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The influence of contextual enablers and challenges in business-to-business product development projects

Categorizing contextual factors in product development projects in Finnish companies according to PESTEL framework

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Abstract

This thesis maps out contextual factors experienced as enabling and challenging in Finnish business-to-business product development projects through empirical qualitative research. These factors depend on the context of the use and development of the product and therefore include some external and societal factors as well as factors internal to the company. Salient contextual factors perceived by engineers working in four business-to-business product development cases were divided into enablers and challenges and compared to the factors found in the literature. Based on this analysis it is deduced what should be improved and what could be better utilized in product development.

Eight qualitative interviews were conducted on four product development cases. In order to systematically analyze the collected data, thematic analysis was used to categorize reported contextual factors according to the PESTEL framework, which includes six contextual societal dimensions: Political, economic, social, technological, environmental, and legal factors. The identified 384 PESTEL connections were mapped to the six PESTEL dimensions: Political (n=32), economic (n=72), social (n=69), technological (n=134), environmental (n=33), and legal (n=44) factors. Furthermore, the PESTEL dimensions were divided into 24 subcategories in total, representing the contextual factors. From this categorization, clear main contextual enablers and challenges are identified.

Comparing the results to extant literature shows that three common themes emerge. First, resources are perceived to dictate the progress of product development projects. Second, the use context of the product influences the user and the used technology. Third, innovation is affected by environmental pressures and legal constraints. Based on these emerging themes, a framework for practical level product development is presented as a guide to handle the practical level product development for anticipation and managing of the challenges and enablers related to the project at hand.

To conclude, this thesis identifies a comprehensive list of relevant contextual enablers and challenges in product development projects and lays a basis for the next steps in leveraging and addressing these factors to improve product development.

Keywords Business-to-business, contextual factors, PESTEL framework, product development

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Tiivistelmä

Tässä diplomityössä kartoitetaan empiirisen kvalitatiivisen tutkimuksen avulla suomalaisessa yritysten välisen liiketoiminnan tuotekehitysprojekteissa mahdollistajiksi ja haasteiksi koettuja kontekstuaalisia tekijöitä. Nämä tekijät määräytyvät tuotteen käytön ja sen kehittämisen kontekstista, ja siksi niihin sisältyy joitain ulkoisia ja yhteiskunnallisia, kuin myös yrityksen sisäisiä tekijöitä. Lopuksi löydetyt tekijät jaetaan mahdollistajiin ja haasteisiin ja verrataan kirjallisuudesta löydettyihin tekijöihin. Tämän analyysin perusteella päätellään, mitä pitäisi parantaa ja mitä voitaisiin hyödyntää paremmin tuotekehityksessä.

Työ perustuu kahdeksaan kvalitatiiviseen haastatteluun neljästä tuotekehitysprojektista. Temaattista analyysiä käytettiin kerätyn tiedon systemaattiseen analysointiin, tunnistaen erilaisia teemoja suhteessa PESTEL-viitekehyksen kuuteen kontekstuaaliseen yhteiskunnalliseen ulottuvuuteen: Poliittisiin, taloudellisiin, sosiaalisiin, teknologisiin, ympäristöllisiin ja juridisiin tekijöihin.

Tuloksena löydetyt 384 PESTEL-yhteyttä kartoitettiin kuuden PESTEL-ulottuvuuden mukaan: Poliittiset (n=32), taloudelliset (n=72), sosiaaliset (n=69), teknologiset (n=134), ympäristölliset (n=33) ja juridiset tekijät (n=44). Nämä jaettiin yhteensä 24 alaluokkaan, jotka edustavat kontekstuaalisia tekijöitä. Tämän luokittelun perusteella nousee esiin selkeitä keskeisiä kontekstuaalisia mahdollistajia ja haasteita.

Verrattaessa tuloksia kirjallisuuteen, havaitaan kolme yhteistä teemaa. Ensinnäkin resurssien katsotaan sanelevan tuotekehitysprojektien etenemistä. Toiseksi tuotteen käyttökonteksti aiheuttaa käyttäjään ja käytettyyn teknologiaan liittyvää kehitystä. Kolmanneksi ympäristöpaineet ja oikeudelliset rajoitukset vaikuttavat innovaatioihin. Esiin nousevien teemojen pohjalta esitetään käytännön tason tuotekehityksen viitekehys, joka ohjaa vastaavien viitekehitysten jäsentämistä kulloiseenkin projektiin liittyvien haasteiden ja mahdollistajien ennakointia ja hallintaa.

Tämä diplomityö identifioi kattavan luettelon kontekstuaalisista mahdollistajista ja haasteista tuotekehitysprojekteissa, ja luo pohjan seuraaville vaiheille tuotekehityksen parantamiseksi hyödyntäen näitä tekijöitä.

Avainsanat Yritysten välinen liiketoiminta, kontekstuaaliset tekijät, PESTEL-viitekehys, tuotekehitys

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It is a bit confusing that I have now reached the end of my studies which has been a significant era in my life. I am proud that I have had the energy and motivation to go through the whole process. Let's see what the world has to offer me next!

Lisbon, Portugal, June 28, 2022

Raimo "Rami" Vepsäläinen

Table of Contents

1 Introduction

A product is the core element of corporate strategy making product development a key function for a company pursuing competitive advantage in the marketplace (Brown & Eisenhardt, 1995). Product planning and development processes have been improved and explored extensively (Cormican & O'Sullivan, 2004; Firth & Narayanan, 1996; Wheelwright & Clark, 1992). The studies indicate, however, that systematic management processes do not suffice for world-class product development due to unpredictable characteristics of user markets, technological progress and socio-political environment (Cooper & Kleinschmidt, 1996; March-Chordà et al., 2002; Tatikonda & Rosenthal, 2000). The need for anticipation of, and reacting to, situational strategic issues apart from regular planning has been emphasized already by Ansoff (1975), and could be applied to improve product development.

Product developers must attempt to design the best possible solution under the influence of uncertain contextual political, economic, social, technological, environmental, and legal factors (Blind, 2012; Business Finland, n.d., 2020; Pelkmans & Renda, 2014). In theory, product development can be described as a very structured process, such as Ulrich & Eppinger (2012) present in their book "Product Design and Development", but in reality these steps and the whole process are affected by local and global factors and practices such as regulations, changes in economics and politics, technological advances, and globalization, depending on the business (Cormican & O'Sullivan, 2004; Daft, 2010; Johnson et al., 2017; Kammerl et al., 2017; Pelkmans & Renda, 2014; Sbernini et al., 2018; Ulrich & Eppinger, 2012).

However, these contextual factors may not be only limiting, but also enabling factors, such as technology development and innovation (Dodgson et al., 2006; Pelkmans & Renda, 2014; Satish, 2019). An even broader scale to be considered involves factors from the global politics and economics, ethical considerations such as health and safety, technology development and wider regional regulation (Dodgson et al., 2006; Helbing, 2019; Korhonen et al., 2018; Salminen & Halme, 2020; Santisteban & Mauricio, 2017; Satish, 2019). Moreover, it has been suggested that the enablers from external sources may provide game changing growth possibilities especially for startups (Wallin et al., 2016).

The impact of the business environment of product development in the real world has clear research potential. Namely, if the advantages and disadvantages of the contextual factors are identified, it is possible to minimize or prevent the impact of the disadvantages and make the most of the advantages. In Finland, for example,

there are many supporting factors and incentives related to R&D funding, taxation, training, and employment, which may be leveraged in development efforts, according to the Business Finland websites (Business Finland, n.d., 2020). Better awareness of contextual factors may even provide new business opportunities, as there are examples of starting the development of a product due to recognizing initial needs coming from the surrounding society or it's changes (Kammerl et al., 2017).

1.1 Research objectives and scope of the study

This thesis aims to map out contextual factors, both enablers and challenges, of product development projects, and to compare them to factors found in the literature. The motivation of the present study is to elucidate the effects of contextual factors of the environment where the product development takes place, with emphasis on the practical level. Information on this aspect of product development is lacking, as in most of the previous analyses and studies the company, business or organization has been the center of attention (Business Finland, 2020; Daft, 2010; Johnson et al., 2017). The identification of potential contextual enablers and challenges influencing product development is carried out to enhance the efficiency and quality of future product development processes. The objective is to highlight main contextual factors and themes having positive or negative impact on business-to-business product development projects. A multiple case study of four cases in the business-to-business market are studied and results are compared to existing literature and theory. To reach the goal, this thesis strives to answer the following research question:

What types of contextual factors do engineers working with business-to-business product development projects recognize as enablers and challenges on and by the development?

Addressing the research question will highlight what should be improved and what could be better utilized in product development. The iterative and practical nature of this thesis leads to a process of defining the research question according to the gathered data and results. The research scope of this thesis is product development projects in business-to-business markets of Finnish companies which represented a product already publicly available on the market and where the product development process had been completed. Keeping these factors constant across the cases helps to identify variance relevant to the studied dimension of contextual factors, and eases constructing also theory based on the multiple case study (Eisenhardt, 1989).

This thesis consists of four parts. First, a literature review on the PESTEL framework and contextual factors is presented. Second, the research methodologies for data collection are presented, as well as the data gathering analysis. In the third chapter

the results of the study are presented. Finally, in the discussions chapter the research questions are answered by connecting the case study results to the reviewed literature and concluding the thesis research.

2 Literature review

In this chapter, the literature and theory related to the thesis is presented. First, the PESTEL framework – a tool for mapping societal and contextual factors – is presented and previous studies using PESTEL are reviewed. It is evident that PESTEL has been used in many fields of studies but not as commonly in product development. Secondly, PESTEL related contextual factors are presented with examples in the literature and previous studies. This allows comparison of thesis results and findings in previous literature.

2.1 PESTEL framework

The PESTEL framework has been traditionally used as a strategy planning tool. Originally the framework was known as PEST, covering only political, economic, social, and technological aspects. PESTEL is considered to be an extension of PEST. Over time, alternative versions have been structured for more specific inspection of certain situations and strategy environments. These are for example STEEPLED (Kalous, 2013) (adding ethics and demographic factors), SPELIT (adding legal and intercultural factors) (Schmieder-Ramirez & Mallette, 2007), and DESTEP (adding demographic and ecological factors) (Osseweijer et al., 2017). Also, the PESTEL form is sometimes used in the form of PESTLE (Perera, 2017), which is in practice the same as PESTEL. In this thesis the form PESTEL is used.

The PEST framework was invented by Francis Aguilar from Harvard Business School in 1967 and first presented in his book "Scanning the Business Environment" (Aguilar, 1967; Aithal, 2017). It was invented for the need of a strategic tool which could provide help for predicting decision outcomes – whether they created threats or opportunities. PESTEL framework is often used to perform a PESTEL analysis, where the possible opportunities and threats are identified and categorized to political, economic, social, technological, environmental, and legal influences, for example in decision making (Yüksel, 2012). Furthermore, Johnson and colleagues' (2017) book "Exploring Strategy" presents PESTEL analysis as part of Macro-environment analysis.

In his book, "PESTLE Analysis", Perera (2017) offers a summary of the purposes and advantages of using the PESTEL framework. According to him, by analyzing the external factors in the company environment, the PESTEL framework provides a comprehensive evaluation of the dynamic and competitive aspects. The framework enables a broad understanding of market position, which helps to define what should be changed and what should be kept as it is. The generated holistic understanding also improves product development as it makes room for new product innovations

and re-engineering according to newly discovered enablers and challenges. For example, handling costs and estimating uses of other resources could have a remarkable positive impact in product development.

PESTEL analysis has the potential to be used in various situations of different businesses and industries, with previous research offering examples of its usage for multiple purposes. In the construction and building industry, the PESTEL framework has been used to improve strategy and to identify risks in the projects (Pan et al., 2019; Rastogi & Trivedi, 2016; Ulubeyli et al., 2019). The projects in this industry require well-constructed structure and therefore the analysis is an important tool. In the automobile industry the PESTEL framework has been recognized as a useful tool for analysis, especially for emerging trends such as e.g., development of Toyota's hybrid vehicles and Tesla's fully electric vehicles (Kissinger, 2019; Tan et al., 2012). Additionally, in their studies of strategic models based on PESTEL, Ahmadi et al. (2019) and Issa et al. (2010) also introduce the possibilities to develop strategy by using PESTEL as a tool for a development model and reach a more sustainable strategy plan in the field of cloud computing. Recently PESTEL has been also used to improve the healthcare sustainability in waste management during the COVID-19 pandemic (Thakur, 2021).

In this thesis, the PESTEL framework is used as an approach to inspect the contextual factors in product development, with emphasis on the practical level, but also to examine some theoretical implications.

2.2 Contextual factors in product development projects

Factors which influence the relationships between the surrounding environment and product development within a company are known as societal and external factors (Sbernini et al., 2018). According to the Merriam-Webster dictionary the definition for the word "context" is "*the interrelated conditions in which something exists or occurs; environment, setting*" (Merriam-Webster, n.d.), which can be applied to mean the setting where products are developed and used. The definition of contextual factors in company operations is often fuzzy and varying as the definition of context depends on the area of study (Gericke et al., 2013). Mack & Pützschel (2014) define contextual factors in their study of the influence of contextual factors on the entrepreneurial process as political and legal, economic, technological, environmental, social, and cultural factors influencing entrepreneurial process, which is heavily based on the initial product development stages.

On the other hand, Daft (2010) in his book "Organization Theory and Design" and Ismail & Monsef (2012) in their conference paper on contextual factors related to

the organization structure, define contextual factors through dimensions of organization's size, technology, environment, goals, and culture. These can have contextual influence on the organization and on product development projects within the organization. Organizational technology encompasses the tools, techniques and actions utilized in product development. This includes also the concrete technological methods for developing the product or integrated to the product. The contextual factors defined by Daft (2010) and Ismail & Monsef (2012) can be interpreted with reference to product development and they also have connections to the factors related to the PESTEL framework.

