewards and increase the chance of adoption. The **maturity** of the technology was not considered to a large extent, and in this case, was no major factor. A reason why it was not having a major role is that the company is trying something new and what was discussed in the **internal** section is that they are more tolerant to risk and don't expect Technology X to have a track record.

Complementary services were not discussed, because the project is not a full-scale investment and could become more relevant for full-scale investment.

The **society** factor has worked as a trigger in this case, although it has not affected the **external institutions** or **market** to a large degree, making LI's current decision seem irrational. However, as a strategic decision for the future, it becomes more rational. Further, the **relative advantage** is the deciding factor for the technology to be potentially adopted.

5.1.5 General recycling and waste management

External

This case highlights the vast impact that **society** factors can have. There is a clear trend on both a local and global scale towards companies being more circular and aware of the climate, which is affecting the industry. The EU is going green and RW notices that the general awareness in Sweden is rapidly increasing. The landscape pressure is big and it slowly and indirectly changes the industry from a higher level (Geels & Kemp, 2020). Although there is not a direct effect on adoption, it has triggered a change and is affecting other factors to have a positive impact on the adoption of new technology, such as **external institutions**, **market** and even several internal factors. This is in line with the theory that it doesn't impact lower levels such as regimes and niches directly (Rip & Kemp, 1998). On the contrary, without the pressure from **society** factors, many actions seen today would not have taken place, as inflicting such large changes would be too complex to carry out (Rip & Kemp, 1998). In this case, actions toward reacting to the pressure from climate change and being more circular are having a positive effect on the adoption of Technology X.

The **external institutions** in this case were a positive factor. The external institutions used to be stable and the rules of the game (Bergek et al., 2018) provided no incentives for any change, as there had been no larger (technological) changes in the previous 20 years. However, the new regulations demanding sorting and recycling whenever possible pushed towards change. This has been having a positive effect on the adoption of new technology. This resonates with Peng et al. (2009), who argues that although trends are present, it is the formal external institutions that will have the larger effect and impact decision-making more directly. Further, the **market** has also been influenced by the **society** factor since customers want to lower their CO2 emissions, although they do not want to financially contribute to this. RW thinks, however, that once one firm starts sharing CO2 emissions costs with customers, other firms will soon follow. This would be in line with NIT (Suddaby et al., 2013) that states that firms react to the pressures from other organisations, even though it might not be favourable in the beginning in economic terms. Further, Technology X is compatible with the new values and beliefs of the market and could further explain the positive impact the **society** factor indirectly has on the market (Rogers, 2003).

Internal

The **internal institutions and risk** were affected by the **society** factor and changed in terms of company values and behaviour. This led to Technology X being more compatible with internal company culture, resulting in a positive effect for adoption (Rogers, 2003). However, RW characterises the organisations as reluctant towards change and doing something for 20 years sets its marks and shows what Sydow et al. (2009) describe as organisational lock-in. **Path-dependency and resources & capabilities** would thus harm the adoption. RW, though, does not think that lock-in will pose a large problem when adopting Technology X. Additionally, there would be a need for new knowledge and related processes, but RW does not see big adjustment problems here either. The cost related to this update would not have a large negative impact either (Arthur, 1989; Weiss et al., 1994; David, 1995).

Technological

The **ecosystem fit** is not to be considered a large challenge in this case and would be managed rather easily according to RW. In that case, the interaction risk (Adner, 2006) would be rather low and this would then have a positive effect on adoption. RW does not see the low **maturity** of Technology X as large risk, as the first tests with the technology showed satisfactory results. The newness and uniqueness of Technology X show the lack of maturity but is within RW’s expectations of new technology.

The **relative advantage** of Technology X, including the potential of gaining valuable materials from waste, was still the most important factor, in line with Rogers (2003) and Ventakes et al. (2003). Further, the most promising test with Technology X showed a clear financial incentive; material, which usually carries a disposal cost of 1200 SEK/ton, could be transformed into a value that could be sold for 500 SEK/ton, increasing RW’s profit with almost 2000 SEK/ton. This, however, does not include the cost of Technology X and additional related knowledge and processes. **The complementary services** could still be a potentially important factor but were not further covered by RW, as they are in the midst of the adoption process. The stated reason for not investing in Technology X yet is because the producers have not been clear on the form of payment, whether it would be a commission, rolling service, or another option. Even if the type of payment would be clear though, it seems like complementary services will not make or break the decision at this stage.

