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DESIGNING AND VALIDATING A PAY-PER-X MATURITY MODEL WITH ACTION DESIGN RESEARCH

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ABSTRACT

Joonas Schroderus: Designing and Validating a Pay-per-x Maturity Model with Action Design Research
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The objective of this study was to find out how to design and validate a maturity model to use as a tool to assess the internal readiness of small to medium, business-to-business equipment manufacturing companies implementing new, service-based pay-per-x (PPX) business models. These business models focus on services related to the use, output or outcome of the equipment product, instead of the more traditional sale of the product itself. This means that potentially several, crucial changes in the companies are needed internally, which is why there is also a need for understanding the requirements for change. Consequently, a maturity model that aims to assess the readiness of a company to implement a new type of business model can be developed, in order understand the requirements that are needed in the implementation.

In order to address the need for assessing the companies' readiness to implement the PPX business models, this study focused specifically on designing and validating a maturity model for assessing the PPX readiness of the internal aspects of the small to medium, business-to-business equipment manufacturing companies. With the help of the existing maturity model design frameworks, this study was built on an action design research approach, where the preliminary, theory-based maturity model was evaluated and modified by a continuous process of consulting different focus groups and other groups of experts. The study started with a literature review that was the basis of the preliminary maturity model, after which the preliminary model was modified through rounds of focus group discussions and expert workshops.

The result of the study was a suggestion of a maturity model with seven different dimensions, including organizational governance, strategy, risk management, competences & culture, product & production technology, data analytics as well as product life cycle processes. Moreover, five general reference levels for the pay-per-x business model maturity were created, as well as the individual minimum and maximum maturity level descriptions for each of the dimensions. Although the scope was limited to these specific companies and the internal readiness, these dimensions and reference levels were found out to be useful in initially assessing the readiness of implementing PPX business models in the specific context of the study. Moreover, in addition to validating the model, the study helped in validating the design criteria and maturity model development process in general, allowing the systematic development of PPX maturity models in the future as well, and potentially in other contexts as well.

Keywords: B2B, equipment manufacturer, small and medium-sized enterprise, pay-per-x, maturity model, maturity, readiness

TIIVISTELMÄ

Joonas Schroderus: Pay-per-x-kypsyysmallin suunnittelu ja validointi suunnittelutoimintatutkimuksen avulla
Diplomityö
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Tämän diplomityön tavoitteena oli selvittää, miten suunnitella ja validoida kypsyysmalli, jota voidaan käyttää työkaluna mittaamaan pienten ja keskisuurten, yritykseltä yritykselle myyvien laitevalmistajien sisäistä valmiutta toteuttaa uusia, palvelukeskeisiä pay-per-x (PPX) -liiketoimintamalleja. Nämä liiketoimintamallit keskittyvät käyttöön, tuotantoon tai tuloksiin perustuviin palveluihin sen sijaan, että keskittyisivät perinteisesti laitteen myymiseen. Tämä tarkoittaa sitä, että mahdollisesti monia, kriittisiä muutoksia tarvitaan yritysten sisällä, minkä vuoksi on myös olemassa tarve ymmärtää kyseisten muutosten tarpeita. Näin ollen voidaan luoda kypsyysmalli, joka tähtää arvioimaan yrityksen valmiutta toteuttaa uusia liiketoimintamalleja, jotta voidaan ymmärtää niitä tarpeita, joita muutoksissa tarvitaan.

Vastatakseen tarpeeseen arvioida yritysten valmiutta toteuttaa PPX-liiketoimintamalleja, tässä tutkimuksessa keskityttiin kypsyysmallin suunnitteluun erityisesti pienten ja keskisuurten, yrityksiltä yrityksille myyvien laitevalmistajien sisäiseen PPX-valmiuteen. Olemassa olevien kypsyysmallisuunnittelukehysten avulla tämä tutkimus rakennettiin suunnittelutoimintatutkimuksen lähestymistalla, jonka mukaan alkuperäistä, teoriaan perustuvaa kypsyysmallia arvioitiin ja muokattiin toistuvalla prosessilla, jossa kuultiin eri kohderyhmien ja asiantuntijoiden mielipiteitä. Tutkimus alkoi kirjallisuuskatsauksella, joka oli alkuperäisen kypsyysmallin perusta, minkä jälkeen mallia muokattiin kohderyhmäkeskustelujen ja asiantuntijatyöpajojen avulla.

Tutkimuksen tuloksena saatiin ehdotus kypsyysmallista seitsemällä eri ulottuvuudella, sisältäen organisaation hallinnan, strategian, osaamisen & kulttuurin, riskienhallinnan, tuote- ja tuotantoteknologian, data-analytiikan sekä tuotteen elinkaariprosessit. Lisäksi luotiin viisi yleistä viitetasoa PPX-liiketoimintamallien kypsyystasoille, sekä minimi- ja maksimitaso kaikille yksittäisille ulottuvuuksille. Vaikka tutkimuksen laajuus rajoittui tiettyihin yrityksiin ja sisäiseen valmiuteen, näiden ulottuvuuksien ja viitetasojen todettiin olevan hyödyllisiä alustavassa PPX-liiketoimintamallien toteutuksen valmiuden arvioinnissa tämän tutkimuksen kontekstissa. Lisäksi mallin validoinnin ohella tutkimus auttoi vahvistamaan suunnittelukriteerejä sekä yleisesti kypsyysmallin kehitysprosessia, mikä mahdollistaa systemaattisen PPX-kypsyysmallien kehittämisen myös tulevaisuudessa ja mahdollisesti myös eri konteksteissa.

Avainsanat: B2B, laitevalmistaja, pieni ja keskisuuri yritys, pay-per-x, kypsyysmalli, kypsyys, valmius

PREFACE

As part of Business Finland's SNOBI project investigating the implementation of pay-per-x business models in manufacturing companies, this study focused on designing and validating a maturity model specifically for the business-to-business equipment manufacturing companies, considering the companies' internal readiness of implementing pay-per-x business models.

Writing and working on this thesis has been very educational, at the very least. I was lucky enough to get a place as a research assistant and a thesis worker at the university and right from the moment of starting my new job, I had a wonderful team to support me on my way to work on thesis and learn more about the academic world in general. Of course, I would certainly lie if I said everything went smoothly and always according to plan, but as cliché as it may sound, those obstacles and difficulties made me appreciate my team, close friends and family members even more than ever.

First, I would sincerely like to thank prof. Hannu Kärkkäinen for guiding me throughout the whole process of writing my thesis. I know you have a limited amount of time, yet I never felt I was left without supervision or help if I needed it. The same goes to you, Karan Menon, who has been a great project manager and a supporter throughout the process as well. Both of your help and understanding has been an immense resource not only in helping me with the progress of the thesis, but also for supporting my wellbeing overall. I feel very lucky to be able to say that, as I know it is not something that can or should be taken for granted.

Moreover, I would like to thank all the other experts such as Lester Lasrado, that were involved in the process of designing and validating the maturity model. Last but not least, I would also like thank my close friends and family members, that as always have been there to support me during the whole process.

Tampere, 11.6.2021

Joonas Schroderus

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LIST OF SYMBOLS AND ABBREVIATIONS

PLC	Product Life Cycle
PLM	Product Life Cycle Management
PPX	Pay-Per-X
RMT	Remote Monitoring Technology
SME	Small and medium enterprises
SNOBI	Systematic Development of Novel Business Models

1. INTRODUCTION

1.1 Research background

Traditional product-centric companies have faced a lot of pressure from the globally saturated markets and changing customer demands to move towards more service-oriented business models (Kindström, 2010). Combined with driving force of the technological and digital advancements that industries are facing (Bock & Wiener, 2018), new pay-per-x (PPX) type of business models have started to develop especially in manufacturing, as companies are pushed towards selling for example the use or performance of the product, instead of the mere product itself (Adrodegari et al., 2015). This servitization of business models is not a new phenomenon itself but can nonetheless be a complex one and can bring with it different corporate challenges (Vandermerwe and Rada, 1988), and is especially true in the case of small and medium-sized enterprises (SME) in manufacturing, which can face major challenges in transitioning from the traditions of product-oriented approach to the new service-oriented approach (Teso and Walters, 2016).

Responding to the challenges related to the implementation of these new types of PPX business models can be difficult, since obtaining competitive advantage through the new business models requires new operational capabilities (Teece, 2007) as well as general understanding of the threats that companies might face in the process (Gebauer et al., 2017). Moreover, the process of implementing business models is generally a less developed area (Poandl et al., 2019; Berends et al., 2016), and many companies fail to implement new business models successfully (Christensen et al., 2016). Consequently, the need for systematic ways of implementing new business models persists.

As a solution, maturity models can be developed for companies to understand the requirements of implementing the PPX business models by aiding them in assessing the maturity of e.g., different capabilities and competencies needed in the process (de Bruin et al., 2005) and providing them a common framework or language to facilitate the organizational change (Menon et al., 2016). Maturity models have already been widely accepted as effective tools in areas such as IT management (Pöppelbuß et al., 2011), in addition to more extensive processes such as product service systems (Neff et al., 2014) as well as manufacturing and services (Wendler, 2012), which is why they can arguably serve as a tool aiding the systematic process of PPX business model implementation as

well. In the best-case scenario, in addition to providing common language to the organization, a PPX maturity model can help companies in defining their current as-is situation in relation to their readiness to implement PPX business models, recognize any bottle necks related to the implementation and consequently help in defining the roadmap towards the actual PPX business model implementation (Becker et al., 2011; Neff et al., 2014; Silva et al., 2021; de Bruin et al., 2005).

However, even with hundreds of maturity models developed, at times there is still some vagueness in how the models are built and developed (Becker et al., 2009), meaning the use of any existing maturity model does not guarantee success. Moreover, in the context of SME equipment manufacturing companies, the move towards service-based business models is an even less researched area, not to mention difficult due to the manufacturing companies' strong product-based heritage (Teso and Walters, 2016). Consequently, while the need to move towards the service-based PPX business models persists, the solution is necessarily not as simple as using an existing maturity model for assessing the requirements needed to move towards the new PPX business models in this specific context or PPX in general.

This need for proper solutions to help SME equipment manufacturing companies move towards the novel, service and data-driven PPX business models is addressed in the Systematic Development of Novel Business Models (SNOBI) project: with the help of international research cooperation and 5 Finnish partner SMEs, the aim of the project is to provide the manufacturing SMEs tools for a systematic transformation process from the product-oriented business models towards the new PPX business models (Tampere universities, 2021). As a part of the project, this thesis aims to figure out how to design and validate a maturity model for the internal PPX business model readiness analysis in the context of business-to-business (B2B) equipment manufacturing SMEs. This need, or research gap investigated in the thesis is depicted as the blue area in the Venn diagram in figure 1, where the need for a maturity model in the context of B2B equipment

manufacturing SMEs and PPX readiness from the specified, internal perspective is recognized:

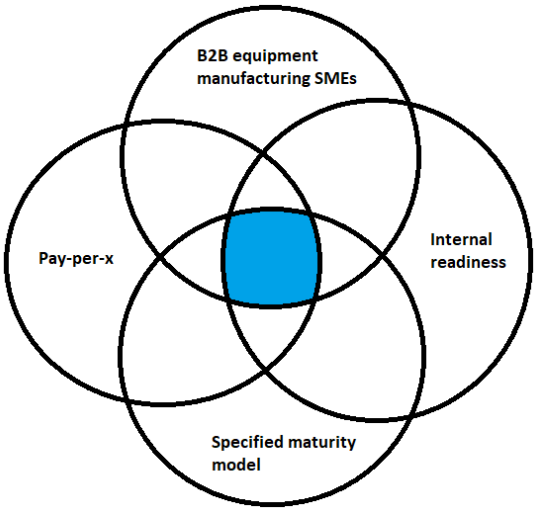

Figure 1. *Venn Diagram of the research gap.*

1.2 Research objective and questions

As said, the main objective of the research is to design and validate a maturity model for PPX business model readiness analysis for the B2B equipment manufacturing SMEs, from the company's internal perspective. For now, there are many different maturity models that can be used in different industries and areas for readiness analysis, but in the scope of the objective, none of the current maturity models address the needs of these specific companies wishing to implement PPX business models. Consequently, the primary research question of this study is:

> **How to design and validate a maturity model for the PPX business model readiness analysis in business-to-business equipment manufacturing SMEs?**

Building a new type of maturity model within the scope of the research naturally requires assessing the ways in which maturity models can be built and validated, as well as some research in terms of what the B2B equipment manufacturing SMEs need. Consequently, there are 5 secondary research questions, that support answering to the primary research question. These questions are:

1. **What are the critical success factors, benefits and challenges related to the implementation of PPX business models in B2B equipment manufacturing SMEs?**

2. **What are the critical design criteria of this PPX maturity model for B2B equipment manufacturing SMEs?**

3. **What are the critical dimensions that affect the internal readiness of business-to-business equipment manufacturing SMEs implementing PPX business models?**

4. **How to describe the general reference levels of maturity as well as the minimum and maximum maturity level of each critical dimension of this model?**

5. **How can the model be validated step-by-step with the Action Design Research approach?**

In other words, while the main goal of the thesis is to design and validate the maturity model, another aim is also to understand the requirements of the model specifically in the scope of the B2B equipment manufacturing SMEs. In the end, the idea is that this thesis provides an initial, suggested maturity model, that companies will later on be able to use in order to assess their readiness towards implementing PPX business models. However, although having limited scope, the thesis will also provide a systematic approach to developing the PPX maturity model, which can help in the creation of PPX maturity models in other contexts in the future as well.

1.3 Research scope and limitations

In this thesis, the research scope in terms of who the maturity model is built for is set specifically to the internal readiness of the relevant partners: due to the SNOBI project's nature, partner companies and the need to address the requirements of equipment manufacturing SMEs, the maturity model is specifically designed, as the primary research questions says, for the B2B equipment manufacturing SMEs.

In terms of the maturity model, the scope is also set to assess the PPX business model implementation readiness of the companies from pay-per-use, pay-per-output and pay-per-outcome business model perspective. Consequently, although the research and literature review involve addressing the relevant terms such as Industry 4.0, digitization, product-service systems and servitization among others, the model is designed specifically in alignment with the pay-per-use, -output and -outcome business models.

As narrow as the target audience and business model choices are, the maturity model aims at providing a holistic view of the company's maturity, but only internally. In other words, the maturity model encompasses different processes, people and technology within the company, in order to provide an overarching view of the company's maturity and potential development needs. Still, what is taken into account is limited to the internal

aspects, as taking into account e.g., customer readiness or the whole value chain would make the model very complex and consequently not as easy to make use of. Consequently, as important as the customer aspect might be, it is beyond the scope of this study, as it might even require its own maturity model in the future.

Finally, related to the use of the model, it should also be noted that the scope of the thesis includes the design and validation of the model, but not the implementation of the model. That is, although the model is designed with and for the companies, the aim of this research is to design and initiate the validation process of the model, but not to take it into action. Consequently, even with the active redesign and validation process aimed at creating the maturity model, the actual readiness analysis is left outside the scope of the thesis. As a complex phenomenon, it is acknowledged that this study cannot provide a comprehensive and ready-to-use maturity model, rather than providing the basis for the process of deriving one in the future.

1.4 Research structure

The thesis consists of 7 chapters, including the introduction, PPX and maturity model theory, research methodology, the results related to the design and validation process of the maturity model as well as discussion and conclusions. More specifically, the theory part introduces the context of PPX business models in manufacturing SMEs as well as how maturity models can be designed and used to asses the readiness to implement PPX business models. Consequently, the literature review in the theory chapters provides the basis for the empirical part of the study, by providing the tools to create the preliminary, theory-based maturity model that is then validated through the expert workshops.

After PPX and maturity model theory as well as the creation of the preliminary, theory-based maturity model, the thesis includes a section for research methodology. In addition to explaining the research philosophy, approach and strategy in general, the research methodology chapter introduces the Action Design Research (ADR) approach in the context of this study. Moreover, this section describes how data is collected in the empirical part of the study, meaning the expert workshops and the maturity model validation phase.

The empirical part and results that follow focus on the validation phase of the maturity model. In other words, the results section focuses on validating the theory-based maturity model, which is done through expert workshops as well as focus group discussions. As the end result, the section concludes with presenting the suggested maturity model

dimensions, general reference levels for maturity and minimum and maximum levels for each dimension.

Lastly, the final chapter sums up the the research, answers the research questions introduced in the beginning of the thesis and provides ideas and thoughts on the academic contributions as well as managerial implications of this study. Moreover, the limitations of this study are addressed, as well as the potential reasearch topics that can be done in relation to this study in the future.

2. PAY-PER-X BUSINESS MODELS

This chapter helps in answering the primary research question through the secondary research question 1 related to the critical success factors, benefits and challenges related to the implementation of PPX business models in B2B equipment manufacturing SMEs. This is done by first introducing the concept of pay-per-x business in general, which helps clarifying the main functions of PPX business models and consequent success factors, benefits and challenges. Afterwards, the specific concepts of pay-per-use, -output and -outcome are introduced. Finally, the context is narrowed down further, as the PPX business models are taken to the specific context of the thesis and the B2B equipment manufacturing SMEs.

2.1 Concept of pay-per-x business models

As manufacturing companies are pushed away from only selling the product and more towards selling services related to the product (Adrodegari et al. 2015), the concept of PPX can be used to describe the phenomenon in general terms: the x in PPX can be for example use, output or outcome, describing that instead of selling the product, the subject being sold is related to using the product, the amount of output produced or for example part of the savings gained from improved production (Menon, 2019). The division between product-oriented and PPX business models, however, is not black and white, as the transition towards the PPX models can include many different variations, as shown in figure 2:

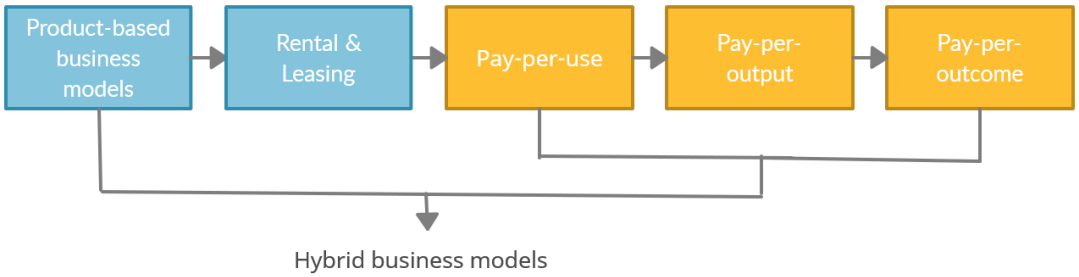

Figure 2. *Hybrid business models (adapted from Menon, 2019).*

At the far left of figure 2 are the traditional, product-based business models. Next, there are the rental & leasing services, which have allowed e.g., consumers in the car market to use cars irrespective of the rise of costs of owning your own car (Lytton and Poston, 2012). Then, there are the PPX services, which can include anything from pay-per-use to pay-per-output and pay-per-outcome business models. This, however, does not mean that the models are completely cannibalized by each other, since as Menon (2019) demonstrates, it is possible to have a hybrid model that includes some aspects for example from the product-based business models and some from the PPX business models. One could, as an example, sell the product to the customer, but have an outcome-based business model on the side, charging a specific part of the savings gained by the customer from the use of the product.