However, some authors do refer to contextual factors in different ways. For example, in their book "Product Design and Development" Ulrich & Eppinger (2012) introduce the design approach of focusing on critical economic factors of product development and design for environment (DFE). Kammerl et al. (2017) and Sbernini et al. (2018) in their studies of contextual factors influencing product design and development, explore the meaning and definition of contextual factors in global scale product development. The former authors present factors from all the PESTEL framework categories, with emphasis on legislative changes and new technology, whereas the latter have a similar approach as the present thesis with the research question "Which contextual factors are critical for a successful global product development process?". Outside of product development literature, the textbook by Johnson and colleagues (2017), "Exploring Strategy", offers a comprehensive overview of contextual factors, introducing different analyses and frameworks, including the PESTEL framework. The work by Johnson et al. (2017) is referred to frequently in this thesis, as it provides an excellent background to the work on contextual factors.

Based on the literature reviewed for this thesis, a listing of dimensions covered in previous studies and sources is presented below in Table 1. The following sections examine each of the PESTEL dimensions and their factors in more detail.

Table 1. Contextual factors influencing product development.

Dimension	Authors	Factors
Political	Business Finland (n.d.)	R&D funding Political stability*
	Daft (2010)	Local government Laws, rules, and sanctions Regulations
	Johnson et al. (2017)	Government support Global political stability* Lobbying
	Satish (2019)	Political stability*

Economic	Business Finland (2020)	Economic growth* Local economy
	Business Finland (n.d.)	Tax incentives Taxation
	Daft (2010)	Financial community Globalization Competition
	Johnson et al. (2017)	Economic growth* Workforce Economic cycles
	Kammerl et al. (2017)	Product costs* Competition Limited resources* Globalization
	Santisteban & Mauricio (2017)	Competitive rivalry Financial capacity / resources*
	Ulrich & Eppinger (2012)	Product costs* Development costs* Manufacturing costs* Sales Product price
Social	Daft (2010)	Industry Customer attitudes
	Johnson et al. (2017)	Aging Population growth Health Safety Distribution of wealth Client profiles User profiles Cultural attitudes Cultural mindsets
	Kammerl et al. (2017)	Society
	Ulrich & Eppinger (2012)	Social trends Social attitudes
Technological	Daft (2010)	Technological tools and techniques Internet
	Dodgson et al. (2006)	New technology* ICT Virtual tools Prototyping Experimentation
	Helbing (2019)	Machine learning Artificial intelligence

Technological (continued)	Johnson et al. (2017)	New technology* Technology development Internet Nanotechnology New materials Sensor technology
	Kammerl et al. (2017)	Innovations
	Santisteban & Mauricio (2017)	Changes in technology
Environmental	Johnson et al. (2017)	Pollution Waste Climate change Recycling
	Kammerl et al. (2017)	Sustainability
	Korhonen et al. (2018)	Circular economy Material selection Energy consumption
	Ulrich & Eppinger (2012)	Environment-friendly materials Recycling Clean energy Emissions Reusable packaging Environmental attitudes
Legal	Blind (2012)	Environment protection regulation Labor force regulation Safety regulation Product liability regulation IPR (intellectual property rights) regulation
	Johnson et al. (2017)	Regulation Taxation Legislation Requirements Global politics
	Kammerl et al. (2017)	Legislation changes* Laws
	Pelkmans & Renda (2014)	Patent laws Technology transfer legislation Tax credits Standardization Pre-commercial procurement regulations Obligations to cross-license Legislation changes* Level of legislation

Legal (continued)		Local politics Regulation (uncertainty)*
	Salminen & Halme (2020)	Regulation*
	Stewart (2010)	Regulation*
	Ulrich & Eppinger (2012)	Government regulations Legislation changes* Environmental legislation

* = The factor was found in multiple sources.
Some sources only mention the significance of the factors' influence and some further study the direction or whether the effect is positive, negative, or neutral.

2.2.1 Political factors

Political stability is presented as an enabler and as a challenge or threat (Business Finland, n.d.; Johnson et al., 2017; Satish, 2019). Business Finland webpage (Business Finland, n.d.) highlights political stability as an advantage in Finland when describing it as a stable business environment. Moreover, in a case study of the Tesla supply chain, Satish (2019) as well as in their textbook on strategic management Johnson and colleagues (2017) point out that political instability might turn out as a challenge in local and global politics. They state that political instability in some countries could be considered as a threat for the company's global expansion.

Literature presents support from local government as an enabler for businesses but also the lack of it as a challenge. The book by Johnson and colleagues (2017) introduces government support as a source for new opportunities. Johnson et al. (2017) also mention lobbying as part of the political dimension related to local government. In contrast, in his textbook "Organization Theory and Design", Daft (2010) states that the government is a major stakeholder group which expects organizations to obey laws and regulations and to practice fair competition. Daft (2010) presents an example of the negative influence of government in tightening regulations of monitoring organizations' functions by requiring stricter certifications of financial results. This was seen as a political challenge for the organizations. Moreover, Business Finland webpage (n.d.) lists R&D funding as a political enabler as it helps companies to operate. R&D funding among other starting tools are offered for companies entering the Finnish market.

2.2.2 Economic factors

Local economy is identified by Daft (2010) in his book as an external enabler. Business Finland's (n.d.; 2020) websites agree on this as in Finnish society, the local economy supports businesses (Business Finland, n.d.; 2020). According to their

webpage, Business Finland's (2020) announced strategy includes for example fiscal support in the form of tax incentives in business operations (Business Finland, 2020).

Limited financial resources are defined as potential challenges by Santisteban & Mauricio (2017) who present a comprehensive literature review on success factors in the information technology industry. Kammerl et al. (2017) agree on these challenges in their case study of external influences on product design. Johnson and colleagues' book (2017) point out workforce as an important factor for companies with possibilities to be an enabler or challenge. Related to company capabilities, competition is identified both as an enabler for successful product development (Kammerl et al., 2017; Santisteban & Mauricio, 2017), but also as a challenge due to the pressure it creates for the development (Daft, 2010).

Globalization is listed by Daft (2010) as a challenge because of the complexity it creates, whereas Kammerl et al. (2017) list it as an enabler for added efficiency coming from the complexity. Related to global economic factors, economic growth is mentioned by Johnson et al. (2017) as an important factor, influencing as an enabler when it is fast and creating challenges when it is slow. In addition, the economic cycles are mentioned also by Johnson et al. (2017) as an important macro-environmental trend. At the local scale economic growth is listed on Business Finland webpage (2020) as an important factor which is strongly supported by Business Finland in its activities.

Ulrich & Eppinger (2012) present in their book "Product Design and Development" general characteristics of successful product development. Related to the costs, managing to define the optimal product, development, and manufacturing costs are crucial. Moreover, Kammerl et al. (2017) agree on this for product costs. Lastly, Ulrich & Eppinger (2012) also add to this reaching the optimal product price and sales figures.

2.2.3 Social factors

Social factors related societal and cultural attitudes are mentioned in many contexts in the literature. For example, understanding the attitudes and mindsets of society enables developing products which better answer the customer needs (Daft, 2010; Johnson et al., 2017; Kammerl et al., 2017; Ulrich & Eppinger, 2012). In addition, in their book, Ulrich & Eppinger (2012) argue that social trends and attitudes significantly influence product development, such as increasing environmental awareness which drives for more sustainable products and processes.

Societal and cultural attitudes also define client and user profiles which are similarly important to understand to benefit from their possible enabling influence (Johnson et al., 2017). Daft (2010) presents in his book "Organization Theory and Design" industry as a social factor which could be influenced by a company developing products or *vice versa*. Furthermore, Johnson and colleagues (2017) introduce many social factors related to demographics such as ageing, population growth, health, safety, and distribution of wealth. The need to maintain life quality standards related to these aspects creates new challenges for society, meanwhile offering opportunities for product development.

2.2.4 Technological factors

The technological contextual factors presented in previous literature are new technology and technology development, including innovations, which are identified only as enablers for product development due to creating new opportunities (Dodgson et al., 2006; Johnson et al., 2017; Kammerl et al., 2017; Santisteban & Mauricio, 2017). Furthermore, in a case study of technological changes affecting Procter and Gamble (Dodgson et al., 2006), it has been pointed out that new technologies enhance prototyping and experimenting which enable more rapid testing during the product development project.

Different types of tools used in product development are another common theme that emerges from the literature. Many tools are listed as enablers, including internet, nanotechnology, new materials, information, and communication technologies (ICT), sensor technology, and virtual tools for simulation (Daft, 2010; Dodgson et al., 2006; Johnson et al., 2017). These have been shown to increase the efficiency and straightforwardness of product development. However, as Helbing (2019) views challenges posed by digital revolution in his book "Towards Digital Enlightenment", as he argues that the new technological tools such as machine learning and artificial intelligence pose challenges related to privacy of collected personal data and the control of self-learning methods. With regards to the present thesis, it is important to note that an important property of the technological factors in the PESTEL framework is that they are not related to a single industry but impact multiple industries (Johnson et al., 2017). Accordingly, it is important that the technological factors are separated from product-specific or industry-specific terms.

2.2.5 Environmental factors

Acknowledging climate change is an important theme and frequently brought up in the literature. Issues relating to climate change impact on society, business, and companies developing products and therefore can be considered as contextual factors in product development. Combating climate change requires new solutions for

product development and novel design choices (Johnson et al., 2017; Korhonen et al., 2018). Sustainability related to climate change is clearly an enabler and smart design choices driven by sustainability can also enable product developers to become more innovative (Kammerl et al., 2017).

Environmental pollution is mostly presented in the literature not as a clear challenge but as a limiting influence which could generate challenges. Minimizing pollution, emissions, and waste are listed as general goals for the developers (Johnson et al., 2017; Ulrich & Eppinger, 2012). The potential challenges might come from limitations in the materials that are needed as they need to be environmentally friendly (Korhonen et al., 2018; Ulrich and Eppinger, 2012).

Recycling and reuse of materials concerns factors relating to use of recyclable materials and the concept of circular economy (Johnson et al., 2017; Korhonen et al., 2018; Ulrich & Eppinger, 2012). These aspects largely account for whether a product has positive or negative influence on the environment. Johnson et al. (2017) point out that there are many benefits from environmental activities such as establishing a business based on the recycling industry. In addition, in their study of the influences of circular economy, Korhonen et al. (2018) define the enabling effect of the circular economy as they see it as a positive concept promoting sustainable decisions in strategy and development. Interestingly, however, most sources in the literature do not identify these as challenges or enablers, but as neutral factors that need to be considered.

Ulrich & Eppinger (2012), in their book, also consider environmental attitudes that influence product development through environmental legislation, market demand, competition, and social pressure. For example, tightening environmental legislation brings challenges because of additional requirements for product development. Market demand as an economic and social factor affects the company reputation when selling the product. On the other hand, although environmental attitudes might create more requirements, when these requirements are met, it will improve the sales even more (Ulrich & Eppinger, 2012).

2.2.6 Legal factors

Considering legal factors in literature, regulations are mentioned in many contexts. Johnson et al. (2017) and Ulrich and Eppinger (2012) present that as regulations are often set by the government they can be considered as political factors, but the outcome of the regulations themselves create direct legal challenges and enablers for product development. Challenges or even obstacles for a product development project could result from the area of business being too restricted or uncertain, which

might even lead to development failure (Pelkmans & Renda, 2014; Stewart, 2010; Ulrich & Eppinger, 2012). Uncertainty related to regulation could create a pressured situation with negative effects due to lack of clear requirements.

On the positive side, regulation has the potential to lead to environmentally friendly solutions, higher labor safety products, and promotes the acceptance of new products among the consumers, as stated also by Ulrich & Eppinger (2012). Moreover, in reports and studies of the effects of regulation with regard to innovation and product development in the Finland, EU, and United States (Pelkmans & Renda, 2014; Salminen & Halme, 2020; Stewart, 2010), regulation uncertainty is identified as potential enabler development and innovation processes as it could enable more creativity and enable new innovations.

In addition, studies regarding effects of regulation on innovation and product development in OECD countries and EU (Blind, 2012; Pelkmans & Renda, 2014) list separate types of regulation as legal factors for product development and innovations. These factors being pre-commercial procurement regulation, environmental protection regulation, labor force regulation, product and consumer safety regulation, product liability regulation, and intellectual property protection regulation. Blind (2012) states that the environmental, labor force, and product and consumer safety regulations have the negative effect of restricting innovations with additional requirements and limitations and creates compliance costs, which is largely in agreement with previous authors (Pelkmans & Renda, 2014; Stewart, 2010). Blind (2012) concludes that for the OECD countries, product liability regulation tends to have a contradictory effect, but still somewhat more positive than negative. Blind (2012) concludes that intellectual property rights regulation may be an enabler due to patents that enable at least a temporary monopoly setting. This leads to increased investments in R&D.

Legislation and laws also include references to environmental, patent, and technology transfer legislation (Johnson et al., 2017; Kammerl et al., 2017; Ulrich & Eppinger, 2012). It has been indicated that limitations from legislation could turn out to be a challenge (Johnson et al., 2017; Pelkmans & Renda, 2014). Moreover, changes in legislation may enable new opportunities for product development but may also challenge technological development (Pelkmans & Renda, 2014; Ulrich & Eppinger, 2012). Other legal factors are standardization and requirements related to working conditions, environment, and consumers (Johnson et al., 2017; Pelkmans & Renda, 2014).

Finally, there are also legal factors that are related to politics as the local and global politics play a role in decision-making and controlling legislation (Johnson et al.,

2017; Pelkmans & Renda, 2014). Johnson et al. (2017) give an example of global politics which aim at reducing the carbon footprint, but at the same time create new legislative requirements for organizations developing products. Locally politics control the taxation and possible support via tax credits on R&D which might enable savings in product development (Johnson et al., 2017; Pelkmans & Renda, 2014).

3 Research material and methods

The objective of this thesis is to identify contextual challenges and enablers influencing product development projects in the development considerations of business-to-business products. For this purpose, the thesis engages in qualitative research of four product development case studies and the contextual factors perceived in these. Qualitative research is a viable approach when inspecting the depth and nature of data characteristics, and not the occurrences of characteristics. Characteristics such as interaction, experiences and process environment are in focus in qualitative research (Silverman, 2009).