This case clearly shows the interplay between the factors, which impedes the determination of importance per factor. The **society** factor, though, worked as a trigger for a series of events that led to actions that pushed towards new technology. It impacted **external institutions** and the **market**, which had a direct positive effect on the push towards sustainability and the adoption of Technology X. In the end, though, it comes down to **relative advantage** if specifically Technology X will be adopted. But if the **society** factor did not inflict the changes that it did, the company would probably not have bothered to look into the technology at all

5.2 Cross-case analysis

In this section, cross-case analysis will take place. First, a brief display of the common patterns of factors that affect the cases will be covered, to further move into specifically the factors and how they had an effect on the adoption decision and how the factors relate to each other. Generally, the **relative advantage** is the factor that has had the largest and most consistent impact on the adoption and is working as a fundamental factor that has to be satisfied. Further, **society** factors have been working as an underlying force creating an environment that has made adopting Technology X easier and triggered actions for change, it has had different indirect impacts on the cases. Further, each case brings some uniqueness, and just looking at some particular factors will not tell the whole story.

5.2.1 Similar factor effects across cases

The **society** factor has been having a positive effect on all adoption cases. Technology X's sustainability, applicational area, and innovativeness fits well within the expectations of current environmental trends and is underlying all other factors. Further, the **relative advantage** is one of the most important factors in each case that has been covered and is a fundamental factor that is affecting each case as well. There is also a clear positive effect coming from the **internal institutions and risk** factor in most of the cases. Additionally, the **ecosystem fit** does not positively affect the adoption decision in any of the cases.

The **society** factor affects each case through environmental trends that are pushing towards change. It acts like a primary factor that is of higher importance than the other factors because it is what pushes the change in each case in the first place. Environmental trends are highlighted as primary landscape drivers in each case, but climate change is regarded as a large and long-term change to the world in these cases as well. Though societal views, legislation, and policies enforce change towards sustainability, the individual responsibility for this change is felt in most cases as well. In resonance with theory, these developments together form a mould through which businesses can innovate (Rip & Kemp, 1998). It can be argued that without this mould businesses could innovate in any direction and wouldn't choose to utilise Technology X as the next step in sustainability that can bring their business forward in environmental terms. Without the consideration of adoption in the first place, other factors don't come into play at all.

The positive contribution of the environmental landscape pressure towards adoption is noticeable in each case. In case (1) there was a strong call to isolate black carbon to be able to recycle it. Black carbon is very polluting and can't be discarded anywhere without negatively affecting the environment. The call to take care of it came from the landscape level and while it didn't explicitly force any business to innovate here, the pressure was felt by RW and they reacted. Case (2) has shown that HP had good possibilities to extend up- and downstream operations by copying overseas techniques, but the pressure from Swedish society was too large to adopt these unsustainable techniques. HP rather waited for a good opportunity to innovate into sustainability to maintain the positive picture that society had of them in the first place. SQ in case (3) has explicitly mentioned legislation and policies that were forcing their industry to become more sustainable. Although these are institutional pressures, these institutions have already been heavily influenced by landscape developments. The environmental trends have, however, personally affected SQ to a large degree, so the landscape pressure was extra large in this case. In case (4) it had a direct effect on the **internal institutions and risk** and fundamentally changed the company's values and made the company look into the technology. In case (5) the **society** factor had a direct effect on the **external institutions**, which forced companies to change and adopt new technologies.

In cases (1) and (2) the **society** factor had an indirect effect on adoption and acted as an underlying force. In case (3) and (4) the landscape pressures had a personal impact on the adopters (interviewees), which led them to adopt sustainable innovations. In case (4) this happened before external institutional pressures turned towards sustainability. In case (5) the landscape pressures have already affected the external institutional environment which, characteristically, enforced change from the regimental actors (Bergek et al., 2018). Without external institutional change, RW would not have looked into potentially adopting Technology X.

The **relative advantage** factor poses as the most important factor that after the **society** factor is considered before any other factor. In every case, the relative advantage - meaning the advantage it potentially has over existing technologies or methods - is strongly considered before adoption. If a potential adopter does not see the advantage of Technology X over their current technology and processes, they won't move to adopt Technology X. If there is, however, a relative advantage over current methods, adoption is not excluded, but not guaranteed either. In the case of positive relative advantage, the other remaining factors will then be considered and an adoption decision - either positive or negative - will be made after this consideration. **Relative advantage** is strongly considered in every case and is something that has to be proved through many tests. There is no evidence that after exclusively positive tests a guaranteed adoption will take place.