As a term, pay-per-x is also related to many other concepts in literature: in a way, pay-per-x relates to the servitization of business models described by e.g., Vandermerwe and Rada (1988), in addition to which literature mentions service-based business models (e.g. Adrodegari et al., 2015; Kindström, 2010), product-service systems (e.g. Mont, 2002; Beuren et al., 2013), non-ownership business models (e.g. Bock and Wiener, 2018) or specific terms such as outcome-based business models (e.g. Visnjic et al., 2017). Moreover, since PPX business models are inspired by technological advancements (Bock and Wiener, 2018), many business model concepts related to for example Industry 4.0 (e.g., Schumacher et al., 2016; Lizzaralde et al., 2020), digitization (e.g., Blatz et al., 2018) and data-driven business models (e.g., Weber et al., 2017) are also relatively close to the concept of PPX. In other words, even if PPX business models are not mentioned specifically, there are a lot of other terms that can relate to the concept and help in defining it.

2.2 Types of pay-per-x business models

As said, although pay-per-x business can be based on multiple different concepts in literature, one way of dividing them is to categorize them into pay-per-use, pay-per-output and pay-per-outcome business models (Menon, 2019). In this section, these three main types of pay-per-x business models are introduced, clarifying the concepts and supporting the PPX understanding.

2.2.1 Pay-per-use

Pay-per-use services are about the customer only paying for the use of the product in terms such as per operational hours, without actually buying the product itself (Gebauer et al., 2017). In effect, pay-per-use services are consequently moving from the input-

oriented business models of selling the product towards a more output-oriented approach, where value is created through the services related to the product (Worm et al., 2017).

2.2.2 Pay-per-output

Pay-per-output business models are, in a way, taking the pay-per-use business models a step further. Again, the customer pays for the product usage, but the fee depends on a clearly specified measurement such as the output of the product/equipment (Krenz and Kronenwett, 2019). In other words, the model focuses on the results from the use of the machine, which is often described in monetary terms (Uuskoski et al., 2020).

2.2.3 Pay-per-outcome

Pay-per-outcome business models focus on the added value derived by the customer, again after using the equipment received from the manufacturing company (Uuskoski et al. 2020). However, instead of merely focusing on the usage, output or other prescribed specifications, these business models focus on the outcomes (Bramwell, 2003), in effect focusing on the more complex value creation process as a whole, and thus enabling the customer to pay for the actual value created instead of certain, individual activities (Ng et al., 2013).

2.3 Pay-per-x business models in the research scope

Globalization has brought saturation into the product-centric industries, in addition to the new and varied demands from customers (Kindström, 2010). To add, manufacturing companies are facing pressure to create new and advanced solutions, as digital developments have opened the door to making more use of new technologies (Bock and Wiener, 2018). Consequently, developing pay-per-x business models in the B2B equipment manufacturing SMEs can both provide a solution to the problem of saturation and new demands, but also creates even more challenges that need answering. In this section, the PPX business models are described more specifically in the context of equipment manufacturing SMEs, including the benefits, motivation and challenges related to the implementation of the PPX business models. In other words, this section helps to answer the first supportive research question in terms of describing the critical success factors, benefits and challenges related to the implementation of PPX business models in the equipment manufacturing SMEs.

2.3.1 Pay-per-x business models in the business-to-business equipment manufacturing small and medium sized enterprises

While finding new ways of earning can be attractive, the nature of equipment manufacturing companies does not make PPX business model implementation easy: as manufacturing companies and their product and service offerings are often complex and highly customized, scaling up the servitization processes and finding new ways of earning can be difficult (Kohtamäki et al., 2019). On the other hand, PPX business models can bring the customer and equipment manufacturer closer together, as they can strive more closely towards shared goals for example in terms of improving efficiency (Sumo et al., 2016). In any case, implementation of PPX business models is a very specific instance and consequently requires a lot of planning from the equipment manufacturing company.

There can be many ways in which the PPX business models and their elements can be described in the context of equipment manufacturing SMEs, and one of those ways used also in this research is the concept of product life cycle (PLC). The PLC is based on a biological analogy that is often used to aid planning and policy formulation processes related to the product throughout its life (Polli & Cook, 1969). The cycle comprises of four different phases, which can be seen in figure 3:

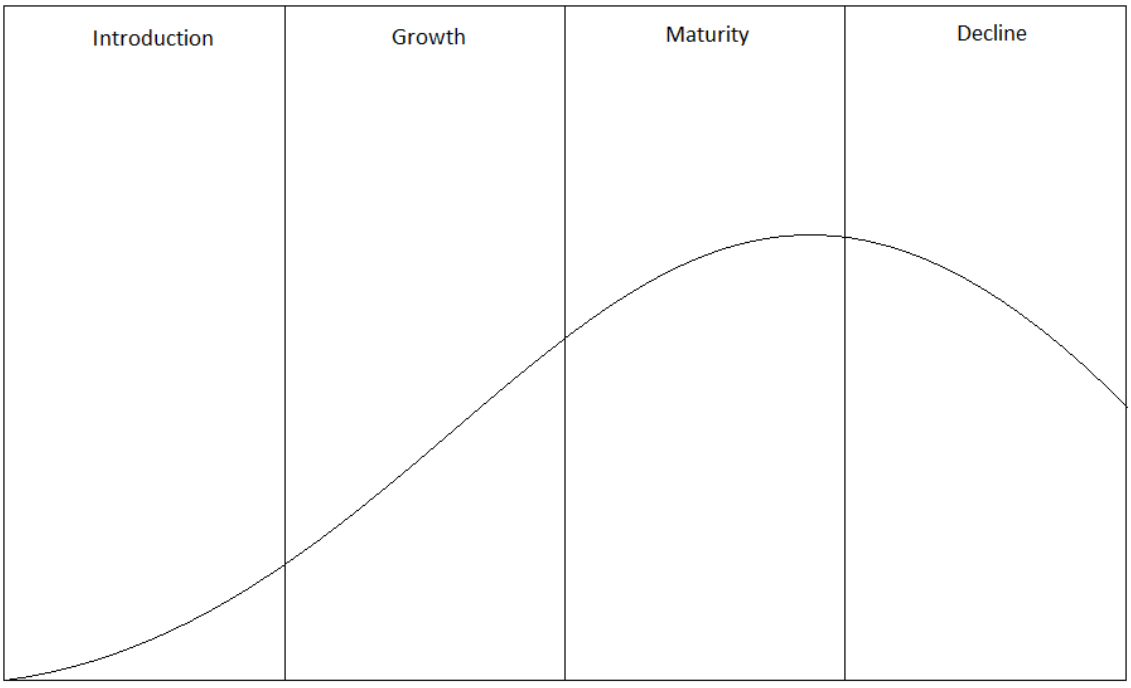

Figure 3. *Product Life Cycle (derived from Polli & Cook, 1969).*

The first phase of the product life cycle seen in figure 3 is the introduction phase. In this phase, it is estimated that a product is bought at a limited rate, as the product is still in its infancy and phases initial resistance of acceptance in the market. Later on, when the

product is established and its value is communicated properly, the product enters the second, growth phase of the cycle. In the third, maturity phase of the PLC, the growth rate starts to decline, and eventually decreases in the last phase of declining phase. (Polli & Cook, 1969) In the context of PPX business models as well as maturity models, these phases of the product's life cycle could help equipment manufacturing companies to utilize the product life cycle taxonomy and related information to make decisions related to the implementation and development of the PPX business models and consequently, the PLC type of thinking could also aid in the formulation of the most critical dimensions that are required to secure functioning product life cycle in the companies' PPX business model implementation.

Of course, the product life cycle's usability depends on how well the information is managed, meaning product life cycle management (PLM) is a key factor in the management of PLC phases. While PLM has more traditionally focused on the development and design processes of the product, the availability of data and information has broadened the term to also include all the other processes of the life cycle, including aspects such as the production and customer processes (Silventoinen et al., 2009), although the latter are not included in the scope of this research. Still, in addition to the 4 life cycle phases it is possible to divide the PPX PLM processes into the beginning, middle and end of life processes of the life cycle management, which include the PPX product and service generation, usage, logistics & maintenance of the PPX product and related services as well as the disassembly, disposal and reusage of the PPX product.

The benefits of this type of PLM can in general lead to improvements in product functionality, sales processes, maintenance functions and services as well as more effective re-use of the product (parts) among other things (Stark, 2004), which could mean B2B equipment manufacturing SMEs could also use the acquired data and information to develop their PPX business models. Of course, especially in the case of SMEs, there are still challenges such as fear of costs and risks related to extensively changing ways of working in terms of technologies, processes and managing people (Silventoinen et al., 2009), so even an effective PLM strategy requires its own risk management measures.

Still, irrespective of the challenges related to the PLC theory and its implementation in the B2B equipment manufacturing SMEs, the concept provides a way for the companies to address and organize the potential benefits and challenges of implementing and developing PPX business models in all the different stages of the product's life cycle. Consequently, in the following sections and maturity model development, the PLC theory is used to provide a general framework for helping to assess the most critical success factors, benefits and challenges of implementing and developing PPX business models and

to see how companies could optimize their benefits also in terms of the product life cycle. Consequently, the PLC theory also helps in defining the maturity specifically in the context of PPX business model implementation in the later stages.

2.3.2 Motivation towards pay-per-x business model implementation

Arguably, PPX business models would not exist if there was no benefit to implementing them. Moving towards service-based business models is said to help with responding to new customer needs and combatting saturated markets (Kindström, 2010), in addition to which the technological advancements, when successful, can bring other benefits to the company as well: Baines et al. (2017) gather that in addition to the improved response to customer needs, consequent customer loyalty and growth in revenue, moving towards service-based business models can lead to new product innovations, gaining completely new revenue sources and having a better ability to compete within the market.

In terms of equipment manufacturing SMEs, growth and generally competing and staying in the market is a relevant topic, as they are often part of bigger value chains and need to align their actions accordingly (Blatz et al., 2018). In that sense, given the potential benefits of growing revenues that PPX type of business models can bring (Baines et al. 2017), it would make sense for equipment manufacturing SMEs, if not other product-oriented companies, to adopt them. In fact, it is argued, that in addition to growing revenues, moving towards service-based business models can lead to differentiation, that in combination of higher customer satisfaction can even lead to competitive advantage (Bustinza et al., 2015).

Profits and revenues aside, technological developments needed in PPX business models can benefit not only the customer, but the equipment manufacturing company as well. Referring to the product innovations (Baines et al. 2017), actions related to a company implementing advanced PPX-type of services go hand in hand with aspects also related the technological advancements of e.g., Industry 4.0 and integration of human actors, intelligent machines as well as advancements in production lines and processes across the organization. These advancements can also lead to new and improved value chains (Schumacher et al., 2016), meaning preparation for PPX service offerings can have extensive benefits to the whole company. Developing the new type of PPX business models does not only answer customer needs but can lead to innovations across the company and improve efficiency of the product as well as production processes throughout the product life cycle.

These extensive changes require a lot of planning and reorganizing company operations, but that can also have positive strategic implications. For example, in the case of an outcome-based business model, a company might have to take more responsibility in monitoring production processes, which can end up bringing value to customer through accountability (Visnjic et al. 2017), but also improve the company's efficiency as well. For example, increased monitoring in the case of Remote Monitoring Technology (RMT) can help with improving performance and the availability of the products, enhance product maintenance efficiency as well as give more information for research & development (Grubic, 2014). Moreover, as company takes more responsibility over production processes, the need for more comprehensive risk management measurements (Gebauer et al., 2017) can lead to better risk management and mitigation measurements in general.

2.3.3 Challenges related to pay-per-x business model implementation

With the benefits and motivation to move towards PPX business models comes also different requirements and challenges. Changing operations across the company can not only have major financial requirements, but requires difficult decisions related to forming the service offerings, allocating resources and dealing with challenges in organizational culture as well as internal communication. If not done well, the changes in organizational structure can consequently have a negative impact on e.g., finances and performance (Zhang and Banerji, 2017).

As far as the financial benefits go, sometimes the extensive investment needs can lead to offsetting any benefits the company might gain from PPX services, especially in the initial stages (Neely, 2007). This relates to the service paradox, which describes the difficulty of companies achieving the expected returns from developing service-based business models (Gebauer et al., 2005). Moreover, while PPX-related services can lead to new revenue streams, in the cases such as pay-per-use models where there is a danger of customer using the product relatively little, the service offering can lead to less than expected revenues and returns (Gebauer et al. 2017).

Even with financial benefits acknowledged, fundamental changes in the organization can also be problematic, as challenges in understanding what brings value to the customers and developing and designing the service offerings accordingly can deter potential benefits of developing PPX business models (Hou and Neely, 2018). Also, even if companies are able to address the customer needs as well as the new technological capabilities and process needs related to the development of service offerings (Teso and Walters,

2016), one of the biggest challenges faced by equipment manufacturing SMEs relates to the end of the product life cycle and how to recycle and/or redistribute the product when customers no longer need it. Consequently, it is not enough to consider what customers want on how products are developed, as there are many potentially significant challenges towards the end of the product life cycle as well.

Strategy-wise, the development of PPX business models also has its challenges. Fundamental changes in doing business requires fundamental changes in mindsets as well, meaning everything from struggling to develop service-based marketing and sales to developing an overall service-oriented culture can slow down the progress towards servitization (Neely, 2007). Moreover, changes in the organization require different, innovative capabilities from the staff, while management also needs to rethink how to approach the changing and potentially increasing risks when offering e.g., outcome-based business models to the customers (Teso and Walters, 2016).

All in all, implementing PPX business models can consequently be very risky. Although there are certainly potential benefits to implementing PPX business models when done correctly, the risks can also outweigh the benefits if companies are not careful. In that sense, the existence of benefits, risks and challenges related to the implementation of PPX enforces the argument for the need for a PPX maturity model or another tool, that could be used to have a systematic and well-thought transition into the new business models.

3. MATURITY MODELS

This section helps to answer the primary research question by first defining maturity and maturity models in general in terms of their design and validation processes. More specifically, first defining the purpose of maturity models helps in understanding the following sections, which deal more directly with other secondary research questions related to the design criteria and structure of the maturity model in the scope of this thesis. As with the PPX business models, the logic of the chapter is consequently built so that it starts with general foundations, after which it intends to answer the research questions in the specific context of this research.

3.1 Concept of maturity models

3.1.1 Definition for maturity

In this study, a maturity model is developed and validated as a solution to the challenge of assessing readiness towards PPX business model implementation. Consequently, in addition to understanding the model development itself, it is important to understand what is actually meant by maturity. Furthermore, it is important to address the relation between readiness and maturity.

A common definition for maturity is that it means a “state of being complete, perfect or ready” (Simpson and Weiner, 1989). In other words, maturity can be seen to imply and evolutionary progress of certain aspect from one, initial stage to the other, desired stage of maturity (Mettler and Rohner, 2009). This line of thinking is also in line with the main goal of the SNOBI project, as it aims at understanding how to design and implement a systematic transformation process from the product-oriented business models to PPX business models (Tampere universities, 2021).

Readiness, or readiness models are sometimes discussed interchangeably with maturity models (e.g., Sony and Naik, 2019; Hizam-Hanafiah et al., 2020). However, e.g., Schumacher et al. (2016) distinguish between maturity and readiness in the sense that while readiness assessment takes place before the actual maturing process is initiated, maturity assessment aims for capturing the current situation all the while going towards maturity. In that sense, while talking about maturity model development, it makes sense to talk about readiness analysis in this study, as it also describes the novelty of the issue in the thesis: the maturity model that is created intends to assess companies’ readiness to implement PPX business models, but as the transformation process is at initial stages,

talking about maturity assessment might be too hasty in many of the partner companies. Consequently, although mostly a minor technicality, this study uses the terms maturity model and readiness analysis when describing the process.

3.1.2 Definition for maturity models

Considering the meaning behind maturity, the definitions for maturity models do not fall far from it. Some of the definitions are as follows:

1. A maturity model consists of a sequence of maturity levels for a class of objects. It represents an anticipated, desired, or typical evolution path of these objects shaped as discrete stages. (Becker et al., 2019)
2. Maturity models have been designed to assess the maturity (i.e., competency, capability, level of sophistication) of a selected domain based on a more or less comprehensive set of criteria. (de Bruin et al., 2005)

Already with these definitions, it can be seen that the main idea in maturity models is fairly uniform: maturity models are about assessing specific features, at what stage or level of maturity those features are and what is the difference between the current and desired level. This, in turn, helps with eventually developing a path towards the desired level, that in this case can help the B2B equipment manufacturing companies to move from the product-oriented business models towards the PPX business models. Again, the term readiness model can sometimes be used interchangeably, but in this thesis the term used is maturity model.

3.1.3 Components of maturity models

For maturity models to function, there are some aspects that are required, including definitions for maturity levels and the features that are actually assessed. In more specific terms, a maturity model should according to Lasrado (2018) include at least the following components:

1. Maturity stages or levels
2. Conditions or dimensions
3. Boundary conditions
4. Path to maturity
5. Stage boundaries

6. Assessment of maturity

As said, in order to have a maturity model, there needs to be features or conditions that are evaluated in the model. These are now referred to as dimensions. The dimensions can be related to anything such as Leavitt's (1964) people, processes or technology, as long as they relate to the maturity of the phenomenon in question. Dimensions can also be more complex in terms of having classification into sub-dimensions (Raber et al., 2012, cited in Lasrado, 2018, p 28), which are also used in this study.

In terms of maturity levels, the levels are typically a comprehensive explanation of the conditions of the dimension at each specific level. Moreover, it is not enough to have just levels, as there needs to be certain boundary conditions that help defining the specific requirements needed to move from one level to another. These conditions and the stage boundaries that clearly define level limits are needed in order to also reach the last two components of defining path to maturity and translating the maturity model into quantifiable factors. (Lasrado, 2018) Certain type of reference levels do exist, out of which one widely used example is the Capability Maturity Model Integration (CMMI) maturity level scheme, developed and refined by Chrissis et al. (2011). According to Chrissis et al. (2011), the process maturity model levels are:

1. **Initial:** The level where processes are ad-hoc and there is little or no stability in supporting the processes and success relies on competences or heroics of the people in the organization. Product and service development can be possible, but budgets and schedules might be exceeded often and there is a tendency to either overcommit or abandon processes in times of difficulties.
2. **Managed:** The level where processes are now following a specific policy and are monitored, controlled, and reviewed for adherence. This allows ensuring processes work even in times of stress, as in addition to tasks, relevant roles are assigned, and commitment is established among the people in the organization.
3. **Defined:** The level where in addition to following and monitoring policies and processes the organization has a set of standardized processes. In other words, while at level 2 standards, process descriptions and procedures can vary extensively according to the situation, the standardization at level 3 guarantees more consistent processes even when tailored to a specific instance.
4. **Quantitatively Managed**: The level where in addition to the characteristics of level 3, the organization has quantitative objectives set for quality and performance, which are used to manage, assess, and develop the corresponding pro-

cesses. This, in turn, requires the ability to recognize relationships between different subprocesses, which in turn distinguishes the level 4 from 3 even further: understanding process relationships and being able to measure them enables the use of statistics and consequently predictive methods for process development.