Each of the four cases included two interviews from personnel who had been developing the case products. The data was analyzed with thematic analysis where deductive categorization of the PESTEL dimensions was combined with inductively categorized subcategories. The predefined questions in the interviews followed a structure of introduction of interviewee and overall case, product development process description, and PESTEL connections.

3.1 Multiple case study

Data collection was done by using a multiple case study approach. Cassell & Symon (2004) explain in their book "Essential Guide to Qualitative Methods in Organizational Research", that case study is a research strategy which focuses on understanding the dynamics of a process by extracting qualitative data and analyzing it through a theoretical framework. Case study is a useful strategy to understand influences in the organizational and environmental context of social processes and the everyday practices thereof (Cassell & Symon, 2004; Eisenhardt, 1989). In this thesis, the case product development projects and related decision making are viewed as these social processes.

In addition, Eisenhardt (1989) argues in her study of building theories from case studies that having multiple cases improves theory-building as multiple cases offer a broader scale of data and possibilities to compare the cases to each other. Due to these advantages this thesis inspects multiple case studies. The broad scale of data supports the objective to inspect the common contextual factors in product development projects rather than just the type of factors which influence product development in a certain field.

The initial list of companies to be contacted was gathered with the help of the thesis advisor and supervisor. Nine Finnish companies with business-to-business products on the market were contacted, and from these, four companies agreed to collaborate

in the study. Data was gathered by studying the four case companies' and the case products' websites and other related public sources such as news articles, and by interviewing two individuals from each company.

The selected cases were four Finnish companies which have developed a tangible product with the primary purpose of business-to-business sales. The tangible form is in line with the emphasis on mechanical engineering, either through the products or the background of the product developers themselves. Moreover, the field also connects to the study program of the thesis. Limiting the scope of the thesis to Finland-centered business-to-business companies increases the validity of comparison between cases as it reduces variation across the societal context of the cases within which the PESTEL dimensions and their effects are examined. The definition of being based in Finland means that the company was founded in Finland, had operations in Finland, and had at least one product available on Finnish markets.

Instead of using the company names and product names, anonymized pseudonyms are used in this thesis. The same applies for the interviewed personnel; their titles and roles are presented, but no names or other information is given. The privacy of the interviews was protected by Aalto University practices and General Data Protection Regulations (GDPR). All interviewees were informed about the practices, and all agreed to them. These practices enabled the interviewees to answer the truthfully, without risking any company secrets.

Table 2 below lists information about the four case companies Case Air, Case Dust, Case Waste, and Case Paper. The table includes brief product description, product launch year, the industry for which the product is developed for, interviewees' titles, and company size description. At the time of the data collection, two of the case companies had a global scale market, one operated in the Nordics, and one was active only in Finland.

Table 2. Case company profiles

Case	Product	Product launched	Industry	Interviewees' titles	Company size
Case Air	Integrated appliance	2021	Housing	1. CEO 2. R&D Director	Small
Case Dust	Industrial cleaning equipment	2019	Construction	1. CEO 2. COO	Small
Case Waste	Industrial recycling robot	2020	Waste management	1. CTO 2. Mechanical Engineer	Medium
Case Paper	Paper machine	2006	Pulp and paper	1. R&D Manager / Engineer 2. R&D Engineer	Large

CEO = Chief Executive Officer / COO = Chief Operating Officer / CTO = Chief Technology Officer

A total of eight participants were interviewed, so that each case company had two different roles represented. This provided different perspectives to the product development within a shared company context. For example, a mechanical engineer and a manager might see the challenges and enablers differently due to their position. Majority of the interviewees had M.Sc. (Tech.) degrees and a study background in mechanical engineering.

For cases Air, Dust, and Waste the products have been published in recent years, whereas Case Paper published the product already about 16 years ago. This is a marked difference, but also gives perspective on the different states of society when developing products at different points in time.

3.2 Data collection

The data was collected through individual semi-structured interviews, built around key themes and follow-up questions to elicit in-depth reflections without limiting the scope of interviewees responses. A semi-structured interview consists of a list of predefined questions, with no predefined answers, which direct towards discussion about the research topic (Kallio et al., 2016). This type of interview supports Silverman's (2009) recommendation in his book "Doing Qualitative Research: A Practical Handbook" to use open-ended questions in qualitative research. If the interviewee seemed confused by the question or asked for clarification, multiple

options were suggested as examples to help them answer, however, without influencing the answer. The same examples and options were provided for all the interviewees for these situations. The interviewees did not need to prepare for the interview, but a list of the interview structure contents was sent in advance.

The conducted interviews focused on the product development challenges and enablers that the interviewees had experienced. In addition, the interviewees were asked about the PESTEL connections of the product development project. Appendix 1 shows the topics covered in the interviews from the different stages of product development and their links to the PESTEL dimensions in the overall development of the product.

The question set was divided into four sections to get a comprehensive outline of the interviewees' participation in the product development process of the product in question:

A. Product description and interviewee's role in product development
B. The evolution of the product idea
C. Perceived PESTEL connections and influences related to the case
D. Additional information

In the first section (A) as a warmup, a brief description of the case product was asked for and list of the interviewee's role and tasks regarding the development process. In addition, the overall interview structure was introduced.

In the second section (B), questions focused on the product development process from start to finish. These questions were about the initial idea and need, following steps, turning points and possible challenges and enablers, and questions about testing and prototyping. This allowed for the development phases and implementation to be mapped out to provide a clearer picture of how the product was developed.

The third section (C) included direct questions about the PESTEL connections or political, economic, social, technological, environmental, and legal connections and influences both on the case and by the case. Here most of the mentions of contextual factors were collected.

Finally, in the last section (D), the interviewees were given a chance to add more comments if there was something they had not had a chance to discuss so far. In addition, retrospective questions were asked about possible changes that the developers would have done when they now think back at the process, and questions about future development ideas were also asked. However, as the developers could

have been unwilling to share possible classified ideas for the future, these questions were difficult to get answers to. Possible follow up questions were asked, when necessary, for example if the answer needed refinement or elaboration. The full interview structure and questions are presented in Appendix 1.

The data collection was conducted through video calls. This was done due to the possibility to have more flexibility for the time of the interview, and also due to the COVID-19 pandemic situation. Zoom and Microsoft Teams platforms were utilized for the video calls. One hour was reserved for every interview, and the durations varied between 48-73 minutes with average duration of about 59 minutes. The interviews were conducted in May and June 2021. The author conducted seven of the interviews with a member of the research group and one interview was conducted by two research group members. All interviews were audio-recorded with permission from the participants and later transcribed verbatim for data analysis. Personal or detailed information related to the interviewees was not shared with anyone outside researchers related to this thesis work. The original interview data transcripts have been archived by the research team according to Aalto University regulations.

All the interviews were conducted in Finnish which was the native language of all participants. Analysis was conducted with the original data, but the quotes presented in this thesis were translated from Finnish to English for presentation purposes as the language of this thesis is English. Quote examples emphasize the connection between the transcripts and gathered results, and therefore help to understand the results better (Weiss, 1995). The quotes presented in the thesis were anonymized, omitting identifying data. Omissions and replaced words are marked with "[...]" and "[replaced text]".

3.3 Data analysis

Data analysis followed the guidelines of thematic analysis. According to Braun & Clarke (2012) in their book "APA handbook of research methods in psychology, Vol 2: Research designs: Quantitative, qualitative, neuropsychological, and biological.", thematic analysis is used to identify, categorize, and develop insights to common themes within a dataset. This enables a researcher to realize collective and shared experiences. As advantages the analysis is easy to learn and easy to perform, it enables simple presentation of a large body of data, and it can possibly point out unexpected insights from the data (Braun & Clarke, 2006). Additionally, Braun and Clarke (2012) argue that thematic analysis is ideal to be used with multiple datasets – or case studies in this thesis research. The reason for this being the effect of highlighting the pattern which makes it possible to better inspect the multiple case

study. The aim is to examine the cases as a whole and not compare them to each other (Braun & Clarke, 2012).

On one hand, Braun & Clarke (2006) note that thematic analysis could cause difficulties in defining guidelines for the analysis as the process is flexible. On the other hand, Braun & Clarke (2006) also remind that these difficulties can be avoided if an existing theoretical framework is used when constructing results with thematic analysis. Therefore, in this thesis the PESTEL framework is used to categorize the analysis results. With the codes produced by the analysis, subcategories for every PESTEL dimension were generated.

Braun and Clarke (2006) give a list of six phases to follow when conducting thematic analysis. These steps are presented in Table 3. The conducted data analysis followed these steps directly, except for the initial coding according to the PESTEL framework, which was deductive categorizing and therefore did not include the "Phase 2" in Table 3.

Table 3. Phases of thematic analysis (Braun and Clarke, 2006).

Phase	***Description of the process***
1. *Familiarizing yourself with your data*	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. *Generating initial codes**	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. *Searching for themes*	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. *Reviewing themes*	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
5. *Defining and naming themes*	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6. *Producing the report*	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

* = used only for the inductive categorization of the subcategories of PESTEL factors, not for the deductive categorization of PESTEL dimensions

The coding according to the PESTEL framework was carried out with Atlas.ti – qualitative coding software – by deductively tagging any interview quotes related to political, economic, social, technological, environmental, and legal influences. In addition, the interviewees' roles and tasks, and product development phases were identified with coding. This gave a broad understanding of the sources for contextual factors influencing the cases. For example, the quotes Q1 and Q2 in Table 4, below, were categorized as economic and technological accordingly. As the bolded parts indicate, mentions of money and human resources were categorized as an economic quote. In Q2, mentions of technological methods belong to the technological categorization.

Table 4. Coding process table

Q#	Q1	Q2
Quote	*"[You can't develop the product efficiently] because you **can't afford** **to buy materials**. And if you **don't have enough** **money**, you **can't hire** **competent personnel or outsource assistance from experts**."* (CEO, Case Dust)	*"**We have the experience** from what are the challenges related to the **recognition methods**, because for a long time we have developed our **artificial intelligence software** which **performs the recognition**."* (Mechanical Engineer, Case Waste)
PESTEL dimension	Economic (E)	Technological (T)
PESTEL dimension connection(s)	1. limited resources	1. technical knowledge 2. AI (artificial intelligence)
Valence	Negative (challenge)	Positive (enabler)
Direction	Influence on the case	Influence on the case

Bolded text indicates the keywords determining the PESTEL dimension and connection for the quote.
Red bolded text indicates the words that determine the negative tone for the quote
Green bolded text indicates the words that determine the positive tone for the quote

Next, the PESTEL quotes were moved to Microsoft Excel where they were identified with more precise connections to previously defined PESTEL dimensions, with valence (positive, negative, or neutral), and with direction of influence ("influence on case", "influence by case", or "unclear") (Table 4). Longer quotes were also summarized to short notes which helped to understand the broad picture of the quotes.

Continuing with the example quotes in Table 4, the Q1 quote was coded as economic connection "Limited resources" having negative influence on the case. The limitation of resources was interpreted from the talk of *not having* something or *inability* to do something, and for this reason also the quote was identified as negative. In Q1 the bolded parts define the connection, and the red-colored parts indicate the negative tone. Additionally, the statement is about the lack of resources to use in the case which indicates influence on the case.

Q2 quote in Table 4 was coded with technological connections "Technical knowledge" and "AI", having positive influence on the case. The technical knowledge was interpreted from the bolded parts related to having experience and knowledge from used AI technology. Stating that they *have* the experience to face the challenges implies a positive influence on the case.

The PESTEL connections were then mapped using a digital whiteboard workspace software Mural and Microsoft Excel. Similar themes were clustered together into common PESTEL categories within each dimension, which made inspecting common influencing factors obvious. Quotes and their PESTEL connections can be interpreted as insights which Kumar (2012) in his book "101 design methods: A structured approach for driving innovation in your organization" points out to reveal patterns and relationships, giving a more understandable structure to the gathered knowledge. There are many similarities between the different PESTEL connections and therefore structure, patterns, and relationships could be found. Eventually the clustering to subcategories also made the data simpler to present. The subcategories included 1-6 connections. For example, the connections in quote examples Q1 and Q2 were placed in subcategories as follows:

Q1: "Limited resources" → "Availability and costs of resources" subcategory

Q2: "Technical knowledge" → "R&D" subcategory
Q2: "AI" → "Automated functions" subcategory

Sometimes the same event – challenge, enabler or other – was mentioned multiple times in an interview. All these mentions were counted separately, and the same logic applied to the identified connections. More mentions including a certain connection determined that the connection was highly apparent.

Following the same process of the coding the following quote was categorized as economic challenge on the case with connections "Funding" and "Limited resources", in the *Availability and costs of resources* subcategory:

> *"[…] a challenge is always that money is tight. Even though Business Finland grants money, you must have it for yourself. That has been a continuous challenge, the cash flow."* (COO, Case Dust)

Furthermore, the following was categorized as an environmental challenge caused by the case with connection "Recycling" and "Non-recyclable materials" in *Reuse of materials* subcategory:

> *"[…] it does not matter what the material is, it still goes to mixed waste, because so many different materials are mixed in it. […] So there really are no other choices, so it goes to the mixed waste and gets burned. It can't be recycled, [because it has non-recyclable materials in it]."* (CEO, Case Dust)

In addition, the cases were influenced by enablers. The following was categorized as political enabler on the case with connections to "Global politics", "EU strategy", and "Regulation and deregulation", in *Support from global politics* subcategory.

> *"It really took the need to the next level last year, when the EU declared a directive where [the harmful particles] were identified as carcinogenic just like asbestos."* (CEO, Case Dust)

Cases also had an enabling influence towards society. The following was categorized as a technological enabler by the case with connections "Innovation" and "New technology", in *Advances in technology* subcategory:

> *"Well, our company has been in this industry for so long that I can assure that [the industry has been influenced by our company and case] as we have brought new technology there."* (R&D Engineer, Case Paper)

However, there were also neutral events happening in the background of the cases, which did not have a direct influence. The following was categorized as social neutral event on the case with connection "User safety", in *Product user* subcategory:

> *"Of course, for safety reasons, this device must be such that [the user] cannot injure herself or himself."* (R&D Engineer, Case Paper)

4 Results

Based on the analysis of the eight interviews, a total of 384 contextual PESTEL connections were identified in the four project development cases. The mapping of the direction of influence on the cases is presented below in Table 5. The direction of the influence means whether the influence was toward the case or if the case influenced the surrounding PESTEL dimensions. Mentions where the direction was not clear were labelled as "unclear".