In almost all cases there is a positive effect coming from the **internal institutions and risk,** where either the culture of the company or the characteristics of the adopters has had a positive impact on the decision of adopting. If internal institutions dictate behaviour that does not support adoption, or if the risk is internally perceived as too high, adoption would be very unlikely, as internal support is (completely) lacking. This factor highlights the internal willingness to take on risk and the individual decision-making processes. As Technology X is a new and generally unknown technology, adopting it would naturally be risky for any business as its performance in every aspect is unknown. Therefore, there must be willingness within each business (owner) to take on this risk and try to mitigate it during and after adoption. In line with Peng et al. (2009), the adoption decision requires some strategic decision making from the internal institutional point of view and the alignment of internal values and beliefs. Case (1) has shown willingness to take the risk of adopting Technology X, but also a negative example of when the risk cannot be mitigated. Eventually, negative aspects on performance of Technology X and lack of **complementary services**, after full adoption, led to the disposal and replacement of Technology X. Case (3) and (4) are impacted by the strong willingness to take on risk for a good cause (as dictated by the **society factor**) by the key decision-makers and try to make the adoption of Technology X work in support of environmental trends (Rogers, 2003). Case (5) showed some reluctance internally to the adoption of Technology X but displayed that risk had to be tolerated anyhow to meet **external institutional** pressures (fuelled by **society pressure**) of adopting sustainable innovations. Case (2) is the only case where internal institutions and risks did not play any role in the adoption decision. A possible explanation is that HP is still very early in the adoption process of Technology X and isn't fully aware of the potential risks, performance, and statistics of Technology X.

The general acceptance of risk is a possible explanation for why the factor **maturity** hasn't played a bigger role than it has. Technology X is not mature yet, which is accepted and expected by adopters. Low technological maturity generally brings on more risk and these factors show to be inverse in adoption cases. Another reason for the acceptance of low maturity was shown to be the early stages of the adoption process. Especially in case (2) and (4), the adopters have stated that they are (far) before the full-scale adoption stage and are still familiarizing themselves with Technology X. HP from case (2) is still in the middle of the testing phase and isn't fully aware of Technology X's performance yet. Maturity is a factor that comes in place later for them. LI from case (4) has only just reached the first agreement with the developers of Technology X and will go through a thorough testing phase entering a full-scale adoption phase and starting to more seriously consider maturity.

5.2.2 Arbitrary factor effects across cases

The landscape effect from society, relative advantage, and the risk-maturity factors have been present consistently through each case and affect each adoption decision in their way. Looking at the other factors, it becomes clear that not every factor is always present and that the relative weight put on them by adopters differs each time. While some factors affect cases differently, other factors appear to have very similar effects on adoption cases. The next paragraphs will deal with how these factors behave throughout the cases.

External

External institutional pressures have been described in most interviews, but they affect the adoption decision in different ways. Generally, the guiding pressures of external institutions have been felt throughout the cases where they were mentioned. The dictation of regimental behaviour through setting rules and ensuring that actors become very similar to each other (Teo et al., 2003; Geels, 2004) have mostly been experienced as blocking mechanisms that would rather steer away from adoption of Technology X, apart from the waste management case where it supported the adoption case. They worked to keep the actors on previously set paths and innovate from within the accepted norms and rules (Berkhout, 2002; Geels, 2004). Therefore, the case findings for external institutional pressure resonate strongly with existing theory in that regimes are slow-moving, external institutional pressures act to keep actors on a pre-set path and groundbreaking innovations are generally introduced from outside a regime (Schumpeter, 1934; Rip & Kemp, 1998; Teo et al., 2003; Geels, 2004; Bergek et al., 2018).

On a smaller scale, **market** pressures don't appear consistently in every case either. As Technology X is very new and unique, potential adopters have already considered that the market is unfamiliar with it and that it is unclear how it will react. The market tends to be concerned with technologies and techniques that are already prevalent or that have been introduced to a greater scale than Technology X. People's idea of a mill is pretty primitive and the applications that Technology X has are rather unknown in each case so far. As the market's attention is elsewhere, Technology X can be developed and slowly introduced to market players, unaffected by regular market conditions (Kemp et al., 2001). RW, from the waste-management company, stated, though, that their market was very open to new sustainable technologies as the same old technologies had been used market-wide for a very long time. Further, in case (4) the **market** had a clear negative impact on the adoption of Technology X since the customers didn't want to pay the premium price for a more sustainable product. Societal and external institutional pressures were already large enough that the market had been impacted as well and the path for new technologies has been largely paved. In the other cases, the idea of the market's attention being elsewhere is prevalent, which makes the market a weak factor that does not heavily impact adoption positively or negatively, making it a secondary factor to the other external factors.