5. **Optimizing:** The level where the organization uses quantitative understanding to continuously improve its processes. Here, the continuous improvement is more holistic than in level 4, as instead of focusing on subprocesses and consequent improvement decisions, level 5 is concerned with the overall organizational performance and identifying shortfalls or gaps can consequently lead to more significant and measurable improvements in overall performance of the company and not just specific processes or subprocesses.

The CMMI maturity levels developed by Chrissis et al. (2011) provide an example of how maturity levels and boundary conditions can be developed. However, while the CMMI model talks about the organization in general, it does have some limitations: for example, the CMMI focuses specifically on processes, meaning the maturity levels do not at least directly take into account the maturity of e.g., people-related aspects such as competences or organizational culture. Consequently, when considering the internal PPX readiness of B2B equipment manufacturing SMEs, it could be that these reference levels do not describe all the necessary requirements in the context of the thesis. There are variations such as Curtis et al. (2009) People Capability Maturity Model (P-CMM), that specifically describes the critical people issues and maturity levels in organizations, but even in that case the emphasis is on people and not on other aspects related to e.g., technology or other processes. In other words, while the CMMI and its variations can provide a starting point for developing the maturity levels and related boundaries, they cannot be used directly as they would otherwise compromise some of the aspects that should be taken into account in the maturity model in this specific context. Still, together with the other relevant maturity models, they can work as a theoretical starting point in the process of developing a new, better-suited framework.

3.2 Designing and validating maturity models

There are many ways in which maturity models can be developed, as there are hundreds of maturity models merely in areas such as IT management (Becker et al. 2009). However, the quantity of maturity models does not guarantee quality, as many of the models are poorly documented (Becker et al. 2009). Consequently, designing and validating a maturity model requires logic and a proper framework, three of which are presented and

compared in this section in order to establish a comprehensive and systematic framework for this specific research. However, it should be noted that although the research follows Sein et al. (2011) general Action Design Research process, it is included in the methodology section. Here, the focus is on the design methodologies related to the specific process of designing maturity models.

3.2.1 The generic framework by de Bruin, Rosemann, Freeze and Kulkarni (2005)

De Bruin et al. (2005) emphasize the importance of a standard maturity model development framework, whether the model is descriptive, prescriptive or comparative. In other words, although the purpose of the model can vary, de Bruin et al. (2005) argue that the phases can be seen as evolutionary phases, which allows the creation of a standard, generic framework for maturity model development, as seen in figure 4:

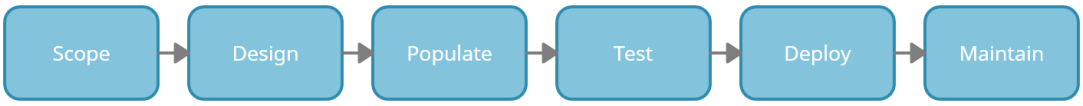

Figure 4. *Generic framework for maturity model development (adapted from de Bruin et al. 2005).*

The first step in the framework shown in figure 4 is to define the scope of the maturity model. Scope definition is important, as it helps setting boundaries to the maturity model, consequently affecting all the other stages in the process. The scoping step will also help in focusing the model to its purpose, or domain, in effect differentiating the model from other models. A domain specific maturity model could be for example the capability maturity model developed for single process of software development, while a more generic model could be some type of management model focusing for example on business excellence. Furthermore, when the focus is clear, there should also be a decision made on who are the development stakeholders, in practice providing input to the design and validation of the model. These stakeholders can include academia, practitioners, government or a combination of these. (de Bruin et al. 2005)

In the second step, design decisions are made in terms of who is the audience, what is the method and driver of application, who are the respondents and how is the application executed. All of these decisions relate to answering questions such as why the model should be applied and used in the first place, how the model can be applied, who needs

to be involved and what could be achieved by using the model. Depending on whether maturity definitions are defined top-down or bottom-up, the decisions also intend to answer questions related to what represents maturity and how that can be measured. (de Bruin et al. 2005)

The third populating step is about the dimensions, so it is about deciding what actually needs to be measured, as well as how it is measured. Literature review can be used to generate a list of dimensions and sub-dimensions, which should be in terms of probability mutually exclusive and collectively exhaustive, i.e., independent and encompassing all the necessary elements. However, in new domains such as PPX maturity models, literature review might not be able to provide complete answers, which means that literature review can only provide a theoretical starting point and validation has to occur by other means such as interviews, the Delphi method or focus groups that are also used in this research. (de Bruin et al. (2005)

With the maturity model having its dimensions and potential sub-dimensions, the fourth step is about testing relevance and rigor. Here, it is important that in addition to the dimensions' validity, reliability and generalizability testing, the construct of the whole model is evaluated. Construct validity can be tested with the methods used in the population step, while the validity, reliability and generalizability can be tested with e.g., surveys and factor analysis. (de Bruin et al. 2005)

The last two steps are about deploying the model and maintaining it. Here, the model is made available for use, helping to also verify the extent of the model's generalizability. It is possible to start testing the model generalizability with the design collaborators, but until the model is deployed to entities outside the development and testing groups, generalizability will not be completely validated. Furthermore, depending on the goal of the model, maintaining the growth and usability of the model and the resources needed in that has to be taken into account. If the model is meant to be kept relevant, it can only be ensured by maintaining the model over time. (de Bruin et al. 2005)

All in all, the steps described by de Bruin et al. (2005) can be beneficial in the development of the PPX maturity model in the scope of this thesis as well. Many of the points described in the process are related to the decisions that have also been made in the thesis, including defining the scope and audience, assessing relevant dimensions through literature review as well as testing and verifying the model's validity. In other words, even if not following the process completely, de Bruin et al. (2005) maturity model design framework certainly provides a checklist that can be used to assess the design process of the PPX maturity model in this research.

3.2.2 The procedure model by Becker et al. (2009)

Becker et al. (2009) emphasize the lack of documentation in maturity model development and as a solution, have developed a manual for methodically designing and evaluating maturity models. Their 8 main steps are show in figure 5:

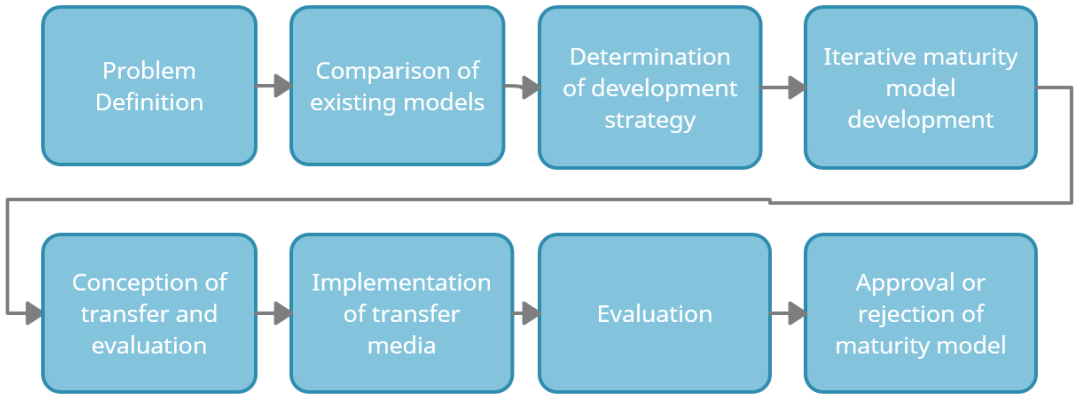

Figure 5. *Procedure model for maturity model development (adapted from Becker et al., 2009).*

The first part of Becker et al. (2009) model in figure 5 is about defining the problem and for what the maturity model is developed for. Again, the targeted domain and target group should be decided here, in addition to reasoning the development of the model in the first place. Related to this there is the step 2, which is about searching for existing models and consequently also validating that there indeed is a need for a new model. In other words, the argument is that it would not make sense to build a completely new model, if there already exists a maturity model for the purpose in question. (Becker et al., 2009)

If the creation of a new maturity model is justified, the third step in the design process is to determine the development strategy of the model. Similarly to how it should be ensured that the new model is needed, the third step is about determining whether a completely new model is required, or whether there is a possibility to develop an existing model further by e.g. combining different models. When this is clear, the maturity model development can proceed to the actual development process, or step 4 in the process model. (Becker et al., 2009)

In the fourth step, the model development is done iteratively. The step includes selecting the design approach, such as the aforementioned literature review in de Bruin et al. (2005) design framework. Furthermore, the step includes the actual design process of the model as well as testing the results. Again, these steps should be done repeatedly and iteratively for best results, being a central part of the development of the model.

Afterwards, in step 5 it is evaluated how well the results of the model transfer for academic and other purposes, as well as what the results are in general. (Becker et al., 2009)

In the last stages, the maturity model is made accessible for all the defined user groups. After doing so, the seventh step is to evaluate and to see whether the model provides what is expected from it and whether it offers a solution to the previously defined problem. This can be done in smaller groups or with wider audiences, depending on what is required. Lastly, there is the step of either approving or rejecting the maturity model, meaning the maturity model can either be published if proven beneficial, or rejected if not. Rejection can then lead to going back to problem formulation, starting the whole process over if needed. (Becker et al., 2009)

All in all, Becker et al. (2009) provide another alternative, systematic way of designing and validating a maturity model. In the context of the thesis, Becker et al. (2009) model can provide a slightly more specific approach to the design and validation process of the PPX maturity model, compared to the more general process developed by de Bruin et al. (2005). Still, while Becker et al. (2009) emphasize the need to ensure problem relevance, de Bruin et al. (2005) seem to have more focus on validating and editing the model after its initial development, instead of just disregarding it in case it is not working as it was supposed to work.

3.2.3 The design science approach by Mettler (2011)

Lastly, the design science approach to maturity model development by Mettler (2011) is introduced. Mettler (2011) argues that although frameworks such as the one presented before by Becker et al. (2009) can certainly be useful in designing and validating maturity models, the more generic nature of the methodologies leave developers and users of maturity models alone with important decision. Consequently, Mettler (2011) divided the maturity model design process into four main steps, shown in figure 6:

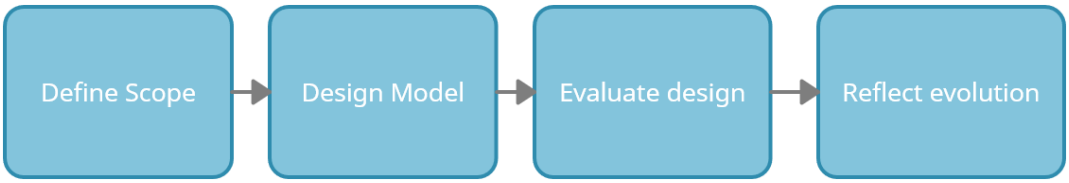

***Figure 6**. Maturity model development process (adapted from Mettler, 2011).*

Although only four main phases, each of the Mettler's (2011) phases include different decision parameters and characteristics that should be taken into account in the designing and validation of maturity models. In the first phase of defining scope, decision parameters in Mettler's (2011) model includes:

- deciding on the focus of the maturity model and whether it is about a general or a specific issue,
- levels of analysis and whether it is a question of group decision-making or at other end, global and societal considerations,
- novelty and whether the issue is emerging, pacing, disruptive or mature,
- audience and whether it is management-oriented, technology-oriented or both,
- dissemination and whether the model is open or exclusive.

After the decisions related to scoping, the process moves to the actual design part of the model. In this phase, Mettler (2011) includes decision parameters including:

- maturity definition and whether it is process-focused, object-focused, people-focused or a combination of all of them,
- goal function and whether the model is one-dimensional or multi-dimensional,
- design process and whether the model is theory-driven, practitioner-driven or both,
- design product and whether only the model's form or both form and functioning is described, or whether the model can be used as an actual assessment tool,
- application method and whether it is self-assessed, third-party assisted or assessed by certified professionals,
- respondents and whether it is management, staff, business partners or a combination of all.

After these phases and designing the model, Mettler (2011) includes the third phase of evaluating the design, consisting of decision parameters including:

- subject of evaluation and whether the design process, actual maturity model or both are assessed,
- timeframe and whether the assessment occurs before, after or both before and after designing the model,

- evaluation method and whether it is naturalistic (e.g., case study) or artificial (e.g., simulations or theoretical arguments).

Then, the fourth and final phase of Mettler's (2011) design criteria includes the reflection of evolution, which includes parameters including:

- subject of change and whether changes need to be made to how the model is designed or functions,
- frequency and whether reflection is non-recurring or continuous,
- structure of change and whether it can be made externally/openly or internally/exclusively.

All in all, Mettler (2011) seems to intend to address the potential shortcomings in the other design frameworks by expanding more extensively on the four main stages defined. Consequently, while the four stages of defining scope, designing the model and evaluating and reflecting on it are close to what the other frameworks include, Mettler's (2011) framework can help in defining aspects in areas that are left more open in de Bruin et al. (2005) or Becker et al. (2009) frameworks. As such, Mettler's (2011) framework can consequently provide a decent starting point for the development of the maturity model.

3.2.4 Comparison of design frameworks

Three different design frameworks for maturity model development by de Bruin et al. (2015), Becker et al. (2009) and Mettler (2011) were presented. To understand the differences better, the three frameworks are compared and summarized in table 1:

Table 1. *Comparison of maturity model development frameworks.*

De Bruin et al. (2005)	**Becker et al. (2009)**	**Mettler (2011)**
	Problem definition	
	Comparison of existing models	
Scope	Development strategy	Define Scope
Design	Iterative development	Design Model
	Conception of transfer and evaluation	
Populate	Implementation of transfer media	
Test	Evaluation	Evaluate Model
Deploy	Approval or rejection of maturity model	Reflect evolution
Maintain		

As it can be seen, the frameworks compared in table 1 have many similarities. It seems that while Becker et al. (2009) emphasize the need to define the problem and make sure the model is relevant, de Bruin et al. (2005) as well as Mettler (2011) put more emphasis on the reflection and maintenance of the model in the later stages. In that sense, Becker et al. (2005) model seems slightly more unforgiving when it comes to the usefulness or relevance of the model, which makes sense given their point of there being so many maturity models in existence without proper design or documentation. In other words, the logic seems to imply, that another model should be developed only if it is certain that there are not any relevant models in existence.

In terms of the actual design and validation process, Mettler's (2011) seems to be the most precise for the purpose of this research, given its decision parameters that are included in the four phases. That makes sense as well, given that Mettler (2011) pointed out the multitude of generic model design frameworks, which leave the developer alone with the decisions at times. Consequently, considering the scope of thesis and goal of designing and validating the maturity model for the PPX business model readiness analysis, making use of Mettler's (2011) design framework seems fitting. Still, de Bruin et al. (2005) and Becker et al. (2009) do have a good point about ensuring the problem exists and is relevant, which is why the design and implementation process will include the

literature review as well as the consequent validation of the problem relevance that are addressed in those frameworks as well. Of course, problem definition and relevance are also already addressed in the formulation of the research topic and questions as well as the SNOBI project in general, meaning that the emphasis will be on the development and future reflection of the maturity model, consequently following Mettler's (2011) framework quite closely.

3.3 Pay-per-X-related maturity models

In literature, although some authors such as Gebauer et al. (2017) address PPX services specifically, literature and theory are yet to provide a maturity model specifically in the context of PPX. Still, literature has focused significantly more on PPX-related maturity models under different terms such as servitization (e.g., Adrodegari et al., 2015; Andersen et al., 2020), digitization (e.g., Blatz and Bulander, 2018) and Industry 4.0 (e.g., Lizzaralde, et al., 2020; Schumacher et al., 2016). In that sense, PPX business models and their maturity is not completely unheard of, but the premise of this study is still that there is still need and novelty in the specific context of developing a PPX business model readiness analysis tool for B2B equipment manufacturing SMEs. Therefore, this section helps to answer the supportive research questions 1, 3 and 4 in terms of collecting and assessing some of the most PPX-relevant maturity models and literature, that help in describing the most critical success factors and dimensions that are needed in the PPX maturity model, as well as how the levels of maturity could possibly be described. At the same time, the literature review works as confirming the problem relevance, emphasized especially by Becker et al. (2009) in their maturity model design framework.