Table 5. Presence of challenges, enablers, and neutral events, and their direction between PESTEL and four cases

Type of connection		Contextual dimension					
		Political	**Economic**	**Social**	**Techno-logical**	**Environ-mental**	**Legal**
Challenges	On case	Air, Dust	Air, Dust, Paper, Waste	Air, Dust, Paper, Waste	Air, Dust, Paper, Waste	Air, Dust, Paper, Waste	Air, Dust, Paper, Waste
	By case					Dust	
	Un-clear		Paper	Paper			
Enablers	On case	Air, Dust, Waste	Air, Dust, Paper, Waste	Air, Dust, Waste	Air, Dust, Paper, Waste	Air, Paper, Waste	Air, Dust, Waste
	By case		Paper	Air, Dust, Waste	Air, Paper, Waste	Air, Dust, Paper, Waste	
	Un-clear	Dust		Paper			
Neutrals	On case	Air, Paper		Air, Paper	Waste		Dust
	By case						
	Un-clear	Waste	Paper, Waste	Dust			

It is evident from Table 5 that all PESTEL dimensions had an influence on product development, both in a negative and positive sense, although there was some variance across cases. There were some environmental challenges that were created

by the case, but no others. Considering the challenges that had an influence on the case there were connections to all the PESTEL areas.

The identified 384 PESTEL connections were mapped to the six PESTEL dimensions: Political (n=32), economic (n=72), social (n=69), technological (n=134), environmental (n=33), and legal (n=44) factors, presented in Table 6. Furthermore, the PESTEL dimensions were divided into 24 subcategories in total, representing the contextual factors. Here "n" represents the number of mentions of each PESTEL dimension.

Table 6. The distribution and valence of PESTEL factors noted in the interviews.

PESTEL dim.	Factor	Chal-lenges	Enab-lers	Neut-rals	Total
Political (n=32)	Support from global politics		12	3	**15**
	Awareness about product		10		**10**
	Local politics control interests on the case	3	2	2	**7**
Economic (n=72)	Company competitiveness on market	4	25	1	**30**
	Availability and costs of resources	16	4	1	**21**
	Product costs and price	11	2		**13**
	Changes elsewhere in the economy	4	3	1	**8**
Social (n=69)	User attitudes	13	13	2	**28**
	Product user	7	7	4	**18**
	Health and safety	5	9	2	**16**
	Industry		4		**4**
	Common societal attitudes support cases		3		**3**
Techno-logical (n=134)	R&D	23	15	1	**39**
	Product performance	24	4		**28**
	Automated functions	7	19		**26**
	Advances in technology	6	16		**22**
	Electrical and mechanical components	10			**10**
	Existing technology	2	3		**5**
	Technical tools		4		**4**
Environ-mental (n=33)	Reuse of materials	2	11		**13**
	Decreasing pollution	2	10		**12**
	Environmental attitudes	6	2		**8**
Legal (n=44)	Standards and directives	16	4		**20**
	Legislation	14	5		**19**
	IPR activity	2	2	1	**5**
Total		**177**	**191**	**18**	**384**

A PESTEL map was constructed (Figure 1) based on Table 6. Here the influence of the contextual factors that were found was simplified by presenting each factor with the influence of majority of the mentions. In other words, because for example political factor *Support from global politics* was considered to have predominantly positive effects or enabling effects, it was colored green. The same applies to coloring factors with red color. If there were equal or close to equal number of positive and negative mentions, the factor was considered to have mixed effects and given a yellow coloring.

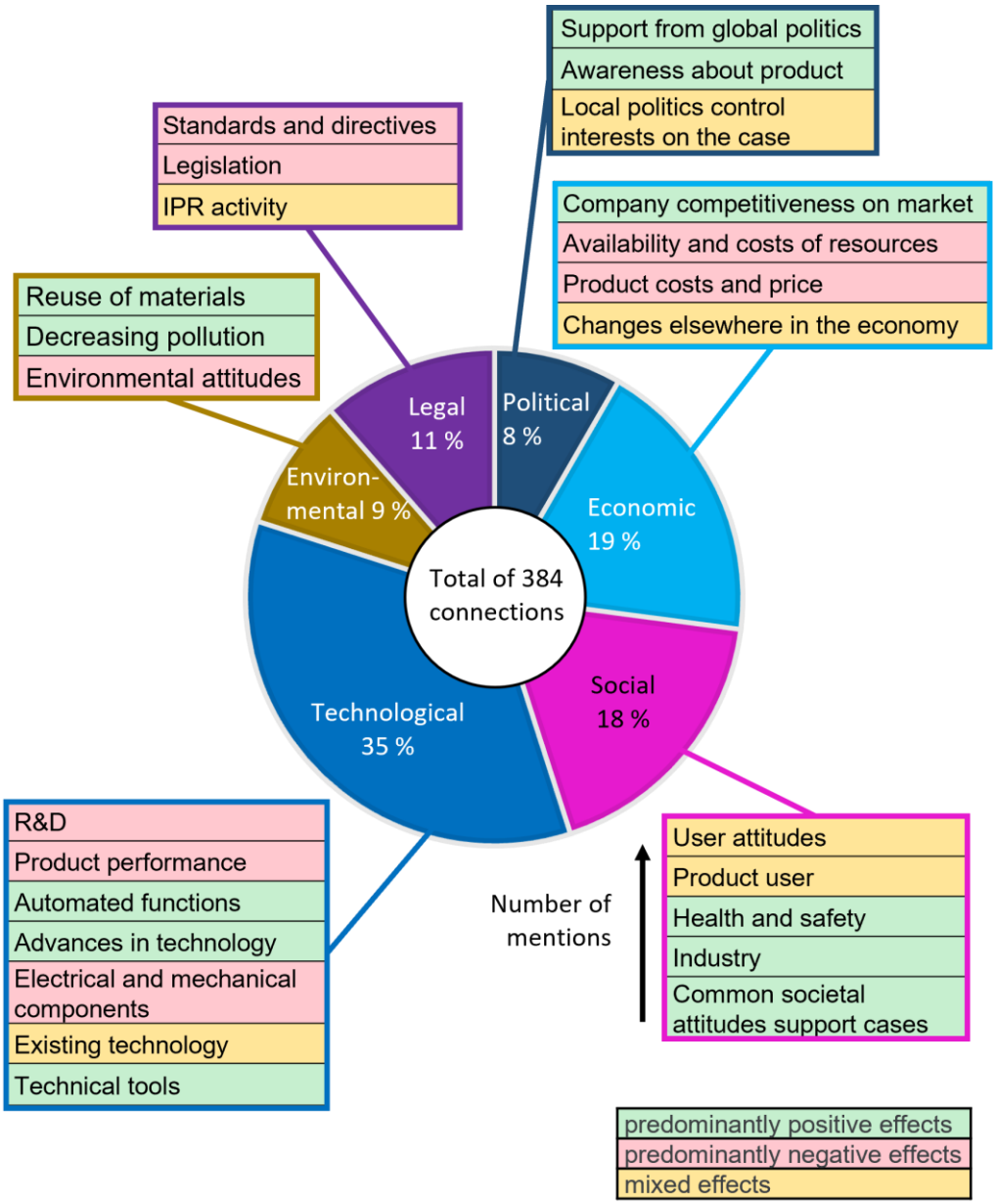

Figure 1. The distribution of contextual factors and the typical valence of their subcategories PESTEL circle map

The PESTEL circle map above shows that in the political and social dimensions the majority of connections were seen as enablers on the cases, with no clear challenges identified. In contrast, the legal dimension was experienced with clear challenges, with no clear enablers emerging. Environmental dimension included only clear enablers and challenges. Economic and technological dimensions had more variety in the emerging identified effects of the contextual factors, having both clear positive and negative effects identified, but also mixed effects were identified. In the following, the results presented in Table 6 and Figure 1 are examined in more detail and explained by using examples.

4.1 Political factors

Political factors were brought up in all interviews but represented a minor part of the contextual factors at 8% (n=32). In total 3 challenges, 24 enablers and 5 neutral events were identified across the cases, indicating that the political dimension was experienced mostly as an enabler.

4.1.1 Support from global politics

The decisions and changes in global politics were seen mostly as enablers and represented the most common type of political influence noted for the cases, with almost half (n=15) of the mentions. This category contains connections to Brexit, EU strategy, global environmental policies, global politics in general, global export and import restrictions, and regulation changes.

Decisions and changes are continuously made in politics globally. These decisions are often motivated by some overriding larger global issues than the cases of this thesis, such as climate change and public health. Here the fact is that often politicians make the decisions on how certain products should operate without considering the experts' point of view. For example, in Case Air the developers reported the following for their industry:

> *[...] In Europe, if we think about legislation on how a household appliance should work, the EU will make a directive, which is a political decision in itself. So, politicians ultimately determine how [these appliances should work].* (R&D Director, Case Air)

Politics on the global scale functions largely as an enabler as cases Air, Dust, and Waste reported benefitting from tightening health, safety, and environmental policies. For example, the developers of the product for Case Waste reported leveraging from the issues created by import ban on waste in China, because it had increased demand for their product:

> *"[..] China's import bans on waste obviously affect the entire [waste management] market. The USA and partly Europe have been in a little trouble because there hasn't been enough capacity to handle [waste] locally and then it will lead to large investments."*
> *(*Mechanical Engineer, Case Waste)

EU strategy towards improving environmental and health issues was experienced as supporting Case Dust as their product aims to decrease the number of harmful particles in air. Namely, changes in EU policies, more specifically in regulations, reflected positively on the case company's increasing need. The demand for the product increased when the EU declared a new directive that the harmful particles are officially carcinogenic and must be removed:

> *"It really took the need to the next level last year, when the EU declared a directive where [the harmful particles] were identified as carcinogenic just like asbestos."* (CEO, Case Dust)

4.1.2 Awareness about product

Spreading information about the product and the problem or issue which it is solving was an enabler for cases Air and Dust. Nine of the ten mentions of awareness of the product were about the enabling influence on the case and one mention was unclear. In practice this meant that spreading awareness simply by engaging in discussions at events and with various relevant unions and agencies had a positive impact on product development. For example, one Case Air developer recounted how they had been able to get their case product to be recommended to every household in Finland:

> *"Of course, we want to speak about the usefulness of the product. It has now proceeded to the level that [devices such as the case product] are now recommended to every household in Finland, and we will see if the recommendation can be turned to official regulation at some point. So, the lobbying has produced some concrete results."* (R&D Director, Case Air)

Additionally, there were mentions of lobbying the product as a solution for communicating with the local politicians and decision makers, such as Case Dust had done when a new case-related directive came into force. These acts of raising awareness had made more parties realize the need for the product and had resulted in an increased demand:

"We have met the legislators regarding the directive, and we have met the AVI (Regional State Administrative Agency), which oversees the [important case-related directive]. We have met the construction industry representatives and The Finnish Construction Trade Union representatives."
(CEO, Case Dust)

4.1.3 Local politics control interests on the case

Finally, the control of local politics on the cases was mentioned seven times, with varying valence. This included some challenges in cases Dust and Paper to get funding since the possibilities of getting it were influenced by political motives, such as Case Dust had noted:

"[...] it's always a political decision in some way [how much funding Business Finland distributes], no matter how much Business Finland money is distributed." (CEO, Case Dust)

Local politics also created enablers for the cases, for example by favoring the technology which was used in the product of Case Waste:

"[Our technology] looks good [...] when you make these calls for tenders so [our offer might seem like the most viable], not only because of the technology but also because there is clearly an investment in the future which will then be seen to raise the profitability of the bid."
(CTO, Case Waste)

4.2 Economic factors

Economic factors were present in about 19 % (n=72) of mentioned PESTEL connections. All the cases included enablers and challenges related to economic factors, and few had neutral mentions. The constructed economic categories were *Company competitiveness on the market*, *Availability and costs of resources, Product costs and price*, and *Changes elsewhere in the economy.*

4.2.1 Company competitiveness on the market

Largest number of connections in the economic dimension was related to the case company's capability to compete in the market (n=30). Most of the mentions within this category were related to business profitability and customer interests. Majority of the mentions in this category (n=25) were identified as enablers, from which n=8 were by case and n=17 on the case. For example, in Case Dust it was considered as

an enabler on the case when the case product was cheaper than the alternative solution, which then directed the clients to select the case product to achieve savings:

> *"The driver for growing demand is the fact that [solving the problem] by using alternative solutions costs more and decreases the quality of the clients' work."* (COO, Case Dust)

An example of an enabling influence by the case on the economy was recognized in Case Paper when their product enabled raw-material savings which led to savings for the client:

> *"[...] more raw material savings through [so] they can make more profit [...]."* (R&D Engineer, Case Paper)

There were n=4 mentions of challenges in this theme. Here competition and convincing customers turned out to be challenging for cases Paper and Waste. However, for example Case Air reported an enabling effect from collaborating with another company, and therefore getting more visibility on the market:

> *"Now we have the luxury of [collaborating with one of the biggest brands in the market] which is making products with big investments [...]"*
> (CEO, Case Air)

4.2.2 Availability and costs of resources

Availability and costs of resources had n=21 identified mentions. The events related to this category had the highest number of mentions of challenges on the cases, but also created some enablers for the cases. However, none of the influences was caused by the cases. Identified resources were money, parts, components, and time. An example of an enabler was noted in Case Paper when getting funding enabled to build an initial version of the product which was a significant step in the start of the case project:

> *"We got the funding and built a realistic so-called pilot equipment."*
> (R&D Manager / Engineer, Case Paper)

However, for case Dust the fact that resources were often limited was seen as a challenge as it forced prioritization and slowed down the development progress:

"[You can't develop the product efficiently] because you can't afford to buy materials. And if you don't have enough money, you can't hire competent personnel or outsource assistance from experts." (CEO, Case Dust)

"[…] a challenge is always that money is tight. Even though Business Finland grants money, you must have it for yourself. That has been a continuous challenge, the cash flow." (COO, Case Dust)