Internal

Path-dependency and resources & capabilities tend to either affect the adoption negatively or not at all. Consistently through adoption cases, when a firm is very locked into their processes and investments, there is a reluctance to adopt a new technology that will break these. On the employer level, the waste-management firm experiences a reluctance to switch to a completely new technology that operates completely different from the old prevalent design. Employers have to be re-schooled, experience and knowledge have to be built up from ground level and there will be a short drop in efficiency as employers are familiarizing with the new technology. From a more corporate perspective, RT from the rubber recycling company mentioned that the current adoption of Technology X cannot take place as large investments have been made in machines and techniques that fit together, can work together, and ensures a smooth chain of efficiency of the recycling process. Technology X would not fit in this chain and disrupt currently used processes, which would create the need of investing in new, fitting technologies and the design of new processes. So, the switching costs would be too great. HP mentioned a very similar adoption process to RT, although they were not as locked-in as RT and had more room to establish new production processes. In all three mentioned cases the internal lock-in makes adoption of innovations more difficult and constitutes a negative factor, in agreement with Arthur (1989) that (technical) lock-in effects would exclude new competing technology, even if it is superior in performance. In the other cases, the technology was unique and efficient enough that no internal disruptions would take place, as it fits within existing processes. Technology X could be "plugged in" and set to work properly.

Technological

The **ecosystem fit** is very similar to what has been described in internal path dependency and lock-in. It has a certain interplay with this internal factor but looks more at how Technology X technologically would fit the external processes in the system, suppliers, addons, complementary systems, etc. In most cases, this factor is not a factor that has a great impact on the decision. Adner (2006) and Pianura (2012) argue that the standalone value of new technology is not exclusively sufficient for adoption and that a misfit to the value chain could even completely prevent adoption. However, an explanation for why this factor hasn't played a large role is that in most cases a new approach or process is being implemented and it doesn't have to be connected to the existing ecosystem, but rather creates a system of its own. This makes the ecosystem factor not as important and weaker than other technological factors in such cases.

Nevertheless, case (4) shows the individual importance of the **ecosystem fit**. If a full-scale investment of Technology X was to be done, a good fit to the logistics system and production line processes is a must and without it, adoption will not take place. Additionally, in case (2), the hemp suppliers require a certain specification of the output and if Technology X couldn't deliver on this requirement, additional investments would be needed to satisfy these criteria anyway, which would affect the adoption decision negatively. **Ecosystem fit** is not a factor that distinguishes itself as an important factor, but it is argued that it has to be taken into account anyway because it still can tilt the adoption decision in a certain direction.

Finally, **complementary services** are an underlying factor that did not surface during the initial decision of adopting Technology X. RT mentioned that after adoption and during application of Technology X the complementary services proved to be lacking or missing, which very heavily impacted the decision to replace Technology X. HP looked in the future and stated that missing or non-adequate complementary services would affect their adoption decision and could lead to a replacement of Technology X, after adoption, as well. In other cases, it was found that complementary services were not a point of concern until the interviewee was explicitly asked for their opinion on them. The unanimous answer of interviewees was that these services are indeed very important and that bad service quality would cloud their judgment of Technology X. As Technology X generally is to be adopted for the long-term, the importance of complementary services only becomes greater. Therefore, complementary services are ranked lower in the order of the first factors to be considered, but the further an adopter comes into the adoption decision and process, the heavier it seems to weigh in the overall decision. These findings resonate strongly with theory; Grönroos & Svensson (2008) describe the developer of technology as a facilitator of value not just in terms of product performance, but especially in complementary and aftermarket services. Manyika et al. (2012) argue that the line between products and services is becoming more blurry, which can be seen in the shaky adoption case of RT.