As said, the literature review in this thesis has focused on maturity models and business model literature related to some of the most PPX-relevant terms, such as servitization, digitization, Industry 4.0 and product-service systems in addition to the equipment manufacturing SME context. In that sense, following Dewey and Drahota's (2016) definition of systematic literature review where criteria need to be defined before the literature review, the following 15 maturity models and their respective dimensions and maturity levels in table 2 were gathered by ensuring that the review included models that address at least one of these relevant terms in the context of the specific business model in question, if not the context of manufacturing SMEs as well:

Table 2. *Maturity Model Literature Review.*

Authors	Title	Context	Scope	Dimensions	Maturity Levels
Andersen, Madsen and Godmiuscheit (2020)	Key dimensions of assessing servitization: towards a conceptual maturity model	Servitization	Manufacturers	6 main dimensions (organizational governance, strategic management, value function activities, market reach, digital integration and service integration)	-
Blatz, Bulander and Dietel (2018)	Maturity model of digitization for SMEs	Digitization	Small and medium-sized enterprises	6 main dimensions (product, strategy and leadership, company culture and organization, IT infrastructure, data maturity, process and operations)	3 levels with first digitization steps, some digitization steps and quantitative objectives & their evaluation, reflection and adaptation
Ganzarain and Errasti (2016)	Three stage maturity model in SMEs toward industry 4.0	Industry 4.0	SMEs	3 main dimensions (Industry 4.0 collaborative diversification vision, strategy and action building)	5 maturity levels, where 1 = initial, 2 = managed, 3 = defined, 4 = transform and 5 = detailed BM
Häckel, Huber, Stahl and Stöter (2021)	Becoming a Product-Service System Provider – A Maturity Model for Manufacturers	Product-service system	Manufacturers	5 focus areas (strategy, culture, structure, practices, IT)	4 maturity levels (level 1 is about pure product, level 2 is product-oriented PSS, level 3 is use-oriented PSS and level 4 is result-oriented PSS)
Lahrmann, Marx, Mettler, Winter and Wortmann (2011)	Inductive Design of Maturity Models: Applying the Rasch Algorithm for Design Science Research	Business Intelligence	Organizations	4 main themes (strategy, processes & organization, IT, quality & service)	5 levels (level 1 is about capabilities related to decentralized BI organization and level 5 is about the proactive and fact-based management of ongoing BI operations)
Lizzaralde, Ganzarain, López and Serrano (2020)	An Industry 4.0 maturity model for machine tool companies	Industry 4.0	Machine tool companies	6 main dimensions (smart products, smart operations, data-driven, smart factory, strategy and organization, employees)	5 reference levels (0= outsider, 1 = beginner, 2 = intermediate, 3 = experienced, 4 = expert, 5 = top performer)

Neff, Hamel, Herz and Uebernickel (2014)	Developing a Maturity Model for Service Systems in Manufacturing Enterprises	Service Systems	Manufacturing companies	3 main parts (strategy, process, information systems)	5 levels with different elements in each part
Paschou, Rapaccini, Peter, Adrodegari and Saccani (2019)	Developing a Maturity Model for Digital Servitization in Manufacturing Firms	Digital Servitization	Manufacturing companies	4 main dimensions (strategy, customer experience, business processes, organization & culture)	3 levels (beginner, experienced, leader)
Classen, Blum, Osterrieder and Friedli (2019)	Everything as a service? Introducing the St. Gallen IGaaS Management Model	Industrial Goods-as-a-Service	Manufacturing companies	11 dimensions (strategy objectives, portfolio and resources; business model value package, revenue model and customer relationship; operating structure, processes and governance as well as risk management and value network)	-
Schumacher, Erol and Sihn (2016)	A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises	Industry 4.0	Manufacturing companies	9 dimensions (strategy, leadership, customers, products, operations, culture, people, governance, technology)	5 levels (1 = not implemented and 5 = fully implemented)
Sony and Naik (2019)	Key ingredients for evaluating Industry 4.0 readiness for organizations: a literature review	Industry 4.0	Organizations	6 key ingredients (top Management involvement and commitment, employee adaptability with Industry 4.0, smart product and services, extent of digitization of supply chain, level of digitization of the organization, readiness of organizational strategy)	-
Teso and Walters (2016)	Assessing manufacturing SMEs' readiness to implement service design	Product-Service Systems	Small and medium-sized manufacturing enterprises	9 main dimensions (effectiveness, experience, service history, external engagement, culture and development, creativity, risk Propensity, communication, awareness)	Based on Design Ladder (stage 1 = no design, stage 4 = design as strategy) and Product-Service System stages (stage 0 = services not considered, stage 3 = result-oriented)

Wagire, Joshi, Rathore and Jain (2020)	Development of maturity model for assessing the implementation of Industry 4.0: learning from theory and practice	Industry 4.0	Manufacturing companies	7 main dimensions (people and culture, Industry 4.0 awareness, organizational strategy, value chain and process, smart manufacturing technology, product and services-oriented technology, Industry 4.0 base technology)	4 maturity levels (1 = outsider, 2 = digital novice, 3 = experienced, 4 = expert)
Weber, Königsberger, Kassner and Mitschang (2017)	M2DDM – A Maturity Model for Data-Driven Manufacturing	Data-driven manufacturing (based on Industry 4.0 and Industrial Internet of Things)	Manufacturing companies	6 major dimensions (data storage and compute, service-oriented architecture, information integration, digital twin, advanced analytics, real-time capabilities)	6 levels (0 = non-existent IT integration, 1 = data and system integration, 2 = integration of cross-life-cycle data, 3 = service-orientation, 4 = digital twin, 5 = self-optimizing factory)
Weyer, Schmitt, Ohmer and Gorecky (2015)	Towards Industry 4.0 - Standardization as the crucial challenge for highly modular, multi-vendor production systems	Industry 4.0	Multi-vendor production systems	6 key issues (production line and process, communication standard, plug and produce, smart infrastructure, manual workstation, control architectures and vertical integration of superordinate IT systems)	-

Summarizing the literature in table 2, the amount of dimensions in the PPX-relevant maturity models varied from 3 to 11 and content-wise the dimensions included aspects related to people & organizational culture (e.g. Blatz et al., 2018; Häckel et al., 2021), strategy and governance (e.g. Andersen et al., 2020; Ganzarain and Errasti, 2016), different technologies and data analytics (e.g. Wagire et al. 2020; Weber et al., 2017) as well as various different organizational operations and processes (Schumacher et al., 2016; Lahrmann et al., 2011). In terms of the maturity levels, the range also varied from 3 to 6 levels.

All in all, this literature review works as the basis for the maturity model design and validation process that follows. Although the actual process follows more closely the design framework by Mettler (2011), this literature review covers the phases that Becker et al.

(2009) would also call problem definition and comparison of existing models, confirming the problem relevance and the need for a new, specific maturity model in the scope of this thesis. Moreover, as the basis for the research methodology of this study is the Sein et al. (2011) Action Design Research approach that will be introduced in the next chapters, this literature review works as a crucial step towards the creation of the suggested maturity model that is based on the development of the preliminary, theory-based maturity model introduced in the next chapter.

4. THE THEORY-BASED PAY-PER-X MATURITY MODEL

This chapter helps to answer the primary research question through all of the five secondary research questions. The chapter focuses on how the preliminary, theory-based maturity model is designed, answering partly the questions related to the critical design criteria of the model, critical dimensions, success factors, benefits and challenges of PPX implementation in the context of thesis as well as the question related to how to describe the levels and related boundary conditions of the model. The chapter is divided into two main subchapters, which are about the process of designing the preliminary, theory-based maturity model as well as the model itself. As said, this preliminary maturity model also works as the basis for the design and validation phase for the maturity model, which includes the focus group and expert workshop development phases in the later stages of the Sein et al.'s (2011) Action Design Research process.

4.1 The pay-per-x maturity model design process

In this section, the focus is on describing the design phase of the preliminary maturity model with the help of the theory-based frameworks and literature review introduced in the previous chapters. Consequently, this chapter helps to answer the primary research question directly as well as the secondary research questions especially related to the critical dimensions and general reference levels of the maturity model. First, the section describes the process of defining the framework for designing this specific maturity model, then how the specific design criteria for the model was developed in focus groups and where the preliminary, theory-based dimensions come from.

4.1.1 Problem scoping: pay-per-x maturity model design framework

From theory, de Bruin et al. (2005), Becker et al. (2009) and Mettler's (2011) frameworks for designing and developing a maturity model were introduced. Out of these 3 frameworks, Becker et al. (2009) emphasized the importance of defining and ensuring the problem relevance, while Mettler (2011) aimed at describing the overall stages of development more specifically. Consequently, as the problem relevance is already confirmed through the initiation of the SNOBI project, the definition of the research scope and the following literature review, the development of the preliminary, theory-based maturity model here follows the more specific framework developed by Mettler (2011). The design

framework for this study's maturity model and the related decisions are shown in table 3:

Table 3. *Maturity model design framework adapted from Mettler (2011).*

Phase	**Decision parameter**	**Characteristic**			
Define scope	Focus/breadth	General issue		Specific issue	
	Level of analysis/depth	Group decision-making	Organizational considerations	Inter-org. consideration	Global and societal considerations
	Novelty	Emerging	Pacing	Disruptive	Mature
	Audience	Management-oriented	Technology-oriented	Both	
	Dissemination	Open		Exclusive	
Design model	Maturity definition	Process-focused	Object-focused	People-focused	Combination
	Goal function	One-dimensional		Multi-dimensional	
	Design process	Theory-driven	Practitioner-based	Combination	
	Design product	Textual description of form	Textual description of form and functioning	Instantiation (assessment tool)	
	Application method	Self-assessment	Third-party assisted	Certified professional	
	Respondents	Management	Staff	Business partners	Combination
Evaluate design	Subject of evaluation	Design process	Design product	Both	
	Timeframe	Ex-ante	Ex-post	Both	
	Evaluation method	Naturalistic		Artificial	
Reflect evolution	Subject of change	None	Form	Functioning	Form and functioning
	Frequency	Non-recurring		Continuous	
	Structure of change	External/open		Internal/exclusive	

The first step in the Mettler's (2011) design framework in table 3 is defining the scope of the maturity model. In this study, the focus was defined as the specific case of internal PPX readiness in B2B equipment manufacturing SMEs, meaning level of focus is also organizational. The novelty aspect describes the novelty of the phenomenon, which in this case is described as 'pacing' due to PPX business models not being a new phenomenon, but given the specific context is still in its infancy with respect to the readiness

analysis and maturity model development. As an at least initially exclusive readiness analysis, the maturity model is also designed for both technological and management-oriented audience.

Continuing with the second phase of the design framework in table 3, the next step was to define the design of the model further. More specifically, as the maturity model considers the internal readiness of the companies, the design of the model was considered to be a combination of maturity dimensions related to people, processes and objects (technology), consequently meaning the model is also multi-dimensional. With respect to the design process, the approach is chosen to be a combination of theory-based literature review and practitioner-based approach, which is in line with the Action Design Research approach and principles applied developed by Sein et al. (2011). Moreover, although the future design product can be considered to be a web-based assessment tool, in the scope of this thesis it is the textual description of the form (how the model is designed) and functioning (how the model works) that is taken into account. Lastly, the model is chosen to be self-assessed by a combination of relevant company respondents, so that for example technology-related dimensions can be assessed by relevant staff and any possible strategic dimensions can be assessed by business management and so on. As discussed, business partners and other external partners are not included, as the focus is on internal readiness of the company.

Finally, the last two main phases in Mettler's (2011) design framework also shown in table 3 are the evaluation of the design phase as well as the phase of reflecting on the evolution. Again, as the research follows the Action Design Research process developed by Sein et al. (2011), both the design as well as the model design process are assessed in this study. Moreover, the idea is that the assessment of design occurs before and after the implementation of the model, so the development of the model through real life cases and theory continues even after the first suggested version of the model. Moreover, although the scope of the thesis does not include the actual implementation of the model and the reflection of its evolution, the initial idea and decision that was made was that the subject of evolution would be both the form, or 'underlying model schema' (Mettler, 2011), as well as the functioning of the model, so practically how the maturity is assessed. Also, to keep the model relevant and logical, internal and continuous assessment can be done if the resources are available in the future.

4.1.2 Pay-per-x maturity model design criteria

After defining the maturity model design criteria with the framework devised by Mettler (2011), the next step was to create a list of design criteria which would reflect the decisions made in the framework. These criteria were created to guide the development of the maturity model and while doing so, the criteria itself was assessed to see whether the design phase itself should be further developed in the later phases of validating the maturity model. The initial design criteria were:

1. Criticality of the dimensions (Do the dimensions deserve their place among the most critical (4 to 7) ones?)
2. Representation of the context (Does the model and the dimensions represent the context of PPX in B2B equipment manufacturing SMEs properly?)
3. Logic of the model (Clear descriptions, understandable and orthogonality (no overlaps))
4. Relevance from the PPX maturity point of view (Can the dimensions be described in terms of how mature they are in the PPX context, considering agility, understanding causality as well as contextuality)
5. Usability of the model
6. Usefulness of the model

The first point and design criteria related to the criticality of the dimensions is based on the cognitive load theory, according to which novel information can be processed by the human brain only in a very limited amount (Sweller, 2011). Consequently, although the maturity model aims at assessing the internal PPX readiness of the equipment manufacturing SMEs holistically, the model should focus on the most critical dimensions, preferably staying within 7 dimensions according to the focus group consensus. In some relation to the criticality, point 2 of the design criteria is also about the importance of the context, meaning that in addition to the criticality of the dimensions the whole model should as a whole represent the context it was developed for.

Speaking from the maturity model development perspective, the third point in the design criteria is the logic of the model. More specifically, the point aims at assessing and ensuring that the model and especially its dimensions and levels are described in a clear manner, are understandable and also not overlapping with each other. In other words, what the orthogonality/no overlaps criterion means is that while assessing the maturity of a dimension, one is not also assessing the maturity of another dimension. More specifically, orthogonality does not mean independence in the sense that the dimensions

could not relate to each other, as for example a strategy dimension could relate to many of the other dimensions such as technology or processes and would be difficult to separate so that it exists in some sort of vacuum. Consequently, dimensions can in that sense be dependent from each other, as long as there are no overlaps in assessing their maturity. As an example, it could be that e.g., strategy can be assessed to be very mature, while the implementation of technologies is still at its infancy.

Related to maturity, the fourth criterion points out the need for the dimensions to be able to be assessed using the developed, context-relevant maturity framework. In other words, instead of just using e.g., the predefined process based CMMI maturity framework by Chrissis et al. (2011), maturity in each dimension should reflect the maturity in the context of the study and take into account the nature of the differences in the dimensions. The aim is to look into the internal PPX readiness of the companies holistically, and so for example the purely process-based maturity definition cannot be used in this maturity model alone. For this criterion, focus group discussion and expert discussions were used to determine what maturity means for the companies, which led to the three points related to agility in developing and implementing the PPX business models, understanding causality through e.g., prescriptive processes as well as understanding contextuality. Here, understanding contextuality means the ability to implement the PPX business models in any possible market by adapting to the different environments.

Lastly, the two final criteria include the later stages of the model and its development, as they relate to the usability and usefulness of the model. In other words, in some relation to all of the previous four criteria, the usability of the model intends to assess whether the model is fitting for its purpose, also mirroring the Mettler's (2011) design framework decisions related to the evaluation of the model. Moreover, it is not enough for the model to be easy to use, as the results should also be useful and in the best-case scenario provide a clear picture of the current and potential to-be situation in terms of the internal readiness of the companies to implement PPX business models.

It should also be noted, that while all the criteria are used in the development and validation process of the model, the emphasis on specific criteria is naturally different in various stages of the expert workshops and overall development and validation of the model. For example, when it comes to representing the context and assessing the usability or usefulness of the model, the emphasis is naturally on the PPX company experts that would be using the model in practice. Consequently, the content of the workshops was developed keeping in mind not only what needs to be assessed, but who the experts assessing the model are.

4.1.3 Theory-based maturity model development

After defining the scope and overall design framework for the PPX maturity model as well as the specific design criteria, the preliminary, theory-based PPX maturity model was created based on the literature review. The overall themes or dimensions that were identified are summarized in table 4:

Table 4. *Summary of identified dimensions and exemplary literature items.*

Dimensional theme	Exemplary dimensions and source
Governance	Operating structure, governance (Classen et al., 2019) Governance (Schumacher et al., 2018) Service-oriented architecture (Weber et al., 2017)
Strategy	Strategy and leadership (Blatz et al., 2018) Industry 4.0 collaborative diversification vision, strategy and action building (Ganzarain and Errasti, 2016) Strategy (Häckel, et al., 2021) Strategy (Lahrmann, et al., 2011) Strategy and organization (Lizzaralde, et al., 2020) Strategy (Neff et al., 2014) Strategy (Paschou et al., 2019) Strategy objectives (Classen et al., 2019) Strategy, leadership (Schumacher et al., 2018) Top management involvement and commitment, readiness of organizational strategy (Sony and Naik, 2019) Organizational strategy (Wagire et al., 2020)
Risk management	Risk management (Classen et al., 2019) Risk propensity (Teso and Walters, 2016)
People & culture	Company culture and organization (Blatz et al., 2018)) Culture (Häckel, et al., 2021) Employees (Lizzaralde, et al., 2020) Organization & culture (Paschou et al., 2019) Culture, people (Schumacher et al., 2018) Top management involvement and commitment, employee adaptability with Industry 4.0 (Sony and Naik, 2019) Culture and development, communication and awareness (Teso and

	Walters, 2016) People and culture (Wagire et al., 2020)
Technology	IT infrastructure (Blatz et al., 2018) IT (Häckel, et al., 2021) IT (Lahrmann, et al., 2011) Smart products, smart operations (Lizzaralde, et al., 2020) Information systems (Neff et al., 2014) Technology (Schumacher et al., 2018) Smart product and services (Sony and Naik, 2019) Smart infrastructure, plug and produce (Weyer, Schmitt, Ohmer and Gorecky, 2015) Smart manufacturing technology (Wagire et al., 2020) Communication standard, smart infrastructure, integration of superordinate IT systems (Weyer et al., 2015)
Data Analytics	Data maturity (Blatz et al., 2018) IT (Häckel, et al., 2021) IT (Lahrmann, et al., 2011) Data-driven (Lizzaralde, et al., 2020) Data storage and compute, advanced analytics (Weber et al., 2017)
Processes	Product, process and operations (Blatz et al., 2018) Practices (Häckel, et al., 2021) Processes & organization, quality and service (Lahrmann, et al., 2011) Processes (Neff et al., 2014) Customer experience, business processes (Paschou et al., 2019) Portfolio and resources, customer relationship, processes (Classen et al., 2019) Operations, products (Schumacher et al., 2018) Production line and process, plug and produce (Weyer et al., 2015)

As it can be seen from table 4, a total of 7 overall dimensions were identified from the literature review. These dimensions include governance, strategy, risk management, people & culture, technology, data analytics and process-related dimensions. As the dimensional names vary, the idea of the table was not to gather only those dimensions that have exactly the same name, but to see whether the dimensions share similarities in meaning, even if the name of the dimension was slightly different. Through that, these

seven dimensions were then formed and later on developed through the iterative processes introduced in the next chapters.

Still, although most of the validation occurs in the future stages, these dimensions were also preliminary assessed against the developed design criteria in focus groups. More precisely, the assessment included confirming whether the suggested dimensions were critical in implementing PPX business models (design criterion 1) and were a good representation of what needs to be assessed in the PPX context (design criterion 2). Furthermore, the logic of the model was an important criterion (design criterion 3), as it was also already assessed whether the dimensions were clear and orthogonal at this stage, so that for example maturity (according to the design criterion 4) of each dimension could be properly assessed without assessing the maturity of another dimension. Quite importantly, it was also seen that this initial assessment is crucial in order to have a preliminary model that is clear and logical enough to be assessed by other experts in the first place.

4.2 The theory-based maturity model

All in all, the aim of the maturity model design phases and focus group development was to have a preliminary maturity model for the validation in expert workshops. In this section, the preliminary maturity model and its dimensions and general reference maturity levels are introduced, helping to answer the supportive research questions related to the critical dimensions and related maturity levels of the model.

To start, in total 6 maturity levels were developed for the preliminary maturity model, based on the maturity model literature review and focus group discussions. These reference levels varied from 0 to 5, and are as follows:

Level 0: The non-existent PPX level, where systems and processes do not take into account any PPX-related needs. Business model(s) are fully product-oriented and revenue comes purely from product sales.