In Case Waste, a similar situation was also reported referring to the limitations on developing the product with external funding:

"We are in the growth company stage. In other words, in practice, we do product development with external money [...]."
(Mechanical Engineer, Case Waste)

4.2.3 Product costs and price

The costs of developing and producing the case product and determining a suitable price for it was recognized n=13 times influencing the cases. This category included mentions of challenges from the amount of manufacturing costs, development costs, and patenting costs. For example, Case Dust reported challenges with high assembly costs which had to be reduced to make the production of the product profitable and make the company grow:

"One clear [challenge] was definitely that we knew that with our product, the company would not grow. [...] the costs had to be reduced. And in particular assembly costs [...]" (COO, Case Dust)

Determining the product price was balanced; determining optimal price enabled the start of the product in Case Air, but also posed challenges in sales in Case Waste as the short term investments were higher than the alternative solution:

"The project would not really have been properly launched if it had not been possible to initially calculate an attractive combo with which it can compete with other products [...]." (R&D Director, Case Air)

"[This product] is intended to replace human labor. In practice, the customer [compares the fact that the investment in human labor pays for itself quickly] but if [this product] reimburses the human labor and [requires certain costs], it means that with this selling price the payback is a few years."
(Mechanical Engineer, Case Waste)

4.2.4 Changes elsewhere in the economy

For the economic dimension, the lowest number of mentions (n=8) was related to the changes in the surrounding economy. Changes in the economy included both global and local scale, and the activity of economic cycles. Local economy and economic cycles caused challenges for cases Air and Paper, as they were seen as external elements controlling the industry:

> *"The construction of [houses] always goes in certain cycles, of course. And through that, our traditional business has very much been that if there is no house to be built, then neither is our product sold [to the kitchen of the house]. In that sense, the construction cycles have had an impact."*
> (CEO, Case Air)

> *"This is a very cyclical industry. Everyone looks at the same metrics regarding when to invest. Sometimes a few years are really busy, everyone buys and we're in trouble for the amount of work. Then at times it all stops, if there's a recession."* (R&D Manager / Engineer, Case Paper)

On the other hand, for example for Case Paper, as a globally large competitor went bankrupt it left an empty market position, which enabled more visibility for the case company and therefore enabled more potential to invest in the case product:

> *"Then we got a lucky strike as a big [company from our industry] from America went bankrupt."* (R&D Manager / Engineer, Case Paper)

4.3 Social factors

Social impact was present in about fifth of the cases, more specifically 18 % of the mentions (n=69). Most of the common categories included enablers, challenges, and neutral factors, and two categories had purely positive effects. Social categories *User attitudes, Product user, Health and safety, Industry*, and *Common societal attitudes support cases* were identified from the interviews.

4.3.1 User attitudes

User attitudes covered almost half of the social dimension mentions (n=28). This category includes user behavior towards the product, demand for the product usability, user experience, attitudes towards the product, and testing the product. This category had variance in the valence and number of mentions but if one considers the number of mentions, user behavior and user attitude were most common factors.

The largest part of mentions about user behavior were about challenges for the cases. The behavior was driven by the lack of interest in the product. For example, related to Case Waste, the unwanted user behavior was related to handling the product too harshly, and not caring about its condition:

> *"The user personnel can easily be the type that solves issues with the largest type of hammer."* (CTO, Case Waste)

Most of the mentions related to the attitudes of the users were about their mindset and attitude towards the product. This factor was equally enabling and challenging; all of the mentioned challenges were directed on the case, and enablers were mostly by the case and few on the case. *User attitudes* might become a challenge when the potential users view the product as an unnecessary addition. Regarding Case Dust, the developers reported connections to larger issues such as hierarchy issues in the client organization where the user is employed.

> *"In one product demonstration I had the supervisors convinced about the usefulness of the product. Then a worker was asked what they thought about using the product. The worker stated that the product is useless and that they won't be using it. The supervisors then agreed that they won't take the product to use, even though they were really convinced about it."*
> (CEO, Case Dust)

It was also possible to turn the user attitudes into an enabler. On most occasions the enabling influence came from the case. This meant that the case was able to convince the users of the issue that the product solves which then made the users favor the product. For example, Case Dust developers added that this made it possible for the users to see the issue with their own eyes, which then helped to recognize the issue:

> *"One of the biggest things was when we added [a function which made the problem visible to naked eye]. Before this the users could not see the issue and therefore did not believe that it really existed. When it was made more visible [the users understood how severe the issue is]."* (CEO, Case Dust)

Another example of an enabler identified related to *User attitudes,* was an enabler on the Case Air when they arranged user testing workshops and used gathered feedback to improve their product:

"We have held workshops that where we have invited all kinds of users ranging from casual normal users to usability experts [to test our product]" (R&D Director, Case Air)

4.3.2 Product user

Product user was the second most common social category influencing the cases with 18 mentions. Here four main connections were product usability, user health, user safety, and user training. Product usability was reported only in Case Dust where it caused challenges as the product needed to be ergonomic and durable, which were features that turned out to be challenging to implement in a satisfactory manner:

"[We asked our designer] whether the defect is in the product or in the market, or in branding, or as customers bought the product only once, but not again, even though the product was working fine. Our designer then noticed quite a few big usability problems as well as really big ergonomic errors in the product." (COO, Case Dust)

User health was an enabling factor both on the case and by the case. Again, this factor was only related to Case Dust. Influence by the case was by increasing awareness about the health risks around the issue that the case product solves. Enablers for the case were occasions when challenges related to user health led to increased demand for the product as it could minimize these challenges:

"Gradually, this industry has begun to realize that this [health problem] really is something that causes people to die." (CEO, Case Dust)

User safety was experienced as positive, negative, and neutral influences. A major part of the mentions was about user safety being a neutral factor on Case Paper. The neutral influence meant that it influenced the case but was not seen as a separate challenge or an enabler. For example, this meant in practice that during development the case product had to be made safe for the users.

"Of course, for safety reasons, this device must be such that [the user] cannot injure herself or himself." (R&D Engineer, Case Paper)

User training had a lot of variation both in the valence of the influence and within the direction. On the other hand, this factor was mentioned only by the Case Paper developers. Generally, user training meant in a neutral sense that it was just a mandatory thing to think about, similarly as with user safety. It became challenging when it was seen to be difficult to train the users. For example, the developers of

Case Paper reported limited user training possibilities as use of the product required a lot of technical knowledge:

> *"No one can train [the users] except those who know a lot about it. The know-how is difficult to outsource. Everything else can be outsourced, but that in-depth knowledge [cannot be] no matter how good the training materials are."* (R&D Manager / Engineer, Case Paper)

4.3.3 Health and safety

Health and safety as a social category had almost as many mentions (n=16) as did the *Product user*. Even though factors related to health and safety came up in the *Product user* theme, they were present also here. The difference was that considering the product user, health and safety has a direct connection to the user(s) when they are using the product. In this category *Health and safety* these aspects were more at the general level, not focusing on the user. This category included connections to common health and common safety in the society, and occupational health and safety guidelines.

Common health had most mentions as having an enabling influence by the case. This was due to cases' Dust and Air products improving health by for example cleaning air or providing a tool for health research, such as Case Air reported:

> *"There are interesting branches of research [related to measuring air purity]. [...] We have played a rather interesting role as we have the technology to study and measure it.* (CEO, Case Air)

Case Air recognized challenges between goals to improve health and wellbeing and mitigating climate change, as improving health could also generate environmental issues and *vice versa*:

> *"If you ventilate a lot of air, it will increase energy consumption because you will be wasting heated air, especially in the Nordic countries. In other words, if you want to minimize the energy consumption of your heating, you should minimize ventilation. But then again, especially cooking is a surprisingly toxic thing, because gas and particles are produced, and it is actually the only really significant indoor air pollutant, especially in Finland. So, on the other hand, you want those [particles] out. That's then the decision you have to make, which agenda to pursue, energy efficiency or the condition of people's lungs [...].* (R&D Director, Case Air)

The cases mostly had positive influence on general safety because they enabled improvements to the safety in the setting in which they were used and when they were used. For example, fire safety, living safety, and work safety were improved. Case Waste developer pointed out that their product improved safety at the workplace by replacing human labor with the product and therefore making it possible for people to avoid contact with waste:

> *"Yes, it improves workplace safety quite clearly, because one does not have to be directly exposed to waste and to the potential biological hazards in it. For example, there may well be all kinds of needles etc. among the waste."*
> (Mechanical Engineer, Case Waste)

4.3.4 Industry & Common societal attitudes support cases

The two least mentioned social categories were the Industry (n=4) and Common societal attitudes (n=3). The industry as a social platform enabled the case companies to network and collaborate with other companies. This was recognized as increasing the visibility for the case product, as the R&D Director of Case Air explains:

> *"This company [which we are collaborating with] has a good reputation in manufacturing slightly more valuable [products] with a surprisingly large market share in the Nordic countries."* (R&D Director, Case Air)

Societal attitudes had a positive influence on cases because they enabled more recognition when the products had potential to solve environmental or health issues. For example, in Case Waste the CTO explains how having a strong environmental mission had helped to improve their company's reputation:

> *"Well, we make garbage sorting robots. So that has an indirect effect on the PR value and reputation of our company in an environmental sense."*
> (CTO, Case Waste)

4.4 Technological factors

A little over one third or 35 % (n=134) of the connections that were found were related to technology. Accordingly, technological dimension had the highest number of mentions of contextual factors. In total, seven different technological categories were formed from clustering the different separate connections. The number of enablers was slightly less (n=61) than the number of identified challenges (n=72). Enablers most commonly had influence on the case, but also some enablers were generated by the case. Challenges were seen as having influence on the case. Only one neutral factor having influence on the case was identified.

4.4.1 R&D

R&D category had the most mentions (n=39). This included connections to electronics design and mechanical design, in-house development and self-developed solution, material selection, and technical knowledge. The most common connections were electronics design and mechanical design. Both design aspects were seen as challenges for the cases Air and Waste. These challenges were related to the fact that the case products must be functional under the prevailing conditions. For example, in Case Waste extreme precision, durability and agility were reported to be difficult to implement for the product when the operating conditions were not ideal:

> *"Because we have a dirty environment, it is easily possible for a bearing to get dirty. This means that the level of friction on the bearing might vary quite a lot. This creates challenges to establish the overall movement of the mechanism so that it compensates for the varying friction. A precise positioning has always been a challenge in machine design but in our case the varying level of friction or varying amount of force creates even more difficulties for a quick and precise positioning."*
> (Mechanical engineer, Case Waste)

Case Air developer reported difficulties in electronics design as there were a lot of components that needed to be fitted in the product, which was small and compact in size:

> *"For example, the number of circuit boards (PCBs) is one thing that is very challenging in many ways. The product has an interface panel with buttons and maybe some LEDs and controls. If there is an automatic sensor, then there is a circuit board for that and then there is a power supply and a motherboard. There may be 6-7 PCBs inside the product."*
> (R&D Director, Case Air)

The second most common *R&D* connection was a self-developed solution. The case products were new in the way that they were not designed with help of already existing solutions. Their novel nature came for example from new technology as part of the product or from developing the product as a solution to a previously unidentified problem. This set-up directed the developers to develop the products purely by themselves as there were no existing products that could have been used for studying the properties. For example, in Case Air self-developed solutions were seen as enabling new innovations:

"As a technological breakthrough, starting from the basic calculations the product is completely our own design." (R&D Director, Case Air)

On the other hand, in Case Paper self-developing caused challenges due to development requiring extensive prototyping and no possibility to learn from an example. There were no guidelines to follow, and everything had to be found out by oneself:

"Then we also had to develop components. We learned how to make these huge steel belts on a smaller scale, for example how to grind them.
(R&D Manager / Engineer, Case Paper)

Technical knowledge was also a somewhat often mentioned technological connection to *R&D*, and it was mostly seen as having an enabling influence on all cases. As the developers possessed technical knowledge from the used technology or operating environment either from experience or by studying it, they had possibilities to invent and implement without facing the same challenges. For example, in Case Waste the Mechanical Engineer stated that past experiences with artificial intelligence methods helped the developers to be more efficient in development of the case product:

"We have the experience on what are the challenges related to the recognition methods, because for a long time we have developed our artificial intelligence software which performs the recognition."
(Mechanical Engineer, Case Waste)

4.4.2 Product performance

Approximately a fourth (n=28) of the mentioned technological connections were related to the technical performance and functionality of the product. *Product performance* included mostly challenges (n=24), but also enablers (n=4). Overall, the *Product performance* category had connections which were mentioned among the linkages to the *R&D* theme, and therefore it included similar issues. However, these were separated as *Product performance* issues, as they focused on performance of the product, not on the planning. For example, in Cases Dust and Paper the developers noted performance and durability issues with the development of the core functions:

"There were still all kinds of technical faults, and the biggest was the filter."
(CEO, Case Dust)

> *"Well, there were all kinds of problems in the beginning. There were cracks in the belt, and we learned how to fix them and how to avoid them."*
> (R&D Manager / Engineer, Case Paper)

The operating environment of the product was seen as a common challenge. However, it should be noted that these influences were not common to all, rather they were almost exclusively related to the Case Waste project path. The operating environment was seen as a challenge when it was described as dirty or otherwise non-ideal for the product functionality which affected the overall performance of the product. This is connected to the novel nature of the products, as the products had not been implemented in these environments and therefore unexpected challenges appeared. These issues were also connected to the *R&D* category presented in 4.4.1. For example, the challenges in the operation environment of a waste management plant were noted by the Case Waste CTO:

> *"Waste management plants are very hostile places in the sense that they are often practically tent-like buildings that are open to the outside air. In the Nordic countries it easily means 20 degrees below zero temperature, and in Central Europe humidity and temperature fluctuations are large. And there's dust and all that stuff, too. "* (CTO, Case Waste)

On the other hand, related to product performance, an enabling influence came from achieving a compact implementation. For example, the R&D Director of Case Air reported compact implementation to have enabled lower manufacturing costs for the product which enabled the launch of the case project:

> *"[...] in our case, [the enabler] was to make the product from fewer modules. In other words, reducing the number of cables, reducing the number of parts, and just making more complex parts. And the fact that we design all those parts by ourselves. It ended up being cheap enough [to make the project] to get the green light [...]"* (R&D Director, Case Air)

4.4.3 Automated functions

All case products contained more or less automated functions, and almost one fifth of the mentions referred to these (n=26). This category included mostly mentions of automation, sensor technology, and artificial intelligence. Automation generated challenges and enablers for the cases and also enablers by the cases. For example, in Case Dust automation was experienced as being challenging because of difficulties and added costs due to complex requirements from the automated functions:

> *"[Adding automated functions to the product] was a very good insight, but this one was not originally planned, and it slightly lengthened the development process and, in a way, made it more costly. [...] Because we wanted to bring this feature, it was a slowing factor."*(COO, Case Dust)

However, in other instances automation was experienced as an enabler for increased efficiency. For example, in Case Waste automation was seen to enhance the overall efficiency as well as the precision and environmental-friendliness of the product:

> *"Here robotics is considered as a futuristic factor, so that the available raw materials can be extracted from the waste stream with a sufficiently good degree of purity. [...] Or not picking up pieces of metal or anything like that. This will make it more efficient to reuse raw materials."*
> (Mechanical Engineer, Case Waste)

Sensor technology was noted having a positive influence on the cases. The quality of sensor technology is constantly increasing, and the cases benefitted from this. For example, Case Paper reported that more precise sensors brought advantages when monitoring the product performance:

> *"Sensor technology, for example, has evolved quite a bit lately. We are able to monitor, for example, the guidance of the belt as to where it comes off. Resolutions and data rates have improved. Automation and component speeds have also improved."* (R&D Manager / Engineer, Case Paper)

4.4.4 Advances in technology

Advances in technology was a relatively commonly noted category among the mentions of technologically influencing connections with n=22 mentions. Using and developing new technology and taking part or benefitting from technology development were the main connections here. A few connections to innovations were also identified, and they were closely related to new technology. New technology was experienced equally as enabling and challenging. The enabling influence was directed on the cases and by them. On the cases new technology was mentioned as an enabler for improved efficiency and usability, and in Case Paper influence by the case was manifested through the fact that the new technology improved the case company image as increased pride and better market position. For example, Case Paper noted that by creating innovative new technology as part of the case, the company also gets more visibility as technology provider:

"We want to bring something new to the industry. It often happens that these [more common product types] can be supplied by numerous other suppliers and you can get them from us too, but this [case product] can only be bought from us at the moment. It is a differentiator [from the competitors]."
(R&D Engineer, Case Paper)

Challenges for the cases caused by using new technology were similar to challenges in *Automated functions*. Namely, the existing operating environment setting was not recognized as suitable for the new technology, and it was difficult to develop as everything had to be experimented on and there was marginal amount of existing information about the used new technology. In addition, the new technology was not trusted right away and therefore convincing stakeholders was challenging. For example, in Case Waste the CTO reported challenges with having the product containing new technology due to having an existing location or demand:

"As we are making a new kind of product, there is, by definition, no proven place for it in the world for that new kind of product, so using the initial setting we have to try to find a place for the product. So the market and demand need to be kind of created from scratch." (CTO, Case Waste)

Technology development was seen as an enabler mostly for the cases but also by them. One mention was about the challenges of the level of the used technology not being necessarily advanced enough. The enabling influence was reported in situations when for example in Case Waste the product received more demand because of offering the latest trends of technology development, in Case Dust the constantly developing technology enabled the development of a more mobile product, and in Case Paper the products, including the case product, brought new technology to the industry:

"Customers buy these [our products] for their existing facilities because they understand what [this advanced technology] can do."
(Mechanical Engineer, Case Waste)

"Telecommunication technology has evolved so much recently [...]. Until a few years ago, you would have needed base stations and all that [for this product]" (CEO, Case Dust)

"Well, our company has been in this industry for so long that I can assure that [the industry has been influenced by our company and case] as we have brought new technology there." (R&D Engineer, Case Paper)

4.4.5 Electrical and mechanical components & Existing technology & Technical tools

Electrical and mechanical components (n=10), *Existing technology* (n=5), and *Technical tools* (n=4) were categories which had less connections. *Mechanical and electrical components* created only challenges for cases as component durability and performance were inadequate. For example, in Case Waste the Mechanical Engineer had experienced issues with stock components not being suitable for their product performance:

> *[...] a manipulator, which used third-party components did not last in the waste management environment. [...] When we wanted maintenance intervals to be half a year to a year without anything major fixing, that [manipulator] was almost every two months [under maintenance].*
> (Mechanical Engineer, Case Waste)

Existing technology was seen as an enabler as there were reports of benefitting from existing solutions. Two instances of challenges were also mentioned here, as existing solutions were not directly suitable for the developed product, and this forced developers to create their own solution. *Technical tools* was a category with less mentions including only positive influence on the cases. For example, cases Air noted information and communication technology and additive manufacturing enabling rapid iterations for the cases.

> *"We are able to do a specific software development thing quickly, even in a week, and publish it for free if desired."* (R&D director, Case Air)

> *"The number of 3D printers in the house has grown inferentially, but all the time they are printing. That it is our strength. [...] We kind of get an updated version out the same day, which is in line with the design. The prototyping cyclicality is really fast."* (CEO, Case Air)

4.5 Environmental factors

Environmental impact on the cases covered 9 % (n=33) of all the PESTEL mentions, and it had the second least number of mentions. This dimension contained more enablers (n=23) than challenges (n=10), and no neutral instances. Both enablers and challenges had influence on the cases, but also by the cases. From the identified connections, three categories were clustered: *Reuse of materials, Decreasing pollution* and *Environmental attitudes*.

4.5.1 Reuse of materials

Reuse of materials was the most common environmental category (n=13). Distribution was strong on the enabling side as only two instances were about challenges and 11 about enablers. The enabling influence was reported for cases Paper and Waste related to supporting circular economy and recycling and using fewer natural resources. These aspects increased the interest and demand towards the products. The largest enabling environmental influence was by the cases Dust, Paper, and Waste as for their clients, they promoted reuse of materials and decreased use of natural resources.

Here it is to be noted that Case Waste product's main ideas were to increase and improve recycling. This created a slightly elevated number (n=4) of enablers by the cases. For example, Case Waste Mechanical Engineer noted the positive influence of their product on the environment as follows:

> *"[...] when materials can be recycled more efficiently, it will then reduce global emissions. There is no need to pump as much oil or dig metals from the earth's crust and thereby pollute the environment."*
> (Mechanical Engineer, Case Waste)

Natural resources savings was identified as the most common enabler (n=5), commonly influenced by the cases, but it was mentioned only by Case Paper. In Case Paper, the mission was to create for the clients a decreased need for raw materials with an economic motive, but this had a positive environmental impact as well:

> *"One big driver, of course, has been resource efficiency, that is, if the same product can be made with less raw material and less energy. In the best case, up to 10 % of the raw material has been saved, which in this case means savings on everything. Starting from the forest, you can leave ten of that kind of tree to grow and 10 % less trucks [are needed], 10 % less everything."*
> (R&D Manager / Engineer, Case Paper)

Lastly, the challenges in *Reuse of materials* were reported only by a developer of Case Dust product. The challenges were about not being able to use recyclable materials in a part of the product, in addition to the fact that as the main function their product also collects non-recyclable material as it is cleaning the construction site area:

"[...] actually it does not matter what the material is [in the filter], it's going to mixed waste anyway because you mix so many different substances into it [when you clean up the environment]. And then again, filter materials are what they are, so we are not really able to build better filter materials. [...] if I think about the environmental friendliness of filter materials, usually they are fiberglass or something else. One does not have that many options, and then it goes into mixed waste anyway [because of the collected substances] and they are all incinerated. It can't really be recycled in any way because inside there you have rock, cardboard, and fiberglass." (COO, Case Dust)

"[...] it does not matter what the material is, it still goes to mixed waste, because so many different materials are mixed in it. [...] So there really are no other choices, so it goes to the mixed waste and gets burned. It can't be recycled, [because it has non-recyclable materials in it]." (CEO, Case Dust)

4.5.2 Decreasing pollution

Decreasing pollution was the second most common environmental category (n=12) with only two challenges and 10 enablers identified. One challenge influencing Case Dust was reported as possible negative influence resulting from pollution via transportation of product. It was thought to be challenging to ensure what environmentally suitable transportation option to choose:

"If you want to get this product to the construction site, then it has to be transported there, there are not many other options. We use a big logistics company for that, but you really do not have many other options [...]."
(CEO, Case Dust)

Enabling factors for all the cases were those which made the products suitable for the environment and therefore also viable for use and more attractive to customers. The case products had enabling connections to the category of positively influencing the environment through their use. These included decreasing carbon footprint and pollution. These were not necessarily the main objective of the products but were still results from using them and were for example connected with saving of natural resources. For example, Case Paper developer noted that less need for natural resources leads to less polluting transportation, and Case Waste developer referred to decreasing pollution by improving recycling, as pointed out also in *Reuse of materials*:

"Via the raw materials savings the [transportation of raw materials] is affected also." (R&D Engineer, Case Paper)

"[...] when materials can be recycled more efficiently, it will then reduce global emissions. There is no need to pump as much oil or dig metals from the earth's crust and thereby pollute the environment."
(Mechanical Engineer, Case Waste)

4.5.3 Environmental attitudes

Attitudes related to environmental decisions and practices were clustered as the third environmental category with about a fourth of the environmental mentions (n=8). This category reflected views on the environmental aspect rather than the concrete results or consequences. These produced only two enablers for the cases and the remaining eight mentions were challenges on cases. Green thinking was the only enabling influence on the cases, and this applied more specifically to Case Paper. Here the fact that the product could promote green thinking by materials savings advanced the development:

"When we realized [that the product is also environmentally friendly as it saves the customer's materials], then of course we added that to our sales materials that there is such an advantage to this device as well. It's environmentally friendly." (R&D Engineer, Case Paper)

Challenges related to *Environmental attitudes* manifested on all the cases as requirements of pressure for green thinking and confrontation of the benefits to nature against economic or health benefits. As an example, CTO of Case Waste stated that the challenge was to keep up with implementation of green thinking in business while still they had to make profit in order to keep their company going:

"The reality is that [our clients and us] can be just as green as ever, but if they don't make a profit, then they stop it. […] [Many of our customers] have their mission statement about the increase of recycling and other environmentally beneficial matters and this is a strong environmental storyline, but it is strong only via business, because if they don't get money or make profit, then they are not implementing their economic visions either." (CTO, Case Waste)

4.6 Legal factors

Legal impact on the case studies covered 11 % (n=44) from the interviewees' mentions related to PESTEL. Of these, 32 mentions were identified as challenges, 11 as enablers, and one as neutral. All the influence was directed on the cases and no influence on legal factors arose from the cases. From the identified legal connection

three categories were gathered: *Standards and directives, Legislation,* and *IPR activity.*

4.6.1 Standards and directives

Standards and directives covered almost half (n=20) of the identified legal connections. This category was seen commonly as a limiting and challenging influence as of the 20 mentions, 16 were challenges, and four enablers. The enabling influence from common standards were reported in cases Dust and Air. Having EU-wide common standards on product development and technical properties enables robust guidelines for the development. Adhering to these standards and guidelines developers can be sure that the product will fulfill the requirements in all EU countries simultaneously and access to the EU market is legally secured:

> *"But now that we have the EU and the standards, we know what is required of us in [for example] both Finland and Italy."* (COO, Case Dust)

> *"[...] this Finnish [standard] also refers to this common European standard. There are common rules for this industry."* (CEO, Case Air)

On the other hand, developers noted common standards also to be problematic to follow. Challenges were reported when some standards imposed very different legal requirements in Europe, either due to non-EU member state legislation, or national regulation of a member state, which may be more specific than the EU standards and guidelines. For example, Case Waste noted this to be a challenge when the product is sold to other countries beyond Europe and the EU, and unexpected additional standards need to be complied with:

> *"Then, of course, there are these country-specific or regional regulations and standards that need to be considered. In the USA, for example, UL approvals are required for electronics, and it is difficult to produce UL-approved electrical cabinets, for example, because there are not many workshops in Finland that have the certificate [to manufacture with UL approval]."* (Mechanical Engineer, Case Waste)

Interestingly, four of the challenges were connected specifically to the Machine Directive (Directive 2006/42/EC of the European Parliament and of the Council). These were reported by cases Dust, Paper, and Waste where they all concluded that it was a limiting factor. For example, developers in cases Paper and Dust had experienced the directive as increasing the requirements for the development:

"[The legal factors affect the case] in the way that the Machine Directive is quite strict. Everything must be very safe, so that you could let a kindergarten group run around the product without anything bad happening to them. And because this is new technology, we have to think about the risk analysis thoroughly. […] It is very strict and precisely regulated."
(R&D Manager / Engineer, Case Paper)

"We have to look at the Machinery Directive and government regulations. After all, all equipment manufacturing is quite regulated. As a device manufacturer, when you bring a product on the market, you must ensure that it complies with the regulations applicable to that device." (CEO, Case Dust)

4.6.2 Legislation

Legislation had the second highest legal connections (n=19). Enabling influence on the cases was (n=5) smaller than the challenging influence on the cases (n=14). The enabling influence came from changes in legislation and once from country-specific legislation. Connections to legislation supporting the company mission led to new openings and increased demand for Case Dust in cleaning, and Case Waste in recycling:

"The biggest thing for us in business was the EU directive that made dust management [where our product helps] mandatory." (CEO, Case Dust)

"Especially the tightening recycling requirements [increased demand]. It's kind of slowly raises the cost of not recycling, and it's nice because it creates demand [for our product]." (CTO, Case Waste)

Country-specific legislation was seen as an enabler for Case Air when another Nordic country had legislation supporting their mission and this could improve possibilities for such changes in legislation to be also adopted in Finland:

"[...] In Norway, it has been mandatory for 10 years to install a [product similar to our product] in homes to prevent fires. Of course, that has acted as one driver and has its own drivers for the business." (CEO, Case Air)

The challenges related to legislation originate from connections such as how to interpret legal requirements correctly, vagueness of definitions, legislation too loose for increasing the demand, changes towards stricter legal requirements, and educating legislators. Most of the challenges connect to the fact that legislators are not necessarily the experts on the technical area and therefore the legislation might

be misleading or contain redundant requirements. These challenges had an influence on Case Dust and Air. In Case Dust the product was new and therefore the legislation around it had to be corrected by the developers:

> *It went more in the direction that we wanted no overly strict filter requirements to be required there [in the law]. This was a completely new device for the legislation as well. [...] This device of ours was not possible to categorize, and that was a big thing we had to explain.* (CEO, Case Dust)

Case Air had to intervene with the legislation of a certain standard as it was about to be defined to require redundant and unnecessary items:

> *"[A relevant standard] was going in the direction that it defines a technological solution. We then took a stand against it because it was totally the wrong way to standardize it. The required functions and situations should be defined, but the technological solution should stay open. Surely it doesn't make any sense that a car should have five wheels if four is better. It's not the standards' job to define that. We got our message through, and now the standard is a series of required functional tests."* (CEO, Case Air)

4.6.3 IPR activity

The IPR (intellectual property rights) activity had the least number of mentions. It had a variation of enablers (n=2), challenges (n=2), and neutral events (n=1). However, these mentions were only reported by the developers of Case Dust. The challenges came from the patenting process itself as it is an additional task related to the development. Moreover, a patent might not necessarily cover other regions, as the COO of Case Dust describes:

> *"[...] although the patent was obtained in Europe, it may not be straightforward to have it elsewhere."* (COO, Case Dust)

On the other hand, if patenting had been successful, the achieved legal protection was identified as an enabler, because it was experienced to prevent competitors from using the ideas:

> *"We developed our own filter solution [...] We got a patent for it last year."* (CEO, Case Dust)

4.7 Case-specific differences and similarities

The cases had some differences and similarities regarding the identified influences of the contextual factors. Overall case-specific statistics of the number of mentions for each PETSEL dimension are presented below in Table 7. Here the quantities of the identified PESTEL connections are presented according to PESTEL dimensions in each case study.