5.2.3 Inter-relatedness of factors

Several adoption factors cannot be viewed independently from the others when looking at how they affect the adoption decision. Underlying every other factor is the **relative advantage**. Throughout the cases, the performance of Technology X is the very first thing that is looked at when considering adopting. The relative advantage, in every case, has to be similar at least, but ideally vastly outperforming current technologies to justify any investment or process changes that will have to take place later. If Technology X would underperform on any of the adopter's expectations, other factors won't even be considered as the decision of adopting the technology has already been negatively made. Relative advantage is the engine that drives the decision; without an engine, there is no movement. The importance of **relative advantage** is discussed in theory and considered as one of the most important factors (Rogers, 2003; Venkatesh et al., 2003) – a view that is supported in this report as well. However, the way the factor integrates with the decision is not very clearly discussed. We would argue that **relative advantage** works as a prerequisite for adoption to take place, thus **relative advantage** has to be positive but that doesn't mean that the technology will be adopted. Further, the **relative advantage** itself is complex, and performance can vary in dimensions, relativism, and is viewed as subjective by the adopters. This makes the factor more sensitive to the variance in cases. For example, in case (3), the expectancy of performance was huge, but the reason why that might have been the case could be influenced by the characteristics of the adopter flowing from **internal institutions and risk**. SQ showed very clearly the visionary nature of the adopter and without this characteristic, the expectancy and potential of the technology might have been perceived differently. Further, in a lot of cases, Technology X is used to bring some uniqueness which could be valued very differently, either as a risk or as a strategic advantage as in case (4). Although the general take is that the factor is one of the most important and works as a must for an adoption to take place, how that **relative advantage** is fulfilled or not seems to differ in cases.

The external **society** factor is a driving factor as well. It works as an underlying force that guides actions and pushes companies in a certain direction. It becomes more clear how important the effect of the **society** factor is in stable regimes with consistent rules (Teo et al., 2003; Geels, 2004). In these cases, **society** could work as a destabilizing force on the regime (Rip & Kemp, 1998), which triggers a change that will have a positive effect on several actions. In most cases, it pushes towards actions in an indirect way by influencing factors in the external, internal, and technological umbrellas**.** Consistently through the data collection phase, the landscape has proven that it has pushed potential adopters to consider Technology X. If, for example, society's concerns wouldn't focus on climate and sustainability, but something to the contrary, Technology X would not be able to score as well on its sustainability aspects and adopters would not actively search for innovations such as Technology X. The **society** factor can influence internal and other external factors that led to being looked into the adoption in the first place. Further, there is some evidence that the effect of the **society** factor has increased over the years. In the timeline of the most dated cases, there are three active mills of Technology X. Currently, though, there are outstanding orders of 25.000 mills, which, apart from individual business success, could be a sign of slowly changing regimes that have been gradually affected by landscape pressures (Geels & Schot, 2007).

The **maturity** of Technology X seems to be very tied to the **internal institutions and risk** that potential adopters are willing to take. In every case, it has been obvious for the interviewees that Technology X is a novel innovation, unique and that it has no track record. Therefore, Technology X has not matured or even entered the maturity stage. The risk of adopting it becomes automatically higher (Turnheim & Nykvist, 2019), and adopters with a high(er) risk tolerance are needed to allow Technology X to see daylight. Therefore, it has been seen that the interviewees don't consider maturity as an important factor, as its effect on adopting would be negative by nature. Additionally, it has been seen that adopters in the early adoption stages are more concerned with other factors, such as performance, and don't consider maturity at this point. In all cases, except case (1) the adopters have been in an explorative phase and trying something new. This exploratory phase and searching for something new also becomes evident that the internal factors have played a positive role, with the risk-taking and characteristics of the adopter, further the **path-dependency and resources & capabilities** in an explorative phase would not either be affecting a decision in a negative way to the same effect as if the objective would be to substitute a technology. **Maturity** could then still be a major factor in a case where substitution or a full-scale investment would be the objective, in the aspect that in a substitution case there is something to easily compare to and in a full-scale investment the perception of advantage might switch towards more of reliability than the flawless output.

Finally, **path-dependency and resources & capabilities** are linked with the technological **ecosystem fit**. The ecosystem consists of a firm's connection to external systems and supply lines that have been established before the adoption of Technology X which is connected to the internal of the firm. If a supplier is accustomed to the output of a specific process or previous machine it will expect the same output in the future, so just because an internal change might work it doesn't mean it will fit the ecosystem surrounding Technology X, which is in line with what Adner (2006) describes. These factors then become interlinked in both ways and it is important to try to picture a full view of the situation to be able to understand what consequences some actions might have. Although it might improve internal efficiency, the whole picture might bring less value to the company. See Figure 5 for a visualisation of the inter-relatedness of the factors.