Level 1: The initial level, where PPX benefits are realized, but strategy is still product-oriented and PPX-related processes are purely ad-hoc with little or no stability and reliability in terms of execution. PPX processes do not follow a standard and rely on commitment from employees to be successful. 25 % or less of revenue comes from PPX services.

Level 2: The experimentation level, where PPX-related processes follow specific policies. Processes are monitored for compliance, enabling the allocation of roles and increasing stability and reliability of the PPX processes. Less than 50 % of revenue comes from PPX services.

Level 3: The systematic level, where PPX-related processes follow specific policies and are standardized for consistency as well as better understanding and agility in implementing PPX processes in specific contexts. Revenue comes about 50% or more from PPX services.

Level 4: The managed level, where PPX-related processes are fully standardized across the company and management is able to use precise metrics to control and monitor PPX processes for better agility and usability in different contexts. Statistical methods also allow better understanding of specific process relationships and causalities, enabling more predictive methods and further increasing agility of implementing PPX business models in specific contexts. Around 75 % of revenue comes from PPX services.

Level 5: The optimized level, where PPX can be implemented globally and in an agile manner in any possible & feasible market. Systems and processes follow standards, are controlled, monitored, managed and optimized for allowing automation of processes and understanding causalities through predictive and prescriptive processes. Revenue comes mostly from PPX-related services.

With the maturity reference levels in place, 7 preliminary dimensions were created based on the literature review. These dimensions are introduced next.

4.2.1 Organizational governance

Organizational governance is about the collection of standards, rules and regulations which are the most critical in PPX implementation and maturity.

The dimension deals with standards, rules and regulations that define how different systems and processes for PPX business models are built and who takes responsibility for them. It also takes into account how data and information is governed and who owns it, ensuring quality, structure, usability, access and availability of PPX data & information. Although governance provides structure and accountabilities, governance is not about the actual implementation of different processes, technologies, data analytics or risk management including data security.

Organizational governance is divided into three subdimensions, which are:

- System governance: The standards, rules and regulations related to the architecture of PPX processes and related tools & technologies.
- People governance: The standards, rules and regulations related to the architecture of organizational roles and accountabilities in different PPX processes.
- Data & information governance: The standards, rules and regulations ensuring quality, structure, usability, access and availability of data & information in respect to data ownership. While data governance deals with these aspects, it is not about the related data & information security risks, which are taken into account in risk management.

4.2.2 Strategy

Strategy is about the plan of action for overall company goals and use of resources that are the most critical in PPX implementation and maturity.

The dimension deals with planning PPX activities & goals and aligning them with the company vision. Consequently, it is also about allocating resources to PPX business models as efficiently as possible. Strategy is not about defining the standards, rules and regulations that it follows, but about making strategic decision within those restrictions managed by governance. Strategy dimension also does not directly deal with identifying, analyzing, or mitigating business risks, which is addressed by risk management.

Strategy is divided into three subdimensions, which are:

- Business strategy: Defining goals and strategy towards implementing and developing PPX business models.
- Strategic alignment: Aligning strategic PPX goals to company vision and existing systems and processes.
- Resource allocation: Defining PPX-related business model needs in terms of resources and allocating those resources accordingly.

4.2.3 Risk management

Risk management is about identifying, analyzing and mitigating emerging risks that are the most critical in PPX implementation and maturity.

The dimension deals with identifying, analyzing and mitigating emerging PPX risks related to business (including financing, customer acceptance, business model cannibalization, contracting, market-related and legal risks), operations (including risks related to

changing internal systems and processes) as well as risks related to data in terms of data security and leakage.

Risk Management is divided into three subdimensions, which are:

- Business risks: Identifying, analyzing and mitigating risks related to financing, customer acceptance, business model cannibalization, contracting, market-related and legal risks.
- Operational risks: Identifying, analyzing, and mitigating risks related to day-to-day product life cycle processes as well as product & production technology.
- Data security risks: Identifying, analyzing and mitigating risks related to data in terms of data security and leakage. Data & security risks are not about data governance, that deals with the ownership, quality, structure, usability, access and availability of data & information, but about mitigating the risks related to the use of this data.

4.2.4 Competences, culture & leadership commitment

Competences, culture & leadership commitment is about the novel employee competences, attitudes, knowledge-sharing culture and leadership commitment that are the most needed in PPX implementation and maturity.

The dimension deals with the most critical competences that are needed in PPX business models, including collaboration with customers; process, product & service design; marketing & sales; data analytics; estimating and aligning costs with expenses as well as risk management. The dimension also describes the culture in terms of sharing knowledge across the company departments (e.g., sales, marketing, design and production) and attitudes towards PPX change, as well as leadership in terms of management commitment in driving the PPX change forwards within the organization.

Competences, culture and leadership commitment is divided into three subdimensions, which are:

- Competences: The most critical employee competences that are needed in PPX business model implementation and maturity, including collaboration with customers; process, product & service design; marketing & sales; data analytics; estimating and aligning costs with expenses as well as risk management.
- Culture: Company-wide knowledge-sharing culture (sharing information & data across departments, e.g., sales, marketing, design and production) and attitudes towards PPX change.

- Leadership commitment: Management commitment needed to drive PPX change forwards within the organization.

4.2.5 Product & production technology

Product & production technology is about the product and production technologies related to hardware, software, connectivity and cloud that are the most critical in PPX implementation and maturity.

The dimension deals with the technologies such as the production machinery, sensors, actuators, self-storage capabilities and software that enable monitoring, controlling, optimizing and automizing PPX production processes and related products. It also includes the systems and technologies enabling machine connectivity as well as cloud-based applications, platforms and databases enabling company-wide access to data & information. Technology does not include data analytics, which deals specifically with how process and product data is further collected, processed, combined, visualized and applied. Technology is not about the related competences or developing the architectural guidelines for technology either, but about the actual implementation of the technologies.

Product & production technology is divided into three subdimensions, which are:

- Smart product & factory: the PPX product and production-related hardware and embedded software (including sensors, actuators, self-storage capabilities and software) enabling monitoring, controlling, optimizing and automizing PPX production processes and related products.
- Connectivity: the systems of technologies that enable product communication and connectivity to the internet as well as machine-to-machine communication
- Cloud: cloud-based applications, platforms and databases enabling company-wide access to data & information

4.2.6 Data analytics

Data analytics is about the methods, software tools and technologies related to data collection, processing, combination, visualization and application that are the most critical for PPX implementation and maturity.

The dimension deals with the different methods such as descriptive or diagnostic analysis; software tools such as Excel & BI tools and technologies such as databases, that support data collection, processing, combination, visualization and application. Data an-

alytics is specifically about the technologies utilized in analytics, so it excludes the technology utilized in products or production processes. Data analytics does not take into account the competences needed in data analytics either, as they are described in their own dimension.

Data Analytics is divided into three subdimensions, which are:

- Data collection: Methods, tools and technologies related to collecting relevant PPX data.
- Data combination & processing: Methods, tools and technologies related to combining and processing different PPX data sources.
- Data visualization & application: Methods, tools and technologies related to data visualization and applying data in decision-making.

4.2.7 Product life cycle processes

Product life cycle processes is about the collection of pre-delivery, delivery and post-delivery tasks which are the most critical in the maximization of life cycle profits in PPX business models.

Product life cycle processes deals with the tasks related to manufacturing; implementing production, product & service design plans; logistical processes related to distribution, disassembly & redistribution; marketing & sales as well as maintenance. The processes are about implementing the specific tasks and not about the strategies, competences, technologies or data analytics behind them.

Product life cycle processes has three different options for its subdimensions. These options are:

- Option 1:
    - Pre-delivery processes: processes related to manufacturing; production, product & service design as well as the marketing & sales of the product-service offerings.
    - Delivery processes: processes related to the distribution of the product.
    - Post-delivery processes: processes related to maintenance, disassembly and redistribution of the product.
- Option 2:
    - Design processes: processes related to production, product & service design and development.

    - Production processes: processes related to product manufacturing.
    - Sales & Logistics: processes related to the marketing & sales of the product-service offerings as well as the distribution, disassembly & redistribution of the product.
- Option 3:
    - Production & design: processes related to product manufacturing as well as production, product & service design.
    - Logistics: processes related to the distribution, disassembly & redistribution of the product
    - Marketing & sales: processes related to marketing & sales of the product-service offerings, including maintenance services.

All in all, these dimensions were considered to be the most relevant and critical dimensions that were taken into the iterative development phase of the maturity model. With respect to the options in the product life cycle processes, it was considered that the experts in the workshop design and validation phase could pick the best and most clear option available, so the decision was deliberately left for the later phases.

5. RESEARCH METHODOLOGY

This chapter helps to answer the primary research question through the fifth supportive research question related to using action design research (ADR) in the design and validation processes of the maturity model. The logic of the research methodology is explained through a “research onion”, that according to Saunders et al. (2009) include the most crucial aspects of conducting research, starting from the general research philosophy, and ending with the methods related to data collection. The research onion in the context of the thesis can be seen in figure 7:

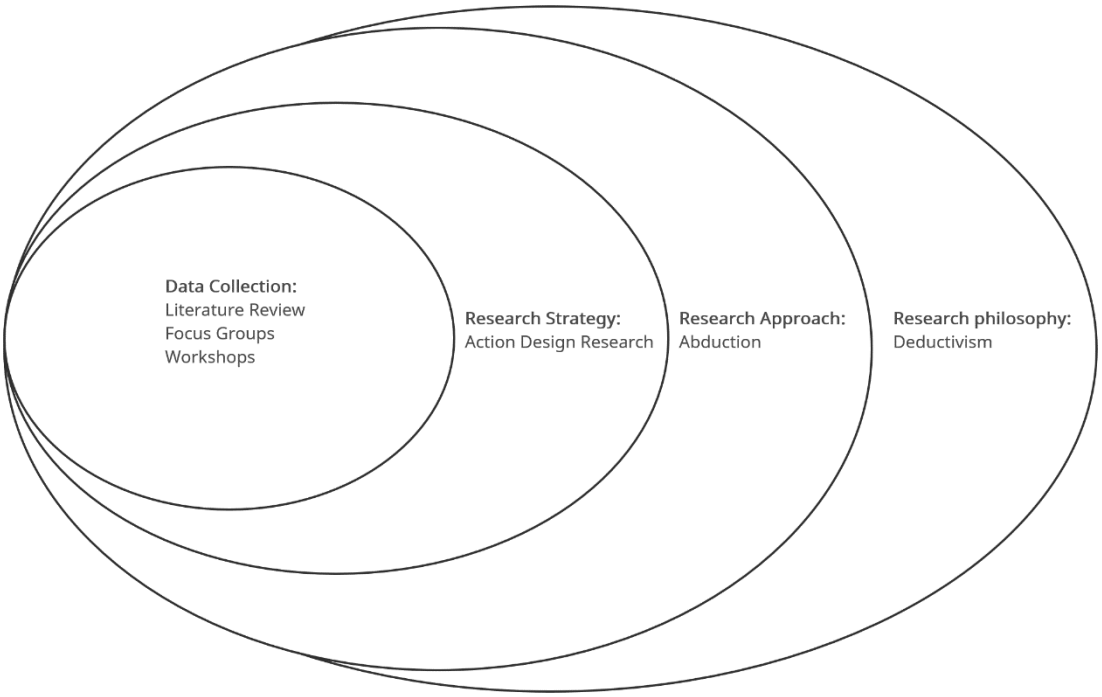

***Figure 7**. Research onion adapted from Saunders et al. (2009).*

The outermost layer of the research onion in figure 7 includes the research philosophy, that defines the overall approach to the research. Then, the next layers include research approach and strategy, that further define and limit the methods used in the research. Finally, the innermost layer includes the core of the research: data collection. Consequently, the rest of the chapter discusses the research methodology in this order, describing how and why the decisions have been made with respect to answering the research questions and collecting data.

5.1 Research philosophy: pragmatism

According to Saunders et al. (2009), research philosophy is a concept that defines guidelines for doing research and provides a starting point for data collection, analysis and use of data. The five philosophies that Saunders et al. (2009) identify are positivism, critical realism, interpretivism, postmodernism and pragmatism.

In this study, pragmatism is chosen as the research philosophy. A pragmatist research intends to understand the benefits of both objectivism and subjectivism by considering different theories and concepts in terms of their practical implications. In other words, a pragmatist starts research with a problem that aims to provide practical solutions for future practices, valuing reality that enables actions to be carried out. (Saunders et al., 2009) As the aim of this thesis is to see how to design and validate a maturity model in the specific context of internal PPX readiness in B2B equipment manufacturing SMEs, it can be seen that there are practical implications that are expected in the end. Moreover, as maturity models are arguably yet to address the needs specifically from this context, it can be seen that while theory can provide guidelines, theory-based methods are not enough. In other words, theory could be supported with testing and developing the different theories and concepts in practice, again valuing reality and its practical implications.

5.2 Research approach: abduction

Saunders et al. (2009) talk about research approaches as ways of using theory and distinguish between 3 different approaches, where in simple terms deductive approach is about starting with theory and testing it, inductive approach is about collecting data and creating a theory, and abduction is about collecting data, exploring patterns as well as generating, modifying and testing existing theories.

In this thesis, abduction is chosen as the chosen approach. As said, abduction is about generating or modifying theories by incorporating existing theories when possible, as well as collecting data to explore different phenomena and testing the identified frameworks and conclusions when possible. (Saunders et al., 2009) Again, as there are some related, but not specific maturity models made for the internal PPX readiness analysis in B2B equipment manufacturing SMEs, abduction seems to provide the approach to answering the research question: while existing theory is used to have the initial premises for the maturity model development, the existing theory has to be tested and modified in order to fit the specific context of the research. Consequently, data collection is focused

on identifying and testing different themes and patterns in reality, enabling the development of the existing theory.

5.3 Research strategy: action design research

There are several types of research strategies, which in practice describe how research is carried out. As the aim of this research is to develop and validate a maturity model in the context of a real organizational challenge, one option would be to conduct action research: using a collaborative approach to develop both theories as well as practices in the organization would also be in line with the pragmatist approach to research. (Saunders et al., 2009) However, since the focus of the research is also on the design of the maturity model, another option would be design research that is based on an iterative and cyclic process of prototyping, testing, analyzing and refining the design in question (Zimmerman, 2003), and would consequently suit the process of both designing and validating the maturity model development.

Still, speaking from a pragmatist perspective and combining methods, action and design research strategies do not have to be mutually exclusive: in the context of information systems, Sein et al. (2011) responded to the need to have a research strategy developed in the organizational setting. In other words, by combining the different design and action strategies into Action Design Research, the approach by Sein et al. (2011) could also help in the development of the maturity model in terms of designing it iteratively and in a collaborative manner. Consequently, Action Design Research is chosen as the research strategy in the scope of this thesis and is introduced in this section more specifically.

5.3.1 Problem formulation

Similar to the problem definition and scoping in maturity model design approaches, stage 1 of ADR starts with problem formulation. Here, the stage draws on two principles, which are that research should see practical issues (or field problems) as knowledge-creating opportunities and that the artifact itself should be supported by theory, consequently combining the world of theory and practicality. In more specific terms, the problem formulation stage in the ADR includes identifying the research opportunity, initial research questions and underlying theories, as well as securing organizational commitment and defining roles and responsibilities to succeed in creating knowledge through practical issues. (Sein et al., 2011) This, in other words, can be used in the maturity model development as well, since the idea is to create a preliminary model (i.e., artifact) that is based on theory, and which is then developed with the help of experts and real-life examples.

More specifically, the problem formulation phase in this thesis corresponds to the formulation of the research questions and defining the scope of the research.

5.3.2 Building, intervention and evaluation

The second stage in the action design research process is arguably quite crucial: it is the building, intervention and evaluation phase, where the preliminary artifact is built, tested and evaluated iteratively with the help from researchers, practitioners or end-users, such as the company representatives. Here, the central principles state that this iterative process should be reciprocal in terms of the artifact helping to understand the organizational context and vice versa, meaning that theory and practicalities should be complementing each other. Moreover, while evaluation certainly includes the design of the artifact itself, the design principles behind the development process should be evaluated as well. All these processes should also be continuous and parallel processes, as the aim of ADR is to have continuous evaluation and redesign activities until the artifact design is validated. (Sein et al., 2011) In maturity model design and validation terms, this means that while theory can and has provided the preliminary build for the model, it should be iteratively evaluated against and complimented with the findings related to practical implications in the scope of the research. This would also allow not only assessing the actual design of the model, but also the theory and design criteria that is behind the model.

5.3.3 Reflection and learning

While the ADR process emphasizes that evaluation is not a separate phase in the strategy, there is still a third stage which deals specifically with reflection and learning. Here, it is emphasized that while design (intentional intervention) and emergence (organic evolution) are often seen as opposites, ADR actually combines these two into “guided emergence”. Here, the emphasis is again on the fact that the preliminary design will be affected not only by the theory it is created with, but also by the practical perspectives and findings. Also, although it is called the third stage, the idea is that similarly to the evaluation processes, reflection and learning is done iteratively and side by side with the other stages. (Sein et al., 2011) In maturity model development, this means that the maturity model in terms of its theory, design and design criteria can, and should be reflected upon and adjusted accordingly if the need arises.

5.3.4 Formalization of learning

Lastly, the ADR process includes the fourth stage of formalization of learning. This stage draws from the principle of generalized outcomes, which states that while the ADR process is highly situational and specific in its organizational context, there should also be process for generalizing the problem, solution as well as the design principles that arise from the research. In other words, generating more general concepts and conclusions in the research can help for example in developing the theories that work as the basis for the artifact, again supporting the idea of theory and organizational practices complementing each other. (Sein et al., 2011) In terms of the maturity model development in this research scope, this could suggest that while we look at a specific instance, the outcomes of the research could be applied to, or at least thought of, in more broader instances as well. Instead of providing solutions merely for the specific B2B equipment manufacturing SMEs, the ADR process could then, for example, help in understanding the overall process of designing and validating a maturity model or have implications on the development of PPX business models in general.

5.4 Data collection

As the ADR process emphasizes iterative design processes that involve both the theory-based artifact as well as organizational interference, data collection methods should reflect that idea as well. Consequently, the data collection methods included in this research and the building, intervention and evaluation cycle of the ADR process are literature review for the development of the preliminary, theory-based maturity model and collaborative methods including focus groups and expert workshops. These methods are now described in this section, helping to answer the 5th supportive research question related to how to design and validate the model with methods related to the ADR.