Table 7. PESTEL coding statistics per case

Dimension	Case Dust	Case Air	Case Waste	Case Paper	sum
Political	16	8	6	2	32
Economic	16	13	15	28	72
Social	33	17	9	10	69
Technological	27	25	61	21	134
Environmental	7	5	8	13	33
Legal	18	12	13	1	44
	117	80	112	75	384

Most of the identified contextual factors were related to the technological dimension and least were related to the political area. Case Dust and Case Waste had more mentions of PESTEL factors (n=117 and n=112, accordingly) where Case Air and Case Paper contained less (n=80 and n=75). There were also some differences in the emphasis between different PESTEL dimensions across the four cases.

Detailed summary of the results is presented in Table 8 according to the PESTEL framework. This summary answers the research question of the thesis: “What types of contextual factors do engineers working with business-to-business product development projects recognize as enablers and challenges on and by the development?”. These main insights are compared to the literature in the Discussion chapter.

Table 8. Summary of contextual factors reported in the interviews.

Dim.	Political	Economic	Social
Factors identified in the interviews	**Cases Air, Dust, Waste:** Benefitting from tightening global health, safety, and environmental policies. **Cases Air, Dust:** Lobbying increases awareness for products. **Cases Dust, Paper:** Local politics challenging due to influencing funding. **Case Waste:** Local politics supporting due to advanced technology.	**Case Paper:** Free resources make possible launch of product. **Cases Dust, Waste:** Challenges with limited financial resources. **Cases Dust, Paper:** Creating savings for clients enables more demand. **Cases Paper, Waste:** Competition and convincing clients challenging. **Case Dust:** Determining a balance with product costs and price challenging **Cases Air, Waste:** Succeeded, enabled increased demand. **Case Paper:** Changes in the market experienced as enablers. **Cases Air, Paper:** Economic cycles challenging due to uncertainty in demand and funding.	**Cases Dust, Paper, Waste:** Users' attitudes cause challenges due to e.g. users handling products harshly or not seeing the product as necessary to use. **Cases Air, Dust:** Answering user feedback with suitable changes enabled increased demand. **Cases Dust and Paper:** Improving health **Case Air:** Challenges as improving health also generated environmental issues and vice versa. **All cases:** Safety caused challenges when difficult to implement but managing to improve safety increased product demand **Cases Air and Waste:** Industry networking noted creating new opportunities. **Cases Waste and Dust:** Societal attitudes positive influence due to enabling more recognition as the products had potential to solve environmental or health issues.

Dim.	Technological	Environmental	Legal
Factors identified in the interviews	**All cases:** Challenges in designing products to be compact and durable. **Case Air:** Successfully reported a compact design enabling lower costs for the product. **Cases Air, Dust, Paper:** Self-developed solutions challenge developers, but enabled innovations; having technical knowledge enabled avoiding repeating certain challenges. **All cases:** Automated functions and advanced technology caused challenges due to complex technical requirements but enabled increased efficiency and improved product performance. **Cases Dust, Paper:** Leveraged from existing solutions as parts of their product. **Case Dust:** Challenges with existing solutions being not suitable for the part of their product. **Cases Air, Dust, Paper:** Technical tools speed up development process.	**Cases Paper, Waste:** Supporting circular economy, recycling, using fewer natural resources increased interest towards products. **Cases Dust, Paper, Waste:** Positively influence the environment by practicing reuse of materials and use fewer natural resources **Case Dust:** Challenges in material recycling only reported in this case - not able to use recyclable materials in a part of the product. **Case Dust**: Challenges related to pollution due to transport of products **All cases:** Decreasing environmental pollution making products more attractive to clients **All cases:** Challenges with environmental attitudes related to pressure for green thinking and mismatch of benefits to nature and economic/ health benefits.	**Cases Dust, Air:** Common standards for product development and technical properties enable robust guidelines for development. **Cases Air, Dust, Waste:** Standards and legislation problematic to follow because of differences in country-specific standards **Cases Dust, Paper, Waste:** The Machine Directive challenging due to directive increasing requirements for development process **Cases Dust, Waste:** Legislation supported the company mission opening new opportunities and increasing demand. **Cases Dust, Air:** Challenges related to legislation from interpreting legal requirements, vagueness of definitions, changes towards stricter legal requirements, and educating/informing legislators **Case Dust:** IPR protection process demanding and challenging, but when patenting successful, prevents competitors from using the ideas.

Dim. = dimension

Some case-specific observations can be made based on the findings shown in Table 8. Only cases Air and Dust developed by the smaller companies had found lobbying to be a useful channel for increasing product demand and interest, whereas Case Waste reported that local politics supported the case as it included advanced technology. Cases Air, Waste, and Paper had benefited from free resources or experienced success to balance the costs and resources which speeded advancements in development, meanwhile Case Dust reported only challenges with regards to resources. In all of the cases challenges had been encountered in developing the case product to be safe and suitable for the users. However, only the smaller companies developing cases Air and Dust had solved these issues by implementing user feedback.

Development of all the cases had run into some types of challenges with technology, but all cases other than Case Waste had also experienced enabling effects. Cases Air, Dust, and Paper utilized technical tools to improve user safety, to make the product more compact, and to monitor the product performance, respectively. All cases were challenged by environmental pressure, but in all cases ways to overcome this were found. All the cases solved this challenge by finding ways in which to promote environmental trends. Case Air was the only one for which matters related to recycling or using fewer natural resources were not reported. All of the cases experienced legislation including requirements, standards, and directives as challenging as it increased the demands for the development. However, in all the cases these matters were solved, with the exception of Case Paper. Case Air benefitted from the coherence of standards, and for Case Waste changes in legislation opened new opportunities. In Case Dust both coherence of standards as well as opportunities from changes in legislation had been experienced.

5 Discussion

This thesis has examined the influence of contextual factors in four selected cases of product development projects. Interviews with eight engineers revealed that the developers were aware of a range of positive and negative contextual influences on and impacts. Table 9, below, summarizes salient factors identified by the interviewees and compares them to previous research. Taken together, similarities in having and using resources, recognizing the use context of the product, and challenges from concrete environmental and legal limitations emerge from this comparison.

Table 9. Observed PESTEL linkages compared to previous research.

Dime	Connections identified by the interviewees	Agreement with previous literature	Contradictions with previous literature
Political	**Cases Air, Dust:** Lobbying increases awareness for the products. **Cases Dust, Paper:** Local politics challenging due to controlling interests and funding.	Lobbying is a potential enabler for increasing interest in the product (Johnson et al., 2017). Local politics can ruin opportunities for companies due to unexpected changes in legislation (Daft, 2010; Johnson et al., 2017; Kammerl et al., 2017).	
Economic	**Cases Dust, Waste:** Challenges with limited financial resources **Case Dust:** Determining a balance with product costs and price challenging **Cases Air, Waste**: Product costs and price in balance, enabling increased demand.	Lack of resources limiting factor leading to challenges and even to closing down the business at early stage (Kammerl et al., 2017; Santisteban & Mauricio, 2017). Product costs influence final selling price of the product, ultimately impact product development economic success (Kammerl et al., 2017 and Ulrich & Eppinger, 2012).	

Social	**Cases Air, Dust:** Answering user feedback with suitable changes enabled increased demand. **Cases Dust, Paper, Waste**: Users' attitudes cause challenges due to e.g. users handling products harshly or not seeing the product as necessary to use. **Cases Waste, Dust:** Societal attitudes considered as positive influence due to enabling more recognition as the products had potential to solve environmental or health issues.	Social attitudes and trends can potentially be enablers for product development; example given of benefitting from increasing environmental awareness (Ulrich & Eppinger, 2012).	The literature does not recognize the same enablers or challenges, but Johnson et al. (2017) and Daft (2010) highlight that user and customer profiles are useful factors, because knowing the users enables effective development according to user needs. Cultural attitudes and mindsets possible challenges as they are channels of generating expectations and assumptions which could be difficult to overcome. Johnson et al. (2017) and Kammerl et al. (2017).
Technological	**All cases:** Automated functions and advanced technology cause challenges due to complex technical requirements but enabled increased efficiency and improved product performance. **Cases Air, Dust, Paper:** Technical tools speed up development process.	New technologies and other advances in technology development are enablers due to offering new possibilities in product development (Dodgson et al., 2006; Johnson et al., 2017; Kammerl et al., 2017; Santisteban & Mauricio, 2017). Technical tools recognized as enablers for increased efficiency in organizations (Johnson et al., 2017; Dodgson et al., 2006; Daft, 2010).	Helbing (2019) points out the potential challenges, but relates this to data privacy with e.g., artificial intelligence.

Environmental	**All cases**: supporting the circular economy, recycling, using fewer natural resources, and decreasing pollution increased the interest towards the products. **Cases Dust, Paper, Waste:** Positively influencing the environment by practicing reuse of materials and less required natural resources for clients. **All cases:** Challenges with environmental attitudes related to pressure for green thinking and mismatch of the benefits to nature with economic or health benefits.	The same enabling factor towards the environment is recognized by Korhonen et al. (2018) when practicing circular economy. Environmental attitudes and factors controlling these attitudes recognized as challenges and limitations for product development and other organizational activities (Johnson et al., 2017; Korhonen et al., 2018; Ulrich & Eppinger, 2012).	Majority focus on possible challenges due to limitations in for example waste, materials, and energy consumption (Johnson et al., 2017; Korhonen et al., 2018; Ulrich & Eppinger, 2012).
Legal	**Cases Dust, Air**: Common standards on product development and technical properties enable robust guidelines for the development. **All cases:** Legislative requirements such as standards and directives also problematic to follow because of differences in some country-specific standards and limitations to product development. **Cases Dust, Waste:** Legislation supported the company mission opening new opportunities and increasing demand. **Cases Dust, Air:** Challenges related to legislation from interpreting legal requirements, vagueness of definitions, changes towards stricter legal requirements, and educating legislators	Regulations, requirements, and standardizations on the products defined challenging when limiting actions, but also as an enabler when acting as a guide to a useful direction and creating common understanding of the “rules” of the area. (Blind, 2012; Johnson et al., 2017; Pelkmans & Renda, 2014; Stewart, 2010; Ulrich & Eppinger, 2012). Tightening legislation may enable useful guidance, while rapidly tightening legislation hampers activities and might ruin plans (Kammerl et al., 2017; Pelkmans & Renda, 2014).	

Dim. = dimension

It is evident (Table 9) that there is agreement with previous studies across many aspects which the developers in the interviews of the present study have stated. However, many of the developers' perceptions differ from the literature as they reflect a more practical experience , whereas the literature presents the same factors and influences from a more theoretical and organizational aspect. On the other hand, there are also clear common themes which influence the cases across PESTEL dimensions that emerge from the comparison.

5.1 Contextual factors influencing across dimensions

The three common themes identified from the comparison are the number of resources controlling the development capabilities, product use context posing challenges, and environmental and legal requirements setting boundaries for innovation. These three themes are discussed in more detail in the following chapters 5.1.1, 5.1.2, and 5.1.3.

5.1.1 Resources dictate advancements in development

Results of the present study, as well as previous literature show that resources largely dictate product development. Limited resources emerge through the political and economic dimensions and cause challenges for developing products. Local politics are an example of a political influence which is seen as controlling the distribution of funding. Economically this generates issues because of lack of funding. Kammerl et al., (2017) and Santisteban & Mauricio (2017) agree that the lack of resources is a limiting factor leading to challenges and even to closing down the business in an early stage. In the present study, limited resources created challenges with product costs and price as it was difficult to finance all of the necessary development tasks. This led the developers to prioritize their tasks, and which therefore controlled the progress and speed of the development.

On the other hand, it is evident that having the resources was an enabler when considering the economic and technological dimensions. For example, the interviews mentioned free resources and technical tools as development resources which had enabled major leaps in development, either for launching a project or speeding up prototyping. This is in line with the literature where Daft (2010), Dodgson et al. (2006), and Johnson et al. (2017) recognize technical tools as enablers for increased efficiency in organizations. In addition, Santisteban & Mauricio (2017) also state that accumulated resources enable more agile product development.