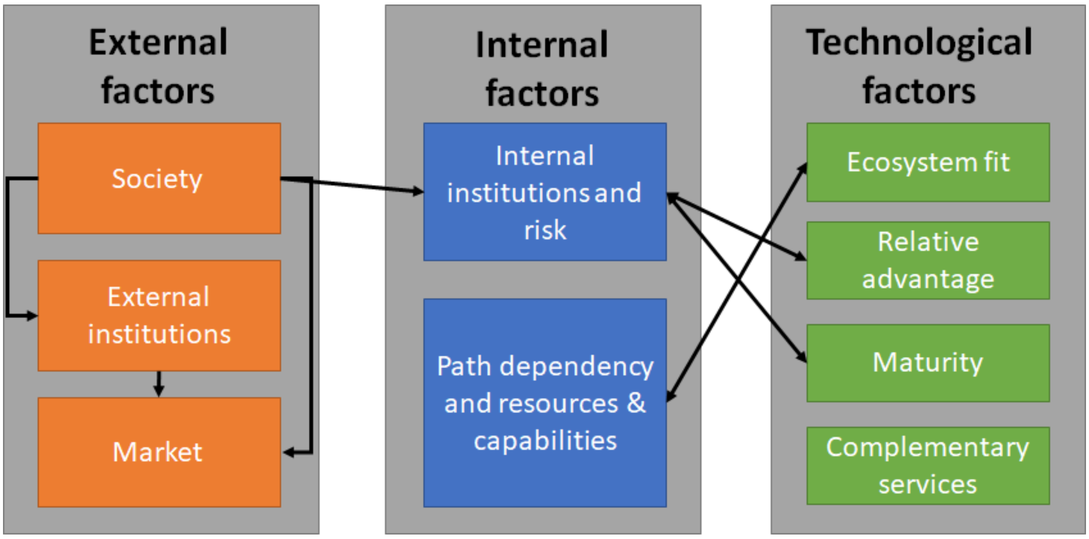

Figure 5*: The interrelatedness of the factors*

6. Conclusion

Research question 1:

How do different factors affect an adopter's decision on adopting a new milling technology?

The purpose of this research is to try to understand how the factors have an impact on the adoption decision and how they relate. The factors **society** and **relative advantage** are the fundamental factors that drive the adoption decision in every case in the first place. The **society** factor provides motivation and incentives for companies or businesses to look into the adoption of a sustainable milling innovation in the first place. Without this driving factor, or if it would point in another direction, Technology X would not surface as a technology of interest to such stakeholders. In some cases the **society** factor has enforced new regulations that triggered the regimental change, while in other cases it enforced a change of internal culture in favour of Technology X. All in all, it has affected the actors' view of the future landscape and how to operate in it, or had a positive effect on their business pushing for larger opportunities.

Once the sights of a potential adopter have been set on Technology X, **relative advantage** becomes the next important factor. It is the factor that determines if the adoption process will be terminated or continued. According to adopters, Technology X has to be similar at the very least, but ideally vastly outperforming current technologies, for the adoption process to continue. If this is not the case, no adoption will take place. It has become clear that although **relative advantage** is central in each case, it is far from being the single factor that decides if an adoption takes place, even if it is positive.

Looking past these two driving factors, each case is subjected to a unique set of factors that impacts the adoption decision differently. It has been found that **internal institutions & risk**, if mentioned to affect the first place, generally have a positive contribution. **Maturity** is a factor that is somewhat connected to internal institutions & risk and its low nature is accepted by most adopters; either because they are risk-takers, or because they are still in the early stages of the adoption process. **External institutions** and the **market** factor affect the adoption cases in different ways and either contribute positively, negatively, or not at all to an adoption. **Path-dependency and resources & capabilities** is a factor that, when applicable, hampers a firm from innovating or adopting unfamiliar innovations within the firm's setting. **Ecosystem fit** either remains unmentioned or surfaces as a negative factor when Technology X has proven not to fit well to existing internal processes and techniques. Finally, **complementary services** are a factor that plays a role in the later stages of or after the adoption process and is not the primary concern during the adoption process. It serves to keep adopters satisfied with Technology X and plays a role in the long-term application process of technology when the value extracted from it is a combination of both the product and related services. It is the sum of all these factors that creates the condition of adoption and what ultimately will decide the outcome.