5.4.1 Literature review

As discussed, when it comes to maturity models, there are hundreds of them already in existence merely in the field of e.g., IT management. (Becker et al., 2009). In other words, while there might not be specific and perfectly documented models already developed for the PPX readiness analysis in the scope of this research, it would make sense to ensure the problem relevance by comparing the existing models and ensuring that the research answers an existing and relevant question (e.g., de Bruin et al., 2005; Becker et al., 2009). Consequently, literature review that responds to the need to relate research to existing theories and tackles the challenge of fragmented and interdisciplinary

knowledge (Snyder, 2019) was used in this thesis, in order to also support the action design research process in terms of creating the theory-based maturity model that is then further developed. More specifically, this thesis uses integrative literature review, that can support creating initial conceptualizations and theoretical models by focusing on combining the most relevant perspectives defined in advance, instead of merely reviewing everything that has ever been published in the context of relevant maturity models. (Dewey and Drahota, 2016; Snyder, 2019)

5.4.2 Focus groups

With the development of the preliminary, theory-based maturity model, the other important part of action design research strategy is iterative and participatory development of the model. For this, the design and data collection process started with focus groups. In other words, as the aim of focus groups is to clarify, extend or challenge data collected by generating information on different participant views and understanding (Gill et al., 2008), this data collection method was used to refine both the problem formulation phase of the maturity model development as well as the actual building and evaluation of the preliminary maturity model. In practice, focus groups in the scope of this thesis are the key to the preliminary development phase, where business model and technological experts from academia as well as practitioners from the partner companies are used to develop the preliminary maturity model and its theory, which is then continuously and iteratively developed through different expert workshops. Moreover, the design framework was both developed, used and assessed with the help of these focus groups, so focus groups are involved throughout the ADR process.

5.4.3 Workshops

Although the focus groups support the iterative development of the maturity model in accordance with the action design research process, the workshops created for experts in the area of maturity models and pay-per-x business models both in academia and companies provide a platform for even more dynamic development of the model: as workshops aim and help to produce data related to e.g. organizational change and design especially in a new and emerging area of research (Ørngreen and Levinsen, 2017), workshops can be used to collect useful information in terms of how the preliminary maturity model should be developed in general, but also in the context of this research in terms of PPX readiness in B2B equipment manufacturing SMEs. The workshops are conducted in three phases, starting with academic maturity model experts and then mov-

ing from academic PPX experts to PPX experts in companies. This way, the design process of the maturity model is considered, as well as its context and relevance specifically in PPX readiness analysis.

As said, the first phase of expert interviews in the form of workshops is held with maturity model experts. The logic behind this order is that before assessing criteria like the usability and usefulness of the model, the model should be at least somewhat logical and especially understandable, so that the practitioners, or PPX company experts could actually assess the usability and usefulness of the model. Consequently, considering the design criteria developed in the focus group and preliminary model design phase, the maturity model expert workshop focused especially on the assessment of the design criteria itself as well as the logic of the model, which would support the forthcoming assessment of the dimensions by academic PPX experts as well as PPX company experts in terms of the dimensions' relevance, usability and usefulness in addition to the clarity and description of maturity. More specifically, the structure of the first workshop is defined as follows:

1. Introduction to the purpose of the research and the workshop
2. Evaluation of the design criteria
3. Introduction to the suggested dimensions of the preliminary maturity model
4. Assessment of each individual dimension in terms of the clarity and understandability of the title, brief definition, function and subdimensions as well as dependence compared to the other dimensions
5. Overlap analysis
6. Analysis of preliminary reference levels for maturity (minimum and maximum)
7. Discussion

As stated, the focus of this maturity model expert workshop was to assess the design criteria for the development of the maturity model, in addition to which the focus was on the logic and understandability of the model. More specifically, the understandability was assessed by looking at the brief definition and function of the dimensions, the division into the subdimensions as well as how well the title represents the overall meaning of the dimensions. This was done by giving a rating for each of the points from 1 to 5, 1 being "bad" and 5 being "excellent". Moreover, to assess the logic in terms of orthogonality, a matrix of the dimensions was filled with assigning each possible dimensional pair a value from 0 to 2, with 0 being "no overlaps", 1 being "potential overlaps" and 2 being "clear overlaps". Furthermore, overall comments about the potential issues were

collected both through discussion as well as comment fields in the actual assessment form.

The second workshop is held with academic PPX expert, again with the focus on the logic of the model, but also more closely related to the criticality of the dimensions as well as the representation of the context. Specifically, the structure of the workshops is as follows:

1. Introduction to the purpose of the research and the workshop
2. Introduction to the suggested dimensions of the preliminary maturity model
3. Assessment of each individual dimension in terms of the clarity and understandability of the title, brief definition, function and subdimensions as well as dependence compared to the other dimensions
4. Overlap analysis
5. Analysis of preliminary reference levels for maturity (0 to 5)
6. Discussion

As it can be seen, the structure of the workshop is quite closely related to the first workshop. However, direct assessment of the design criteria is omitted from this workshop and with respect to the dimensions, a question about their relevance was added to each dimension. Furthermore, in terms of the reference levels, a preliminary division into 6 maturity levels that are based on the comments of the first workshop as well as the literature are introduced.

The third and final phase of the expert workshops within the scope of this thesis is the PPX company expert workshop. As discussed, here the emphasis of the workshop is more towards the representation of the context as well as the usability and usefulness of the maturity model. In specific terms, the workshop structure is as follows:

1. Introduction to the purpose of the research and the workshop
2. Introduction to the suggested dimensions of the preliminary maturity model
3. Assessment of each individual dimension in terms of the clarity and understandability of the title, brief definition, function and subdimensions as well as dependence compared to the other dimensions
4. Question about potentially missing dimensions.
5. Overlap analysis
6. General usefulness of the model

7. Usefulness of the model in terms of determining the as-is situation, the to-be situation, identifying bottle necks, using the model to communicate between different groups
8. Discussion

Again, the workshop structure includes the basic questions on the logic of the model, especially in terms of understandability as well as overlaps. Moreover, when compared to the other workshops, the PPX company expert workshop included questions directly related to the overall usefulness of the model, as well as specific usefulness of the model in terms of assessing the as-is and potential to-be situation, identifying bottle necks and using the model as a tool to communicate between different groups within the company, such as different departments.

6. RESULTS AND FINDINGS: MATURITY MODEL DESIGN AND VALIDATION

After designing and developing the preliminary maturity model, the theory-based model went through the development, or validation phase done through expert workshops. This chapter introduces the results of this validation process, in effect helping to answer the primary research question of how to design and validate the maturity model for the internal PPX readiness through the supportive research questions, that aim at determining the most critical design criteria and dimensions of the maturity model as well as describing the maturity levels of the model. The first part of the chapter introduces the workshop results, while the second part introduces the suggested maturity model that is based on the results and findings of the iterative development of the model.

6.1 Workshops: iterative maturity model development

With the preliminary maturity model with its dimensions and reference levels in place, the model was taken into the second, empirical design and validation phase including the experts in different workshop. In this section, the results of the expert workshops are introduced, consequently answering the primary research question through the various secondary research questions related to the design criteria, critical success factors and dimensions of the maturity model, development of maturity levels and what type of solutions the implemented action design research approach can bring in terms of the expert workshops.

6.1.1 Phase 1: Maturity model expert workshop analysis

The first phase of the expert workshops included assessing the design criteria of the maturity model, the overall clarity and understandability of the dimensions and maturity levels as well as the potential overlaps between the dimension by 3 experts, noted in the comments as *E1, E2* and *E3.*The results specifically from the first workshops were gathered into 2 different tables: one gathering the ratings related to the clarity and understandability of the description, function, subdimensions and the title of the dimension, as well as a table related to the ratings in terms of the potential overlaps of the dimensions. Results related to the design criteria and maturity levels were gathered as text.

In terms of the design criteria, no significant recommendations for changes were made. The only addition that was suggested by *E2* was that the point 2 about representation of

the context should also take into account the purpose of the model, and *E1* suggested that the point about the relevance from the PPX maturity point of view could be clarified. Moreover, all the points were clarified through adding some descriptions, consequently leading into the following form of design criteria:

1. Criticality of the dimensions
    - Do the dimensions deserve their place among the most critical (4-7) ones?
2. Representation of the context & purpose
    - Does the model and the dimensions represent its purpose and the context of PPX in B2B equipment manufacturing SMEs properly?
3. Logic of the model
    - Clear descriptions
    - Understandable
    - Orthogonality (no overlapping dimensions)
4. Dimensional maturity in the context of PPX
    - Can the dimensions be described in terms of how mature they are in the optimization of life cycle benefits and risks in the PPX context, considering agility, understanding causality and understanding contextuality?
5. Usability of the model
    - How easy is the model to use for respondents?
6. Usefulness of the model
    - How useful and applicable is the analysis to the respondents?

In terms of clarity and understandability of the dimensions, ratings by each expert were gathered in another table. The idea was that especially those dimensions with a high standard deviation in the rating would be focused on, as that would also mean higher discrepancy in the opinion of the experts. Still, comments were involved in the analysis of the results, as the mere rating was not seen to be enough to cause a change or even potential change in the dimensions. In the end, the dimensions that were seen as requiring minor clarifications at most were marked in the table with green, those requiring more

significant redefinitions in at least some of the subdimensions with yellow and those potentially requiring significant changes in the overall dimension were marked as red. These results can be seen as summarized in table 5:

Table 5. *Ratings of clarity and understandability of dimensions by maturity model experts.*

Dimension & Subdimensions	Rating and standard deviation of the rating of clarity & understandability (1 to 5, where 1 = unclear and 5 = clear)			
	Brief Definition	Function	Subdimensions	Title
Organizational governance (system, people and data & information governance)	4; 4; 4 (SD: 0)	2; 4; 4 (SD: 1.155)	3; 3; 4 (SD: 0.577)	2; 4; 5 (SD: 1.528)
Strategy (business strategy, strategic alignment and resource allocation)	3; 4; 5 (SD: 1)	3; 4; 5 (SD: 1)	2; 3; 5 (SD: SD: 1.528)	3; 2; 5 (SD: 1.528)
Risk Management (business, production and data security risks)	5; 4; 5 (0.577)	5; 4; 4 (SD: 0.577)	4; 3; 5 (SD: 1)	4; 5; 5 (SD: 0.577)
Competences, culture & leadership commitment (competences, culture and leadership commitment)	5; 3; 3 (SD: 1.155)	3; 4; 3 (SD: 0.577)	4; 3; 3 (SD: 0.577)	5; 4; - (SD: 0.707)
Product & production technology (smart product & factory, connectivity and cloud)	4; 5; 4 (SD: 0.577)	4; 3; 5 (SD: 1)	4; 3; 4 (SD: 0.577)	2; 4; 4
Data Analytics (data collection, combination & processing and visualization & application)	5; 4; 3 (SD: 1)	4; 4; 3 (SD: 0.577)	5; 4; 3 (SD: 1)	5; 4; 3 (SD: 1)

Product life cycle processes (Option 1: pre-delivery, delivery and post-delivery processes; Option 2: design processes, production processes, sales & logistics Option 3: production & design, logistics and marketing & sales)	4; 3; 4 (SD: 0.577)	4; 3; - (SD: 0.707)	Option 1: 3; 3; 5 (SD: 1.155) Option 2: 4; 3; - (SD: 0) Option 3: 4; 3; - (SD: 0.707)	3; 4; - (SD: 0.707)

As it can be seen in table 5, competences, culture and leadership commitment was seen as the only potentially critical dimension that required more significant changes. This was due to the fact that the dimension was seen to be "combining three different dimensions--. One [being] human resources, another [being] cultural baggage." *(E3)* Moreover, it was noted that the dimension included "lot of info cognitively" *(E1),* which potentially affected the understanding of the dimension. In terms of the other dimensions, product life cycle processes, organizational governance and strategy were seen to require less attention, as all the potential issues were related to simple clarifications of the function or certain subdimensions, such as the meaning of strategic alignment in the strategy dimension *(E1).* In terms of the yellow dimensions, risk management was seen to potentially need more subdimensions such as IT-related risks *(E3),* the function of product and production technology was not potentially clearly enough differentiated from IT *(E3)* and data analytics was seen to not be clear enough in terms of its function as aiding decision-making processes *(E3).*

After assessing the clarity and understandability, another assessment was made in terms of the potential overlaps of the dimensions. The results of the overlaps are gathered in table 6, again noting the potentially clear overlaps (at least one rating of 2) with red, those with potential overlaps (rating of 1) with yellow and those with no overlaps (rating of 0) with green:

Table 6. *Overlap analysis by maturity model experts.*

	Organizational governance	Strategy	Risk management	Competences, culture & leadership commitment	Product & production technology	Data analytics	Product life cycle processes
Organizational governance							
Strategy	1; 0; 1						
Risk management	1; 0; 0	0; 0; 0					
Competences, culture & leadership commitment	0; 1; 0	0; 0; 2	0; 0; 0				
Product & production technology	0; 0; 0	0; 0; 0	0; 0; 0	0; 0; 0			
Data analytics	1; 0; 0	0; 0; 0	1; 0; 0	1; 0; 0	0; 0; 1		
Product life cycle processes	0; 0; 1	0; 0; 0	0; 0; 0	0; 0; 0	0; 0; 0	1; 0; 0	

As table 6 shows, the only critical overlaps were seen between strategy and competences, culture & leadership commitment. More specifically, it was questioned whether leadership could go under strategy *(E3),* as it was suggested that the strategy dimension requires leadership commitment in it to function. Moreover, as strategy dimension was seen as "bit complex" *(E1),* it was suggested that there might be some potential overlaps also with organizational governance, which was seen to have potential overlaps with other dimensions as well, such as risk management in terms of risk governance*,* as well as the leadership commitment *(E2)* as well.

The final part of the workshop included the analysis of the general reference levels for maturity, in this case specifically assessing the minimum and maximum levels. Overall, it was seen that there was some ambiguity in the level descriptions, as the level 0 "where systems and processes do not take into account any PPX-related needs" was seen as confusing (*E2).* Moreover, Level 5 description of revenue coming "mostly from PPX-related services" was seen as too ambiguous *(E3),* leading to changing it and other revenue descriptions into concrete percentages.

In summary, the results from the first phase of workshops raised one critical overlap issue between competences, culture & leadership commitment as well as strategy: in addition to both dimensions lacking some clarity, it was seen that leadership commitment is related to the maturity of strategy and potentially even to organizational governance. Moreover, potential overlapping issues were seen especially between product & production technology and data analytics, as it was not clear enough what was meant by data analytics.

In terms of the maturity reference levels, the minimum and maximum levels were assessed. Some ambiguity in the level descriptions was raised as a potential issue, as it was seen that for example the sentence "The non-existent PPX level, where systems and processes do not take into account any PPX-related needs" was too confusing (*E2)*. Moreover, it was seen as a good idea to use quantitative measures if using revenue in the description, so adding for example 0 % in the level 0 description.

Consequently, as a result of the first workshop, some changes were made. However, in order to not cause an endless need for further iteration rounds, the idea was to keep the changes to a minimum. The changes made before the second workshop included:

- Removing confusing and too complex descriptions about what the dimensions are **not** about.
- Clarifying data analytics specifically as the data analytics utilized in decision-making processes.

- Adding quantitative measures to the revenue descriptions in the maturity levels.

6.1.2 Phase 2: Academic PPX expert workshop analysis

Phase 2 of the expert workshops followed the same logic as the first workshop. Results were gathered from two respondents (*E4*, *E5)*, who were assessing the clarity and understandability of dimensions as well as a describing the potential overlaps between dimensions. Similar color-coding was also used, red implying there is a critical issue, yellow marking a potential issue and green signifying minor or no issues. The clarity and understandability ratings, now also marked individually for each subdimension, but without standard deviation due to only 2 respondents, are shown in table 7:

Table 7. *Ratings of clarity and understandability of dimensions by academic PPX experts.*

Dimension & Subdimensions	Rating and standard deviation of the rating of clarity & understandability (1 to 5, where 1 = unclear and 5 = clear)			
	Brief Definition	Function	Subdimensions	Title
Organizational governance (system, people and data & information governance)	4; 3	4; 4	4; 4 4; 4 4; 4	4; 5
Strategy (business strategy, strategic alignment and resource allocation)	4; 3	4; 4	4; 4 3; 3 4; 3	3; 5
Risk Management (business, production and data security risks)	4; 4	4; 5	4; 4 4; 4 4; 4	4; 5
Competences, culture & leadership commitment (competences, culture and leadership commitment)	4; 2	3; 3	4; 4 4; 4 4; 4	3; 3
Product & production technology (smart product & factory, connectivity and cloud)	4; 5	3; 4	4; 5 4; 3 4; 5	3; 4

Data Analytics (data collection, combination & processing and visualization & application)	3; 4	4; 3	4; 3 4; 3 4; 2	3; -
Product life cycle processes (Option 1: pre-delivery, delivery and post-delivery processes; Option 2: design processes, production processes, sales & logistics Option 3: production & design, logistics and marketing & sales)	3; 2	4; 2	3; 2 5; 3 3; 2	5; 2

As table 7 shows, the clarity of dimensions was less clear overall in the second workshop with the academic PPX experts. While organizational governance and risk management were seen as quite clear, all the other dimensions had issues in terms of how they were understood. For example, in terms of strategy, it was not clear what was meant by requirements being dependent from the available resources *(E4)*, in addition to which the definition seemed to lack some clarity overall. Competences, culture and leadership commitment was also seen as a "fuzzy, yet needed dimension" (*E4*), while data analytics and product and production technology had some issues with the definitions of the subdimensions. In terms of product life cycle processes, it was suggested by one of the experts *(E4),* that instead of the given options, the subdimensions would be divided into the beginning, middle and end of life processes.

In terms of the overlap analysis of the academic PPX workshop, table 8 depicts the results:

Table 8. *Overlap analysis by academic PPX experts.*

	Organizational governance	Strategy	Risk management	Competences, culture & leadership commitment	Product & production technology	Data analytics	Product life cycle processes
Organizational governance							
Strategy	1; 1						
Risk management	0; 1	1; 0					
Competences, culture & leadership commitment	1; 1	1; 1	1; 0				
Product & production technology	1; 0	1; 0	1; 1	1; 0			
Data analytics	1; 0	1; 0	1; 1	1; 0	1; 2		
Product life cycle processes	1; 0	1; 1	1; 1	1; 0	1; 2	1; 1	

Following the ambiguities recognized in the assessment of the clarity and understandability of the dimensions, the overlap analysis of the academic PPX experts mirrors the results: all of the dimensional combinations were seen to have some potential for overlaps, while especially product and production technology was seen to be clearly overlapping with data analytics as well as product life cycle processes by one of the experts

(E4), as according to them “some production technology will not even work without analytical capabilities” and technology was seen to carry out many of the product life cycle processes depicted in its dimension. Still, all the dimensions were seen relevant for PPX, with no useless dimensions pointed out.