In addition, lobbying was seen as an enabler to raise awareness or interest for the case products. Perhaps, this could be utilized to receive more funding for product development projects. In the literature Business Finland (n.d.) funding is available

for all businesses in Finland, which indicates opportunities to get funding especially when the interest and need for the product is recognized, for example through lobbying.

5.1.2 Use context of the product sets challenges

Knowing user attitudes – what they think and how they act – was shown to be imperative for successful product development, which has also been stated by Johnson et al. (2017). This was evident, as the interviewees of the present study recognized a wide range of challenges related to use of the products both regarding the product users and the operating environment. Examples of these issues were users handling the products harshly or the operating environment being challenging for the product durability and performance. These issues within the societal dimension were partly in line with the literature, but some differences were evident. The developers in the case projects experienced challenges associated with product usability, user safety and user training. These have not been discussed in previous literature, but Johnson et al. (2017) mention user profiles related to geographical location, and Daft (2010) mentions customer attitudes. Both sources highlight the factors as important influences on organizations and strategy, but they do not classify these as challenges or enablers.

In the context of product use, new technologies and automated functions and advanced technology caused challenges due to complex technical requirements. Helbing (2019) points out the potential challenges, but relates this to data privacy with e.g., artificial intelligence. These issues with complex technology and privacy protection could also reflect to the finished product. If developers struggle with complex technology in a product, it is likely that this also may pose problems for the users.

5.1.3 Pressures and constraints set boundaries for innovation

The developers reported strong limitations across certain contextual factors, including environmental limitations related to sustainability and legislative limitations from requirements and directives. These were mostly seen as added considerations on decision making during the development process. From the environmental point of view, challenges arose from the confrontation of business operations with environmental consequences and requirements. Some challenges were for example limits on the product power consumption. Legal themes were mostly considered as challenges for all the cases studied. Standards and directives were mostly viewed as negative influences because requirements and standards often limit development.

Recyclability, material selection, and energy consumption have also been regarded in previous literature as challenges due to added limitations or requirements for product development (Johnson et al., 2017; Korhonen et al., 2018; Ulrich & Eppinger, 2012). Furthermore, standards and directives as constraints have also been recognized as limiting factors (Blind, 2012; Johnson et al., 2017; Pelkmans & Renda, 2014; Stewart, 2010; Ulrich & Eppinger, 2012). Moreover, environmental attitudes created pressure for the developers as the need for environmentally-friendly decisions has become increasingly important, which has also been documented by previous work (Johnson et al., 2017; Ulrich & Eppinger, 2012).

It is therefore evident that environmental and legal requirements, standards, and guidelines all may limit innovation. On the other hand, as these are all highly justifiable it is important that product development can anticipate these in advance and acquire the needed expertise to turn these into an asset. It is also important that developers take responsibility for influencing legislation, standards, and guidelines, which was also pointed out by Case Air, where the developers themselves made sure that the standards for their industry are set correctly. Overall, legislation was experienced as challenging by the developers due to uncertainty of changes in legislation and unclear legislation leaving room for interpretation. Regulation has been reported to lag behind product development in many fields, and more innovation friendly regulation has been called for also by e.g. a recent Finnish government's analysis (Pelkmans & Renda, 2014; Salminen & Halme, 2020).

The present study also supports the notion that that anticipating and following rules and regulations may also open up new and more efficient practices, and attitudes may evolve into enablers. Namely, by answering to the call for more environmentally friendly products sustainable development was seen to enable more efficient practices. This was evident in Case Waste which operates in improving recycling and for Case Dust, for which tightening of legal requirements on construction sites enabled an increased need for its products. This confirms the notion of Johnson et al., (2017) that supporting environmental goals, may turn attitudes to enablers. All in all, the results are in agreement with the literature in that environmental and legal requirements create limits, which will primarily challenge actions, but in some instances may open up new avenues.

5.2 Practical implications

This thesis has demonstrated that by recognizing contextual influences it is possible to understand the realities of product development and further improve it. The following type of framework (Table 10, below) could be beneficial in for example decision-making and communication concerning the contextual issues related to

product development. Here the factors which are viewed by the developers as challenges and enablers are presented by confronting them. The guidelines are directed to the managerial personnel in the product development projects, who are more concentrated on the decision-making in the projects. Concerning the cases presented in the current study, this type of personnel would be any of the personnel in smaller companies such as in Case Air and Dust or the CTO in Case Waste, or the R&D Manager / Engineer in Case Paper.

Table 10. Framework for contextual factors and guidelines on taking these into account in product development.

Contextual factor	VIEW as CHALLENGE	VIEW as ENABLER
RESOURCE AVAILABILITY	Recognizing LIMITED RESOURCES Difficulties in APPLYING for FUNDING	Finding FREE RESOURCES Utilizing LOBBYING
USE CONTEXT	Determining USER DEMANDS and REQUIREMENTS COMPLEXITY and DURABILITY of TECHNOLOGICAL Solutions	Gathering and analyzing USER FEEDBACK, PRODUCT SURVEYS, CASE REPORTS etc. Reports of NEW TECHNOLOGY Applications, MARKET OPPORTUNITIES, etc.
LEGAL & ENVIRON-MENTAL CONSTRAINTS	Limitations from LEGISLATION Pressure from ENVIRONMENTAL RECUIREMENTS	Acknowledging the LEGAL SCENE Riding with ENVIRONMENTAL TRENDS

The first row of the table concerns the limitations of resources. Not having to struggle with constantly limited resources would give the developers more freedom in the development projects as for example limited amount of money would not limit how many tasks they could perform simultaneously. One guideline to minimize this

would be acknowledging the limited financial capacity for example by budgeting the costs (Cooper & Kleinschmidt, 1996). Another solution would be seeking for free or cheap resources, which emerged from the developers, who stated this being a strong enabler in product development. Applying for funding was recognized as a way to get more resources, but there is an uncertainty in getting it due to political influences. Here it could be suggested to use lobbying as a channel to increase the interest of the funders.

The second row of the guidelines presents the confrontation between used technology and the user requirements in the use context of the product. It is crucial to know what goes through the users' mind and how they perceive the product, and how the product performs in non-optimal conditions. Challenges here are viewed to come from the use context of the product, where the product durability is challenged by the users and the surrounding conditions. As a guideline, the identified enablers should be used to solve these issues: Learning the user demands and requirements from user feedback and studying the used technology provide added knowledge which will be useful in assessing the use context of the product.

The third row of the framework considers the constrains that are viewed to hinder innovation in product development projects. Although the constraints – legislative and environmental – have strong authoritative drivers related from e.g., safety, fair competition, and nature conservation, they impact product development innovation marked (Debnath, 2015; Pelkmans & Renda, 2014). To minimize the constraints, it is suggested that the legal and environmental themes should be acknowledged with regards to the developed product and also searching for opportunities from these.

These presented practical implications and the related framework (Table 10) offer guidelines in product development projects to overcome the anticipated challenges and utilize the identified enablers. Although the guidelines are primarily addressed to individuals involved with practical level product development and managers, they could be used also as common guidelines in for example startups where the personnel share many tasks and might have both practical and strategic tasks.

5.3 Theoretical implications

The recognized emerging contextual insights presented earlier in the discussion section in the chapter 5.1 have many practical implications, but could also be included in theoretical approaches, for example in decision-making. Decision-making theory has been studied in order to solve strategic management issues with classification on positively and negatively influencing factors (Yüksel, 2012), and in

strategic decision-making in product development (Büyüközkan & Feyzıoğlu, 2004; Kandemir & Acur, 2012).

Especially a decision-making theory Case Based Decision-Making Theory (CBDT) would be suitable area to include the results and main insights of this thesis in studies of decision-making in product development as CBDT is based on making decisions based similar previous case studies (Gilboa & Schmeidler, 1999). As this thesis suggests the practical implications as managerial level guideline, CBDT has also been used to improve decision-making on executive level of companies (Lovallo et al., 2012). In fact, Gilboa & Schmeidler (1999) state that CBDT can be used as an alternative for practical decision-making, much like the presented practical framework in Table 10 designed to guide developers in product development projects. Future studies could include a combination of studying the decision-making in the product development projects by identifying the contextual factors. Alternatively, this type of practical multiple case-study approach could be used as a tool in when carrying out a CBDT study.

5.4 Limitations and future research

The qualitative research in this thesis was conducted by using existing processes and known methods, which increases the validity of the research. Also, during the data collection the case study approach included advantages such as all the interviewees coming from an engineering background and therefore having a similar common ground towards the influences on their product development projects. However, the fact that only four case studies were used to collect the data, makes the data somewhat limited for broader generalization.

Other limitations in qualitative research based on the interviews include factors related to data collection and interviewees. Limitations related to the collected data come from the subjectivity of the interview data which is completely based on the views and opinions of the interviewees. However, the subjectivity of the data was reduced by having two interviewees form each case. In addition, the collected data is retrospective data as the developers shared their thoughts and experiences after the development process. Data collected during the development projects when the development decisions and events took place could have looked different, because perceptions about the development project might have changed over time. The effects of subjectivity and retrospective could have been reduced by for example examining the notes made by the developers during the development and looking into other documentation related to the products, such as user manuals.

The interview situation and conditions should also be taken into account. Due to the COVID-19 pandemic the only option for interviews was remote mode using Microsoft Teams and Zoom which might have affected the behavior and communication of the interviewees. On the other hand, such influences cannot be ruled out in any setting, be it physical or virtual.

Despite the presented limitations, the results of the present study correlate well with the results of the literature which supports their validity. Furthermore, the interviews were conducted according to an established protocol created and used extensively by the research team of the Aalto University Design Factory. In future studies the limitations of this study should be taken into account in order to further focus on the development decisions and events as they take place during the development process.

Considering future research, the present study has paved the way for the use of the PESTEL framework for identification of contextual factors influencing product development. Some specific enablers and challenges were identified, which offers the possibility for a more systematic study in the future. The present research included three company profiles, but future work could focus more on certain types of companies such as comprehensively on startups. Based on the results of the present study, it is also evident that the thematic area of environment could be an interesting feature to study in conjunction with the startup focus. The studied market area could also be changed to for example business-to-customer, where the customer might be viewed differently than in business-to-business which the current research focuses on.

Future studies could be also expanded regarding time perspective, by starting the research already at the start of the development projects or during them in the form of longitudinal study. Considering the research methods, in the future a similar study could be done with another framework such as the SWOT framework as it focuses more on the positive and negative influences. Alternatively, further research with the results in this thesis would be to inspect how the contextual enablers and challenges that were found exert an influence during the different phases of the product development project. Here the questions could be e.g., at what phase does each PESTEL dimension have the strongest influence, and whether they are enabling or challenging during those phases. This could provide more realistic results of *when* the found influence of contextual factors should be utilized or minimized.

5.5 Conclusions

This thesis mapped out contextual factors experienced as enabling and/or challenging in Finnish business-to-business product development projects through empirical qualitative research. This study adds to the so far limited knowledge of contextual factors' influence to business-to-business product development projects. This was achieved by collecting qualitative data from an interview study of four case studies including one product and two interviewees from each case. Each of the cases were of different companies.

To help systematically analyze the collected data and identify the contextual challenges and enablers, thematic analysis was used to categorize the influencing factors that were found according to six dimensions of PESTEL framework including political, economic, social, technological, environmental, and legal factors. From this categorization it was possible to identify the main enablers and challenges of the studied cases. In the data collection 384 connections to the PESTEL framework were identified from the interview transcripts.

As result of the analysis, clear enablers and challenges were found. Political and social factors offer mostly enabling influence. Economic, environmental, and technological factors were divided quite equally to enablers and challenges. Legal dimensions posed most of the challenges for the developers of the case projects. From comparing the results to extant literature, three common themes emerge. First, resources are perceived to dictate the progress of product development projects. Second, the use context of the product causes development related to the user and used technology. Third, innovation is affected by environmental pressures and legal constraints.

In conclusion, this thesis identifies a comprehensive listing of contextual enablers and challenges in product development projects and highlights the common themes emerging from the listing. With these insights this thesis lays a basis for the next steps in using these factors and themes to improve product development by following the presented practical framework. Therefore, this thesis reaches the objective to highlight main contextual factors and themes having positive or negative impact on in business-to-business product development projects.

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Appendix 1: Interview structure

The interview structure below was utilized in all of the eight interviews conducted as part of this research. When necessary, additional further questions were asked in order to clarify the main questions.

Introduction (5 min)

- Aim of the research: To gather an understanding of product cases for thesis work and research at Design Factory.
- Confidence: Use and access is restricted to the research team of Aalto University's Design Factory.
    - Have you had time to view the GDPR privacy statement attached to the email?

A) Warm-up (5 min)

- Tell us about this product. What is it and what is new in it?
- What has been your role in the development of this product?

B) Case study (20 min)

I would like to go through the development of the case product with you so that we can get a better idea of what has been involved in developing it.

- Where did the idea or need for this product come from? Why did it seem promising or worth considering?
- What was the idea about? What is the technical core of the product?
- Can you go through what happened to the idea then?
- What happened next? What were the turning points in the development?
    - What supported your work? What made it difficult?
- How was the product tested and prototyped? How did the idea possibly change?

(Continues on the next page)

C) PESTEL considerations (20 min)

We are also interested in what e.g., societal, environmental, and economic factors you see have affected the solution and its need - or how these influenced the shaping of the solution.

- If we think about environmental themes, were they somehow influencing the solution or its development? (e.g., sustainable development, material choices, emissions)
- What economic issues or themes are connected to this? (e.g., competitiveness, order backlog, recessions)
- What about technological connections to the case? (e.g., readiness, Legacy systems)
- Were there any factors influencing the case connected to legislation? (e.g., industry regulations)
- Were there any social connections to this? (e.g., workforce, work attitudes, users, use context, safety, health)
- Were there some politically connected factors influencing the case? (e.g., lobbying, Brexit)

D) Finish (5–10 min)

- What do you want to influence with the case?
- In hindsight, is there anything you would have done differently?
- Is there anything still to be developed here? (i.e. future considerations)
- Is there something to add?
    - Did we miss something important?
- Any questions for us about this study?