Research question 2:

How do these factors interplay with each other?

Each case has brought some uniqueness and the factors are very interlinked. Trying to pinpoint the impact of each factor will be unreliable. Rather, the connection of factors highlights the importance of not looking at individual factors but looking at the complete picture to uncover how the combined factors impact an adoption case. As stated in the answer to the first research question, every factor is underlying to **society** and **relative advantage** factor; without the positive effects of these two, the other factors would not even be considered. They work in different ways, though, whereas **relative advantage** acts as a gatekeeper for a continuation of other factors and the **society** gravitates towards certain actions and breaks chains, thus allowing and/or pushing for change. The **external institutions** and **market**, the latter being a part of the former, showing inter-relatedness by definition, are related to the **society**, as changes on the landscape level can destabilise regimes, introduce legislation and policies and change views and expectations of market actors. The strong relation between the three is especially seen when **external institutions** and **markets** have already changed and together enforce the adoption of innovations in line with their views. Further, **society** has displayed that it can have a direct impact on internal **institutions and risk**, which can be vital for an adoption to take place.

In situations where a company is in an explorative phase, trying to create something new, experimenting, etc, there is a certain tendency that **maturity** won't be playing a large role in the decision and the **internal institutions and risk** will be a positive factor in the sense of being willing to tolerate larger risks.

The **internal institutions and risk** can affect the perceived **relative advantage** of Technology X through the characteristics of the adopter. If the adopter is a risk-taker, dreamer, and optimist, the **relative advantage** increases in their view and is looked at more positively from inside the firm. **Internal institutions and risk** also impact the view on the **maturity** of the technology, as the characteristics of risk tolerance accept Technology X's low maturity and don't perceive it as a strong blocking mechanism.

Finally, the **path-dependency and resources & capabilities** factor is tied to the **ecosystem fit** as a firm's ecosystem consists of its internal processes and techniques. Suppliers and customers are accustomed to certain in- and outputs of the focal firm and just because an internal change takes place, it does not mean that it will fit well into this ecosystem. Therefore, both factors are dependent on each other and determine how well a new technology will fit internally and externally. See Figure 5 for the inter-relatedness of the adoption factors.

6.1 Managerial implications

The research implications are aimed at adopters and producers of new technology. This study shows that producers of technology should not solely focus on the technology's performance, but on the whole picture of adoption factors, as not one single factor is decisive in the adoption process. The adoption decision is more complex than it seems and it is advised that producers consider several factors when looking at the potential adoption of their technology. Several factors cannot be influenced by the producer, while other factors can. The external factors point at why an adopter would consider an innovation in the first place and how their environment would react to that innovation. A producer can use this to understand if their product is aligned with developments in society, industries and markets. The internal factors provide insights into internal adopter processes and can be used to understand what is considered by the adopter when looking at innovations. Finally, the technological factors can directly be impacted by the producer and can alter (improve or worsen) an adopter's view on the producer's technology.

A developer of new technology should be able to use this study to be able to find markets or industries where their product might gain greater traction and thus have a greater chance of adoption. This can be done by using the introduced framework to see in which potential approach to this industry would give an outcome. The first penetration of an industry is hard and finding the first clients is even harder. This study provides a good chance to save a producer's resources and time and allow them to locate the industry with the best conditions for adopting their technology.

In line with technology producer implications, adopters of the technology will benefit from being aware of the combined effect of factors as well, helping the company towards a successful adoption in the end. Some factors, such as society, will affect the decision indirectly and hard for adopters to influence themselves. This knowledge could make it easier to cope with sustainability issues and future regulations and policies on sustainability and environmental issues. Further, although an innovation might get adopted, the implementation and use of the new technology might not go down as expected. This is the result of an immature technology that carries risks, and it would be useful for an adopter to consider those risks and their current situation before adoption. By being aware of the adoption factors, adopters can either prepare themselves by mitigating risks or learning how to deal with them, as an adoption might not be worth it without any of the precautions.

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Appendix A: Interview guide - experts

Short introduction and context of industry

- Industry and business
- What role does the person interviewing have in the company business
- Brief overview: location, size, products, profit, market-structure

Triggers, motivations and initial Incentives for looking into the new technology (what made them consider it)?