In summary, the results from the academic PPX expert workshop confirmed many of the same issues as the maturity model expert workshop: the competences, culture and leadership commitment dimension was seen as somewhat vague dimension with the potential of overlapping with the other unclear dimension of strategy. Moreover, it was noted that data analytics is at the moment overlapping with product & production technology, which also was seen to have the potential to overlap with product life cycle processes. It was also suggested that product life cycle processes could be divided into the beginning, middle and end of life processes, instead of the suggested subdimensions. Also, in terms of the maturity reference level descriptions, it was also noted that the quantitative brackets for revenues should be clear if used, so that instead of for example “50 % or more”, the description would be for example “50 % to 75 %” *(E4).*

Again, the results of the workshop were taken into account before the third and final round of workshops, while changes were made in moderation. The changes before the third workshop included:

- Minor changes in dimensions’ definitions and functional description, clarifying the function of strategy, data analytics and product & production technology.
- Changing the subdimension of data collection into data access.
- Defined the quantitative revenue brackets more precisely in the maturity reference levels, replacing the “or more” expressions with clear percentage limits.

6.1.3 Phase 3: PPX company expert workshop analysis

The third and final round of workshops included PPX company experts. Again, results were gathered about the clarity and understandability of the dimensions, in addition to which the potential overlaps were also discussed. Moreover, comments about the overall usefulness of the model were collected. The clarity and understandability ratings are depicted in table 9, with no standard deviation calculated due to having only two respondents (*E6, E7):*

Table 9. *Ratings of clarity and understandability of dimensions by PPX company experts.*

Dimension & Subdimensions	Rating and standard deviation of the rating of clarity & understandability (1 to 5, where 1 = unclear and 5 = clear)			
	Brief Definition	Function	Subdimensions	Title
Organizational governance (system, people and data & information governance)	2; 2	3; 2	4; 2 2; 4 4; 3	5; 3
Strategy (business strategy, strategic alignment and resource allocation)	2; 3	1; 2	4; 4 2; 3 4; 3	5; 3
Risk Management (business, production and data security risks)	4; 4	4; 4	5; 3 4; 4 4; 3	4; 2
Competences, culture & leadership commitment (competences, culture and leadership commitment)	4; 3	4; 3	5; 3 2; 2 4; 4	3; 4
Product & production technology (smart product & factory, connectivity and cloud)	3; 2	3; 2	1; 1 4; 1 4; 1	4; 1
Data Analytics (data collection, combination & processing and visualization & application)	5; 3	5; 2	5; 3 5; 3 5; 3	3; 2

Product life cycle processes (Option 1: pre-delivery, delivery and post-delivery processes; Option 2: design processes, production processes, sales & logistics Option 3: production & design, logistics and marketing & sales)	3; 3	3; 2	1; - 5; - 1; -	5; -

As it can be seen from table 9, the clarity and understandability ratings were not as high in the PPX company expert workshop. For example, in the case of organizational governance and strategy, the definitions were seen as "somehow difficult" (*E6*), in addition to which it was not clear whether for example the three subdimensions of strategy include all the necessary components needed to assess it (*E7).* Moreover, the biggest issue from one the experts (*E6*) was that according to their point of view, data and data analytics should not be as important as they are in the dimensions and their descriptions.

In terms of the overlaps and other critical issues, the question of whether leadership commitment should be under strategy was raised again, while also considering the possibility of having data analytics under technology. Furthermore, in terms of criticality of the dimensions, it was suggested that instead focusing on the data, there could be a completely new dimension that focuses on the value management and "understanding what you sell" (*E6).* To finish, the PPX company experts were also asked to assess the usability of the model, with ratings shown in table 10:

Table 10. *Ratings of usefulness of the maturity model by PPX company experts.*

Overall usefulness	4; 3
Usefulness in determining the as-is situation	3; 4
Usefulness in determining the to-be situation	4; 2
Usefulness in determining bottle necks	4; 3
Usefulness in providing common language at the company	2; 4

As it can be seen, the overall usefulness was mostly at and above mediocre (3) rating. The usability of the model was seen to be potentially “very relevant” in determining the current situation (*E7),* but it was argued that due to the need to understand customer needs, determining the to-be situation could require other tools *(E6).* The overall usefulness and usability of the model as well as its usefulness and usability in providing a common language was also seen to have room for improvement, as it was emphasized that value creation should be highlighted *(E6)* and that the dimensions should be clarified to properly function as a tool for common language *(E7).*

As a result, these comments as well as the comments from the other workshops were taken into consideration when developing the suggested pay-per-x maturity model. Consequently, the next section introduces the model that was developed within the process included in this research.

6.2 The suggested pay-per-x maturity model

Based on the focus group development and first round of expert workshops and further focus group discussions, a new, edited maturity model was developed. In this section, the suggested maturity model is introduced in terms of the 5 general reference levels for maturity, as well as the dimensions in terms of their brief definition, function, subdimensions as well as minimum (1) and maximum (5) level of maturity, in effect directly answering to research questions 3 and 4 related to the critical dimensions and general reference levels for maturity as well as each dimension’s minimum and maximum maturity level.

As one of the design criteria, an important factor in the design and functionality of a maturity model is that the dimensions can be measured and described in terms of the context of the maturity in question. That is, in order to describe the minimum and maximum maturity levels of the dimensions, general reference levels for PPX maturity were formulated according to the feedback from the focus group development and expert workshops. These reference levels are used to form the minimum and maximum maturity levels of each dimension and are as follows:

- **Level 1: The initial level,** where PPX requirements and benefits are potentially acknowledged or researched, but no concrete measures have been developed or implemented. The company is fully product-oriented, and no revenue comes from the PPX services.

- **Level 2: The experimentation level,** where PPX requirements and benefits are acknowledged, and concepts are tested. PPX-related measures are still non-standardized, and measures are based on ad-hoc decisions.
- **Level 3: The defined level,** where PPX needs and requirements are acknowledged and related measures are standardized, enabling the implementation of small-scale solutions in specific PPX business models.
- **Level 4: The advanced level,** where PPX needs and requirements are acknowledged and related measures are standardized, monitored and optimized for use in specific PPX business models.
- **Level 5: The optimized level,** where PPX needs and requirements are acknowledged and related measures are standardized, monitored, optimized and integrated across the company. Optimization enables understanding causality through automated and prescriptive PPX measures, as well as the implementation of PPX in any possible and feasible market in an agile manner.

The idea for the general reference levels was based partly on Chrissis et al. (2011), while taking into consideration its limitations as process-oriented level descriptions. In the end, level 0 was removed, as level 1 is already based on the idea of there being no concrete implementation of PPX business models or relevant measures, in effect repeating what the level 0 was about. Moreover, as the descriptions were clarified, the percentages of revenue as a maturity factor were removed, as there was no proper basis for their existence or relevance in terms of PPX maturity. In the end, it was seen that if there were to be specific percentages, it would require extensive benchmarking studies or otherwise more reasoned arguments to be valid. Otherwise, these reference levels were used to describe the maturity levels in the dimensions that are introduced next.

6.2.1 Organizational governance

Organizational governance is about the collection of standards, rules and regulations that are the most critical in the optimization of life cycle benefits and risks in PPX business models.

The dimension consists of the standards, rules and regulations that define how different systems and processes throughout the PPX product life cycle are built and who takes responsibility for them. It also takes into account how data and information is governed and who owns it, ensuring quality, structure, usability, access and availability of PPX data & information.

Subdimensions:

- System governance: The collection of standards, rules and regulations that define the architectural decisions in terms of PPX processes and related tools & technologies.
- People governance: The collection of standards, rules and regulations that define the division of organizational roles and accountabilities in different stages of the PPX product life cycle.
- Data & information governance: The collection of standards, rules and regulations that define how to ensure quality, structure, usability, access and availability of data & information in respect to data ownership.

Maturity levels:

- Level 1: Requirements related to organizational governance measures in relation to PPX product life cycle are acknowledged or researched, but are not defined, concrete or executed in any way.
- Level 5: Organizational governance measures in relation to PPX product life cycle are optimized for PPX product life cycle benefits and risks. Performance is measured and monitored for compliance and development needs, ensuring prescriptive changes and agility in applying existing and new organizational governance measures in any context.

6.2.2 Strategy

Strategy is about the plan of action towards the goals that are the most critical in the optimization of life cycle benefits and risks in PPX business models.

The dimension consists of formulating the plan of action towards the PPX product life cycle goals, while aligning it to the overall company vision and available resources. It includes the overall business strategy related to assessing the markets and what brings value to both the supplier and the customer, as well as the plan of how to align the PPX strategy to the overall company vision with the available resources, without compromising or cannibalizing the existing business models.

Subdimensions:

- Business strategy: The plan of action towards implementing and developing PPX business models with respect to market demands as well as the needs of the supplier as well as the customer.

- Business strategy: The plan of action towards implementing and developing PPX business models with respect to market demands as well as the needs of the supplier as well as the customer.
- Resource allocation: The plan of action towards allocating available resources to PPX-related goals, such as product engineering and service design.

Maturity levels:

- Level 1: Requirements related to PPX strategy are acknowledged or researched, but strategy is not defined, concrete or executed in any way.
- Level 5: PPX strategy and related KPIs are optimized for PPX product life cycle benefits and risks. Performance is measured as well as monitored for compliance and development needs by management, ensuring prescriptive strategy development and agility in applying existing and new PPX strategies in any context.

6.2.3 Risk Management

Risk Management is about the processes, methods and competences needed to identify, analyses, predict and mitigate risks that are the most critical in the optimization of life cycle benefits and risks in PPX business models.

The dimension consists of the processes, methods and competences needed to identify, analyze, predict and mitigate risks that emerge throughout the PPX product life cycle processes. It includes the business risks such as overall competition and market-related risks, financing, customer acceptance, contracting and legal risks, as well operational risks related to day-to-day product life cycle processes and related systems. Moreover, risk management includes the processes, competences and methods related to cybersecurity risks, such as data leakage and security.

Subdimensions:

- Business risks: The processes, methods and competences needed to identify, analyze, predict and mitigate risks related to business risks such as overall competition and market-related risks, financing, customer acceptance, contracting and legal risks.
- Operational risks: The processes, methods and competences needed to identify, analyze, predict and mitigate risks related to day-to-day product life cycle processes and related systems.

- Cybersecurity risks: The processes, methods and competences needed to identify, analyze, predict and mitigate risks related to cybersecurity risks such as data leakage and security.

Maturity levels:

- Level 1: Requirements related to PPX risk management methods and competences are acknowledged or researched, but are not defined, concrete or executed in any way.
- Level 5: Risk management methods and competences related to PPX are optimized for PPX product life cycle benefits and risks. Performance is measured and monitored for compliance and development needs, ensuring prescriptive risk management and agility in applying existing and new risk management methods and competences in any context.

6.2.4 Competences & culture

Competences & culture is about the competences, collaboration, knowledge-sharing culture and attitudes that are the most critical in the optimization of life cycle benefits and risks in PPX business models.

The dimension consists of the most critical competences that are needed in PPX product life cycle, including value co-creation with customers, process, product and service engineering and design as well as marketing and sales. The dimension also describes the culture in terms of collaboration, sharing knowledge across the company departments as well as attitudes towards changes needed in the PPX business model implementation. Competences do not include risk management or data analytics, as they are taken into account in their own dimension.

Subdimensions:

- Competences: The most critical employee competences that are needed in the PPX product life cycle, including collaboration with customers; process, product and service engineering and design as well as marketing and sales. Competences exclude risk management and data analytics, as they are taken into account in their own dimension.
- Culture: Collaboration, company-wide knowledge-sharing culture as well as attitudes towards changes needed in the PPX product life cycle.

Maturity levels:

- Level 1: Requirements related to PPX competences are acknowledged but are not present at the organization. Collaboration and knowledge-sharing culture do not support PPX product life cycle development at all and attitudes towards changes needed in PPX product life cycle are very negative.
- Level 5: Competences are optimized for PPX product life cycle benefits and risks. Collaboration and knowledge-sharing culture enables continuous and active PPX product life cycle development across the company and attitudes towards changes needed in PPX product life cycle are very positive.

6.2.5 Product & production technology

Product & production technology is about the implementation of product and production technologies related to hardware, software, connectivity and cloud, that are the most critical in the optimization of life cycle benefits and risks in PPX business models.

The dimension consists of the implementation of technologies related to the PPX product and production machinery, such as sensors, actuators, self-storage capabilities and related software that enable monitoring, controlling and optimizing products and production processes in the PPX product life cycle. It also includes the technologies enabling connectivity to internet, communication between machines as well as the cloud-based applications, platforms and databases that enable the integration and company-wide access to data & information.

Subdimensions:

- Smart Product & Factory: The implementation of product and production-related hardware and embedded software, such as sensors, actuators, self-storage capabilities and software that enable monitoring, controlling, optimizing and automizing PPX products and production processes.
- Connectivity: The implementation of technologies that enable connectivity to the internet as well as machine-to-machine communication in PPX products and production processes.
- Cloud: The implementation of cloud-based applications, platforms and databases enabling the company-wide access to information related to PPX products and production processes.

Maturity levels:

- Level 1: Requirements related to PPX product and production technologies are potentially acknowledged or researched, but are not defined, concrete or executed in any way.
- Level 5: Individual PPX-related product and production technologies and their company-wide integration is optimized for PPX product life cycle benefits and risks. Performance is measured as well as monitored for compliance and development needs by management, ensuring prescriptive technology development and agility in applying existing and new PPX product and production technologies in any context.

6.2.6 Data Analytics

Data Analytics is about the processes, methods, competences, software tools and technologies related to accessing, processing, combining, visualizing and applying data that are the most critical in the optimization of life cycle benefits and risks in PPX business models.

The dimension consists of the different data analytics processes, methods, software tools, technologies and related competences that enable the analysis of PPX-related data in terms of accessing, processing, combining, visualizing and applying it in decision-making processes related to the optimization of the PPX product life cycle. Data analytics is specifically about the technologies utilized in data analytics, so it excludes the implementation of product and production technologies that can individually collect, store and pre-process data utilized in data analytics.

Subdimensions:

- Data access: The processes, methods, competences, tools and technologies utilized to access and collect the most critical data in the optimization of life cycle benefits and risks in PPX business models. Accessing data consists of understanding which data is required in terms of business needs, as well as collecting and validating the relevance and usability of the data for the actual analysis and usage of the data.
- Data analysis: The processes, methods, competences, tools and technologies utilized to combine and process the most critical data in the optimization of life cycle benefits and risks in PPX business models. Analyzing data consists of using different statistical methods, models and related tools and technologies to make

sense of collected data and evaluate the results and their usefulness in the next phase of utilizing data in the decision-making processes.

- Data utilization: The processes, methods, competences, tools and technologies utilized to visualize and apply the most critical data in the optimization of life cycle benefits and risks in PPX business models. Utilizing data consists of visualizing data with different software tools and technologies and using those data visualizations to aid decision-making processes.

Maturity levels:

- Level 1: Requirements related to PPX data analytics in terms of processes, methods, competences, software tools and technologies are potentially acknowledged or researched, but are not defined, concrete or executed in any way.
- Level 5: PPX-related processes, methods, competences, software tools and technologies in data analytics and are optimized for PPX product life cycle benefits and risks across the company. Performance is measured as well as monitored for compliance and development needs by management, ensuring prescriptive development and agility in applying existing and new PPX-related data analytics methods, skills, software tools and technologies in any context.

6.2.7 Product life cycle processes

Product life cycle processes is about the collection of processes related to the beginning, middle and end of life of the product life cycle that are the most critical in the optimization of life cycle benefits and risks in PPX business models.

The dimension consists of the implementation of processes related to the beginning, middle and end of life of the PPX product life cycle. These include operational processes such as product engineering and service design, manufacturing, marketing & sales, logistics, development and provision of services such as maintenance and the disassembly, redistribution and reusage of the PPX product. Moreover, the dimension includes the supporting processes that ensure functioning operational processes, including processes such as accounting, recruitment and safety measures, while management processes and involvement is included in the higher maturity levels of processes. However, the dimension does not include the implementation of processes related to developing governance, strategy, risk management or data analytics measures, as they are their own individual dimensions.

Subdimensions:

- Beginning of life processes: Processes related to the creation of the PPX product-service offering, such as product engineering, service design and manufacturing, as well as the related supportive and management processes needed.
- Middle of life processes: Processes related the usage and maintenance of the PPX product-service offering, such as marketing & sales as well as logistics and development and provision of maintenance and other services, as well as the related supportive and management processes needed.
- End of life processes: Processes related to the reutilization of the PPX product-service offering, such as disassembly and redistribution of the PPX product, as well as the related supportive and management processes needed.

Maturity levels:

- Level 1: Requirements related to PPX product life cycle processes are potentially acknowledged or researched, but are not defined, concrete or executed in any way.
- Level 5: Individual PPX-related product life cycle processes and their company-wide integration is optimized for PPX product life cycle benefits and risks. Performance is measured as well as monitored for compliance and development needs by management, ensuring prescriptive process development and agility in applying existing and new PPX life cycle processes in any possible and feasible context.

7. DISCUSSION AND CONCLUSIONS

With the rounds of focus group discussions and expert workshops, a suggestion of the maturity model for assessing the internal PPX readiness of equipment manufacturing SMEs was made. Consequently, this chapter concludes the study by discussing the relevance of the results and key findings, as well as concluding the study by answering the research questions introduced in the beginning of thesis. Furthermore, concluding remarks are made in terms of academic contributions, managerial implications and future research possibilities in relation to this study.

7.1 Discussion

This thesis started with the SNOBI project inspired question of how to implement PPX business models in B2B equipment manufacturing SMEs. More specifically, the scope of this research focused on designing and validating a maturity model for assessing the internal PPX readiness in the B2B equipment manufacturing companies, which requires understanding of both the PPX business models in its specific context as well as developing maturity models in general. In this section, the results related to these aspects of designing and validating the maturity model are discussed, in effect outlining the basis for the following conclusions. More specifically, the discussion is divided into two parts: discussing the maturity model design and validation process, as well as the maturity model itself.

7.1.1 Maturity model design and validation process

As the main goal and research question of this study was to see how to design and validate a maturity model in this case for the specific context of B2B equipment manufacturing SMEs, an Action Design Research approach developed by Sein et al. (2011) was implemented. More specifically, the process of designing the PPX maturity model started with defining the problem, followed by a literature review that included theory related to both the designing of maturity models as well as a review of the most PPX-relevant maturity models in existence. The literature review and consequent focus group development then worked as the basis for the design of the preliminary theory-based artifact, that was then validated through the expert workshops in three separate rounds. While seemingly different phases, these processes were iterative and complementary in nature, meaning that instead of being separate from each other, the design and validation process was continuous, and theory and practicalities were assessed hand in hand.

When talking about the design process of the maturity model, theory seems to provide frameworks that allow a systematic approach to maturity model design and development (see de Bruin et al., 2005; Becker et al., 2009 and Mettler, 2011). Although a common criticism related to maturity model development theory has been the vagueness of many of the existing models and their design processes (Becker et al., 2009), conducting this study while making use of for example Mettler's (2011) maturity model design framework and complementing it with the other two processes by de Bruin et al. (2005) as well as Becker et al. (2011) provided a solid groundwork for the maturity model development. Moreover, developing the design criteria and especially the actual, individualized PPX maturity definition within the model is something that could easily be omitted in other models, as there could be a temptation to simply use existing, standardized maturity level definitions such as those described by Chrissis et al. (2011), that do not always fit the intention of the maturity model in question.

Still, while theory can contribute to the systematic development of the maturity model, the fact that there are no identified maturity models developed specifically for the PPX readiness analysis in the context of internal readiness of B2B equipment manufacturing SMEs emphasizes the importance of combining theory with real life practicalities. That is, although there are many related maturity models in existence in areas such as Industry 4.0 (e.g., Schumacher et al., 2016; Lizzaralde et al., 2020), digitization (e.g., Blatz et al., 2018) and data-driven business models (e.g., Weber, et al., 2017), PPX-related maturity models and maturity model design frameworks are not necessarily enough to create a perfectly validated PPX maturity model. Consequently, although many different dimensions could, and were considered based on theory, the current, suggested model gained a lot of validation also from the "practical" side of the research, i.e., the expert workshops.

Consequently, the use of ADR process developed by Sein et al. (2011) and combining theory with practicalities in an iterative manner provided a systematic and extensive approach to creating a PPX maturity model, even with the lack of existing maturity models and theory. The suggested model is, in the scope of the thesis, still initial and can certainly benefit from more extensive rounds of validation with the help from theory and PPX experts, but even when considered initial, the research provided a basis for creating a new maturity model in a less research area. In other words, while the steps taken and described in this thesis only provide an initial PPX maturity model, the process can be used to systematically design and validate the model even further in the future.

Moreover, with respect to analyzing the results, it was also quite clear from the beginning that certain decisions had to be made throughout the whole design and validation process: since there are so many options available, certain aspects had to be knowingly emphasized in order to be able to proceed with the dimensions. In this case, the intent was to emphasize simplicity and logicality of the model, meaning the idea was to have only the most critical dimensions and related subdimensions in the model, with as simple definitions as possible. In practice, this meant the emphasis on analyzing the logic of the model especially in the maturity model expert phase, although the analysis of understandability, clarity and potential overlaps was present in the other phases as well. On the other side, the usability of the model and its dimensions was emphasized in the PPX company expert workshop, as it was considered to give an idea of how understandable and consequently usable and simple the current dimensions were.

In summary, as it was seen from the lack of PPX maturity models, this study and the ADR approach emphasized the fact that collaboration between the academic, theory-oriented world and the more practical, company-based world can be extremely beneficial in creating novel concepts such as the PPX maturity model. Still, especially the PPX company expert workshop showed that although theory can help in explaining what and how companies can assess their readiness to implement PPX business models, there is still a lot of room for more cooperation between the academic world: for example, when it came to the definitions of the dimensions, company experts clearly had their own way of seeing the business, which also led to potential confusion at times. In other words, although one of the principles of the ADR process is having the practical side along with the theory, the maturity model design and validation process here showed that there is still need for more comprehensive cooperation. Although it is certainly important to follow the aforementioned design guidelines provided by the maturity model theory to guarantee a systematic approach, it could be considered whether companies or other end-users could be more heavily involved in the development process. Of course, an iterative process such as the ADR process here can be time consuming, so it might not always be realistic to assume heavy participation by all at every stage of the process.

7.1.2 The pay-per-x maturity model

In general terms, the design and validation process for creating the maturity model in the scope of this study made one thing quite clear: although the scope of the thesis was quite narrow, the number of aspects that need to be taken into account in the model is certainly not as limited. In other words, although the focus of the maturity model was only

on the internal readiness of the companies, the literature review, focus group development and expert workshop processes all confirmed the need to have multiple dimensions in the maturity model. Although it is not really surprising that a completely new type of business model potentially requires many significant changes, the number of options is still impressive, considering the scope of the model was narrowed down quite a lot due to feasibility.

More specifically, certain aspects were emphasized in the maturity model, echoing both theory and practicality: while the PPX experts stressed out the need to understand the market and what brings value to the customer, literature also emphasize the benefits of understanding customer needs and moving towards service-based business models as a means to combat potentially saturated markets (e.g., Kindström, 2010). In that sense, although the customer readiness is not in the scope of the developed maturity model, it is quite apparent that an equipment manufacturing company wanting to implement PPX has to have at least an idea of what type of strategy to use in the market. Similarly, while experts emphasized the importance of understanding topics such as financing, legal issues and risks, Gebauer et al. (2005) warn of the service paradox, which also describes how difficult it can be for companies to actually achieve the expected returns from developing service-based business models if they are not prepared. Consequently, it seems that having proper strategies, governance and risk management measures in place really are important also when implementing PPX business models and assessing the internal readiness of doing so.

Interestingly, although many of the closely related maturity models such as those of Blatz et al. (2018) and Lizzaralde et al. (2020) have dimensions such as “data maturity” and “smart product”, the opinion of the company experts seemed to lean towards data and data analytics not being such an important dimension as it turned out to be. The suggested model and dimensions did not have many significant changes in the end as data analytics as its own dimension was supported by literature and other experts, but the point of focusing too much on data raised a good point: as each company is different, there will always be a certain trade-off when creating a maturity model for specific instances, as a very specific model might work for some, but not for all. Consequently, while it could be possible to generate a general PPX maturity model for the B2B equipment manufacturing companies, it could be that an even more specified maturity model could serve some companies better.

This complexity of different options is also reflected in the results. As there are many different aspects that can, or at least could be taken into account, it was also sometimes difficult to define what are the most “ideal” dimensions in the maturity model, even if they

were somehow backed up by literature or experts. Still, even with the multitude of options available and no similarly specific models in existence, the complexity again highlighted the importance of the systematic approach to develop the suggested maturity model. In other words, although it is difficult to assess whether the suggested maturity model really works as it should at this stage, the groundwork is already done and can be developed further according to the findings related to the future work.

All in all, it seems that the results do reflect a decent concept for assessing the internal PPX readiness of the B2B equipment manufacturing SMEs. The current dimensions are backed up by both PPX experts and literature, while no crucial dimensions are seemingly missing especially if the concept of value creation is seen as a part of all the dimensions, as raised up by the PPX company experts. Also, while there certainly were some more problematic dimensions due to potential overlaps or unclear definitions, it seems that at least most of the issues have been addressed in the suggested model and consequently also provides the premise for answering the research questions of this study, addressed in the following section.

7.2 Conclusions

This section concludes the thesis by answering the primary research question with the help of the five secondary, or supportive research questions. Moreover, the conclusions include the academic contributions and managerial implications related to the study, as well as the possible limitations as well as future research possibilities related to the topic.

7.2.1 Research questions

The primary research question of this study was:

How to design and validate a maturity model for the PPX business model readiness analysis in business-to-business equipment manufacturing SMEs?

To help answer this question, five secondary or supportive research questions were made and are now presented here with the answers.

Supportive research question 1: What are the critical success factors, benefits and challenges related to the implementation of PPX business models in B2B equipment manufacturing SMEs?

Based on literature, the most critical success factors related to the implementation of PPX business models in B2B equipment manufacturing SMES include e.g., understanding market requirements and customer needs (Kindström, 2010) as well as implementing necessary technological advancements and product innovations (Baines et al., 2017).

Moreover, looking at the relevant maturity models in literature, a successful PPX implementation can require for example a well-defined strategy, leadership commitment, positive organizational culture and necessary competences (people) and governance measures (e.g., Schumacher et al., 2016). In terms of benefits, moving towards service-based business models can help for example in fighting against saturated markets (Kindström, 2010) and lead into growing revenues (Baines et al., 2017), yet there are also potential challenges: If not implemented well, the fundamental changes in organizational structure can have a negative impact on finances and performance of the company (Zhang and Banerji, 2017), while the extensive investments needed can also offset any benefits the company might gain (Neely, 2008).

Supportive research question 2: What are the critical design criteria of this PPX maturity model for business-business equipment manufacturing SMEs?

In order to assess the design of the maturity model, design criteria were created and validated throughout the action design research process. In the end, the criteria did not change significantly, with the exceptions of some clarifications. Consequently, the critical design criteria of this PPX maturity model for business-to-business equipment manufacturing SMEs are:

1. Criticality of the dimensions
    - Do the dimensions deserve their place among the most critical (4-7) ones?
2. Representation of the context & purpose
    - Does the model and the dimensions represent its purpose and the context of PPX in B2B equipment manufacturing SMEs properly?
3. Logic of the model
    - Clear descriptions
    - Understandable
    - Orthogonality (no overlapping dimensions)
4. Dimensional maturity in the context of PPX

- Can the dimensions be described in terms of how mature they are in the optimization of life cycle benefits and risks in the PPX context, considering agility, understanding causality and understanding contextuality?

5. Usability of the model
    - How easy is the model to use for respondents?
6. Usefulness of the model
    - How useful and applicable is the analysis to the respondents?

In terms of importance, the design criteria provided a sound anchor for assessing the suitability of all individual dimensions for assessing PPX business model implementation readiness. Moreover, design criteria were important in making sure that the maturity model is not only usable, but that the model is logical and that the definition of maturity itself is related to the PPX readiness that is being assessed. Consequently, while changes in the design criteria were not significant, the mere existence of the criteria supported the systematic process of creating a novel PPX maturity model.

Supportive research question 3: What are the critical dimensions that affect the readiness of business-to-business equipment manufacturing SMEs implementing PPX business models?

In this study, 7 different dimensions were found to be the most critical. These dimensions were organizational governance, strategy, risk management, competences & culture, product & production technology, data analytics as well as product life cycle processes.

Although these 7 dimensions were seen to be the most critical throughout the design and validation process in the scope of this thesis, certain dimensions such as data analytics was questioned especially by PPX company experts, in addition to which the potentially missing dimension that describes what brings value to the customer was raised up. Consequently, although e.g., the data analytics dimension was backed up by other experts and literature and the value creation was taken into account with the limitations of focusing on internal aspects in mind, the points raised also emphasized a fair point about the status of the model: as much as it answers the question of what the critical dimensions are, there is also room for developing them further with more validation in the future. Still, as of now, these findings represent the most critical dimensions, that have been systematically derived through theory and iterative development with different experts.

Supportive research question 4: How to describe the general reference levels of maturity as well as the minimum and maximum maturity level of each critical dimension of this model?

In total, five general reference levels were created, including:

- **Level 1: The initial level,** where PPX requirements and benefits are potentially acknowledged or researched, but no concrete measures have been developed or implemented. The company is fully product-oriented, and no revenue comes from the PPX services.
- **Level 2: The experimentation level,** where PPX requirements and benefits are acknowledged, and concepts are tested. PPX-related measures are still non-standardized, and measures are based on ad-hoc decisions.
- **Level 3: The defined level,** where PPX needs and requirements are acknowledged and related measures are standardized, enabling the implementation of small-scale solutions in specific PPX business models.
- **Level 4: The advanced level,** where PPX needs and requirements are acknowledged and related measures are standardized, monitored and optimized for use in specific PPX business models.
- **Level 5: The optimized level,** where PPX needs and requirements are acknowledged and related measures are standardized, monitored, optimized and integrated across the company. Optimization enables understanding causality through automated and prescriptive PPX measures, as well as the implementation of PPX in any possible and feasible market in an agile manner.

In general, these maturity levels were seen to be quite descriptive in terms of the readiness to implement PPX business models. Still, although the levels were systematically developed with the context of PPX in mind, the same logic as the one with the dimensions applies here. That is, the levels are developed systematically, but there is still room for more validation and potential changes, if needed. For now, the levels still serve their purpose, and also provide the basis for each individual dimension and its minimum and maximum maturity level in the PPX maturity model.

Supportive research question 5: How can the model be validated step-by-step with the Action Design Research approach?

Although not separate from each other, the ADR process by Sein et al. (2011) in the context of the study can be divided into two main phases: the design of the theory-based maturity model artifact, or the preliminary maturity model that was developed with the

help of focus groups of technical and business model experts, and the consequent design and validation of the suggested model through maturity model, academic PPX and PPX company expert workshops. Throughout the process, the maturity model was evaluated against the design criteria that were developed earlier, in addition to which the design criteria itself was evaluated. In this study, one round of interviews was held.

All in all, the ADR process seems to be beneficial, as it can create a platform for filling gaps in theory with practicalities. That is, while following theory and the systematic approach of developing a new PPX maturity model with the help from maturity model design theory and the PPX-relevant maturity models, the issue of not having PPX maturity models can be backed up by having e.g., expert interviews in place. In that sense, the ADR can in the best-case scenario provide a sound, theory-based framework for developing a novel maturity model such as the PPX maturity model in this study, although it certainly can benefit from the more specific theory related to the design and validation of maturity models as well. Moreover, including experts from companies in the iterative ADR process can make the whole PPX maturity model development process more inclusive, which can lead into tighter cooperation between academics and company representatives and eventually lead into an even more useful and valid PPX maturity model.

To sum up, considering the supportive research questions and coming back to the primary research question, the answer to how to design and validate a maturity model for the PPX business model readiness analysis in business-to-business equipment manufacturing SMEs is that the design and validation process can indeed be backed up by the action design research approach. More specifically, the iterative development process can first start with the initial, theory-based maturity model and consequent development through workshops. For the rounds, design criteria can be developed, so that there is a framework that will be followed in each round of design and validation and when implemented as needed, the result of the ADR process should be a maturity model with at least an initial idea of the most critical dimensions that should be considered when assessing for example the internal PPX readiness of B2B equipment manufacturing SMEs, in this case.

7.2.2 Academic contributions

In this study, the action design research approach was used to create a novel maturity model for the specific context of internal PPX readiness in B2B equipment manufacturing SMEs. Although PPX-related maturity models exist, there are currently no maturity models created for this specific purpose, which is why the model introduced here provides a

new idea of how internal PPX maturity can be assessed in equipment manufacturing SMEs. In more specific terms, the created PPX maturity model here can provide a starting point for the manufacturing SMEs to assess their current as-is situation in terms of their readiness to implement PPX business models, recognize any bottle necks that might arise in the implementation and help in defining the future roadmap by providing a common language to the company internally.

Moreover, it is possible that the maturity model developed here provides a basis for a more general PPX maturity model as well. Although the future development of the model can require some changes, it could be argued that there is already an initial idea of what PPX readiness is about, even if the context in this study was more limited. In that sense, the maturity model does not only provide a tool to assess the PPX readiness in the specific context of the study but can contribute into describing the nature of PPX business models and the related motivations, benefits or challenges in general.

It should also be noted that thanks to the nature of the ADR process and iterative maturity model development, several different experts in the area of maturity models and PPX business models contributed to the development of the model and making sense of the dimensions. That is, in addition to the literature review and theoretical contributions, the ADR process allowed for a combination of theoretical and practical contributions, further increasing the knowledge on PPX business models and their implementation by complementing theory with practicalities and vice versa.

Lastly, speaking from a purely maturity model design perspective, the study contributed to describing the process of maturity model development through ADR, as well as combining the existing maturity model design frameworks especially by Becker et al. (2009) and Mettler (2011). Although not new on their own, the combination of the frameworks together with the creation of the ADR process can provide insight into how to design and validate a maturity model again with the help from both theory and practicalities, in a systematic and iterative manner.

7.2.3 Managerial implications

The aim and result of this study was to design and validate a maturity model for assessing the internal PPX readiness of B2B equipment manufacturing SMES. In that sense, the scope of the thesis does not go into implementing the maturity model in practice, although that is one of the deliverables in the SNOBI project for which this thesis is also written. However, even when the maturity model is not implemented within the scope of the thesis, the initial dimensions and maturity levels can provide an initial idea for partner companies in terms of understanding the most critical aspects related to the

implementation of PPX business models, in effect providing the so-called common language that can aid in the discussion and understanding of PPX readiness.

As with the academic contributions, the ADR process that combines both theory and practice-inspired research can potentially have future benefits for the companies involved: if maturity models can be created and further developed together with the help from theory, it is possible that companies involved can have a better say in the direction the maturity model goes into, helping them in the consequent development of the new PPX business models. Of course, the co-development process does not have to be limited to creating a maturity model, as the ADR process could potentially work in other co-development projects as well, paving way for more cooperation with the academic world.

7.2.4 Limitations

One of the most obvious limitation in this study is the scope that is limited to the internal PPX readiness in B2B equipment manufacturing SMEs. As emphasized especially by the PPX company experts, it is fair to assume that in reality, the readiness of the customer will have an impact on the implementation of the PPX business model. If the customer is not ready to buy the PPX service or does not understand its value, it would most likely be hard to implement any PPX business model even if the internal readiness of the company is at the highest levels of maturity.

In a way, the novelty of this study is also its limitation. As there are not any specific, internal PPX readiness analysis tools made for B2B equipment manufacturing companies, it also means that the reference models used in this study cannot be very specific, or at least it is hard to prove if they are. In other words, as there are so many different aspects that should or could be taken into account in the PPX business model implementation and its readiness, it is difficult to prove that the model suggested in this study is completely accurate, even if the process for defining the dimensions is systematic.

Furthermore, related to the accuracy of the model, it should be noted that the thesis scope only included one round of design and validation through the expert workshops, with a limited number of experts as well. Consequently, there is still room for redesigning and validating the model structure if the resources are there, and since the aim of the SNOBI project is to implement a readiness analysis tool in the form of a maturity model, it is then clear that future development phases can be done in that area.

Of course, theory and the ADR process are not the only aspects that might limit the accuracy and validity of the model. Especially since the expert rounds consisted of only a few people in total, there is always the danger of experts introducing bias into the

development of the maturity model. Considering for example the needs of the different companies, it would be understandable if the company experts would defend ideas based on their own companies' experiences, which in a way is the point. Still, too much interference might harm the validity of the maturity model, without forgetting the bias that can be introduced by academic experts as well.

7.2.5 Future research

As part of the SNOBI project, this thesis has a natural continuum: as the aim of the project is to create a comprehensive maturity model that can be used as a tool in the assessment of companies' as-is situation in terms of their internal readiness to implement PPX business models, there is already demand for developing the suggested model of this thesis further. Considering the design framework, the model is currently not even in the implementation phase, so there are potentially many different phases ahead, from implementing the model to keeping it relevant through continuous improvement, if possible.

Moreover, although this maturity model was developed in the specific context of internal PPX readiness in B2B equipment manufacturing SMEs, there is a possibility of making a generalized version of the model, that can work for example as a benchmarking tool for a broader audience interested in PPX or other closely related business models. On the other hand, given the scope of the thesis and the focus on internal readiness, the model could be developed further in its specific context as well, but just taking into account other aspects such as the now-missing customer readiness. However, it is difficult to speculate how well these modified maturity models would work, so research is certainly required in order to find out how easy it would be to apply the model into different contexts.

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