General questions

- What do you see as the general main factors that are affecting a company's decision to adopt or not adopt the new technology?
- What are some difficulties/benefits you usually hear?
- Would you agree that the performance is the prerequisite for a company to show any interest at all? (Maslow's pyramid of needs)
- Are there a lot of similarities regarding difficulties/benefits when you are approaching customers of different industries or are the factors that are to be considered of the decision very different depending on the industry??

Technical:

- raw data on performance
  - jet-mill
  - standard older
  - other comparable mills/'previous version'
- efficiency
- cost
- performance
- volume

- Technology
  - Did it fit into the ecosystem with your actors in the industry?
    - suppliers, standards, services- aftermarket
    - Are you trying to win bigger clients now that you previously thought only large output mills could win over?
  - Maturity
    - How did you perceive the risk of new technology?
    - Was the technology tested in a similar context before?
  - Relative advantage
    - Compared to the old technology/processes how was the performance?
    - Compared to the old technology/processes how was the cost changes?
    - How did you perceive the risk-reward with the technology alone?

Ask about the individual cases:

Success/fail criteria

- What was the main factor for success/failure?
- What would make you re-evaluate your decision?
- How did you perceive the overall risk-reward with the decision to adopt the new technology?
- What made you choose this specific technology and not older more established ones?
- How do you look at aftermarket and complementary services offered by Technology X?
    - maintenance
    - replacements
    - full-package
- What were the biggest uncertainties when adopting/not adopting

Why and what are these?

Appendix B: Interview guide - cases

1. **<u>Short introduction and context of industry</u>**

- What is your name and what role do you have in the company/business?
- What industry and business are you in?
- Can you give a brief overview of company/industry dimensions?
    - Location
    - Size
    - Products
    - Profit
    - Market-structure
- How important is the output/product in discussing for the company?

2. **<u>Decision process of adopting</u>**

- How do you assess the new technology (or others) you are investing in?
    - Long-term
    - Short-term
- What criteria are the most important?
- What were the main reasons you adopted or not?

3. **<u>We have divided our research area in three sets of conditions/factors that are applicable for you to adopt a Technology X's mill: external environment, internal environment and technological aspects. Which factors of these sections are most important to you when it comes/came to deciding to adopt Technology X's milling technology? (the following list is made up of suggestions; not each suggestion is necessary)</u>**

    A. **External**

    - Regulations
        - Are there any technical standards that have to be considered?
        - More general regulations to consider?
    - Trends
        - Are there any trends such as the environment which pressure the industry?
        - others?
    - Market
        - What does the market expect from your products?
        - What value do customers see in the product?
    - Industry
        - Is the industry fast-moving?
        - Has the same technology been used for a long time?
            - by all companies?

        - different approaches?
    - Networks
        - Are there a lot of partners involved in making the product/service?
        - Partnerships?
    - Are there a lot of new companies entering the market?

B. Internal

- Organisation
    - What is your company’s vision/purpose?
    - How would you define the culture of the company?
    - How is the company structured
        - Hierarchy
        - Flat
    - Did the new technology fit with the vision/purpose?
- Resources and capabilities
    - What technology, processes, capabilities did you use before the adoption (or still if not adopted)
    - Did you need to invest to be able to use the new technology
        - Knowledge
        - Processes
        - Capabilities
    - Would the new technology destroy some of the old or did it fit into the current system?
        - Knowledge
        - Processes
        - Capabilities

C. Technological

- Did it fit into the ecosystem with your actors in the industry?
    - Suppliers
    - Standards
    - services- aftermarket
- Maturity
    - How did you perceive the risk of new technology?
    - Was the technology tested in a similar context before?
- Relative advantage
    - Compared to the old technology/processes how was the performance?
    - Compared to the old technology/processes, how was the cost changed?
    - How did you perceive the risk-reward with the technology alone?

4. <u>Success/fail criteria on adopting the milling technology</u>

- What was the main factor for success/failure?
- What would make you re-evaluate your decision?

- How did you perceive the overall risk-reward with the decision to adopt the new technology?
- What made you choose this specific technology and not older more established ones?
- What were the biggest uncertainties when adopting/not adopting
    - Why and what are these?

5. <u>Future of the technology and final questions</u>

- Is this technology the future for the industry?
- Do you see more companies adopt it within the short or long term?
- If you would be able to change anything with the technology to make it easier to adopt what would it be?
- Is there anything we haven't touched upon that was important for the success/failure of adopting the technology?
- Is it okay if we contact you later for a follow-up if we need to complement the interview with some extra questions (perhaps email is fine).

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