IDEA MANAGEMENT IN TECHNOLOGY DEVELOPMENT

EVALUATION CRITERIA FOR VALUE PROPOSITION, TECHNOLOGY AND STRATEGY

Thesis in Industrial Innovation Management, 30 credits

Halmstad, 2019-08-15
Markus Dunstheimer
ABSTRACT

Purpose
Idea Management as key activity in the front-end of innovation is crucial for not only targeting new products but also for new technologies. Nevertheless, the interrelations between Idea Management and Technology Development are still not fully understood. Due to the different abstraction levels of products and technologies, an in-depth investigation of evaluation criteria for Technology Development ideas is required. Therefore, the purpose of this thesis is to examine which evaluation criteria are pertinent for each phase of Idea Management, when applied for Technology Development.

Design
The research framework for Idea Management criteria in the context of Technology Development is built on data from 17 semi-structured interviews, two focus group interviews as well as participant observations. The participants of this study are experienced R&D experts from a large Swedish organization in the transport industry.

Findings
The results indicate that the evaluation of Technology Development ideas is more complex due to the high degree of uncertainty and unpredictability. In contrast to the common one-step evaluation process of New Product Development ideas, the findings suggest a three-step evaluation process for Technology Development ideas. Due to the lack of knowledge and maturity when an idea is generated, this three-step evaluation enables a continuous reduction of uncertainty. In addition to this, the result of this study contributes with the suggestion to attribute a focus dimension for each Idea Management phase, which in consequence is helping firms to direct their evaluation resources. The findings are presented in a generic evaluation framework that leads organizations through the assessment process.

Theoretical contribution
The present study contributes to the literature with an improved understanding of TD idea evaluations by suggesting a rather internally use-oriented perspective as well as advances prior research through knowledge about the right timing for the use of evaluation criteria.

Practical implications
Irrespectively of the origin or focus of an idea, evaluation criteria are helping to direct Technology Development initiatives. By having evaluation criteria, defined as pertinent for each phase of Idea Management, Technology Development ideas can be assessed appropriately regarding their contextual circumstances.

Originality
The study is among the first that differentiates Idea Management for Technology Development from the one targeting New Product Development. This study suggests a framework that considers the stages and criteria necessary in the context of Technology Development.

Keywords: technology development, idea management, evaluation criteria, innovation management
ACKNOWLEDGMENTS

The completion of this thesis would not have been possible without the support and participation of more people than I can enumerate here. Nevertheless, I truly acknowledged and appreciate their contribution.

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Lastly, I want to express my gratitude to the interviewees of this thesis, who have contributed with time and by sharing valuable knowledge.

Markus Dunstheimer
Halmstad, August 2019
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<tr>
<td>FFE</td>
<td>Fuzzy Front End</td>
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<tr>
<td>IM</td>
<td>Idea Management</td>
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<tr>
<td>NPD</td>
<td>New Product Development</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
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<td>SEL</td>
<td>Smart Engineering Laboratory</td>
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<td>TD</td>
<td>Technology Development</td>
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1. **INTRODUCTION**

In 2018 and for the sixth time in a row, balancing Research and Development (R&D) long- and short-term objective has been reported as the most significant concerns of organizations (Innovation Research Interchange, 2018). This indicates that the simultaneous pursuance of innovation initiatives for today’s- and tomorrows business is an ongoing challenge. In the field of innovation and technology management, this act of balance is often called organizational ambidexterity (March, 1991), and is described as “the ability to simultaneously pursue both incremental and discontinuous innovation” (Tushman & O’Reilly, 1996, p. 8). For achieving both, long- and short-term objectives, new technological opportunities are crucial to either improve existing products significantly or create new product offerings. By understanding this, the important role of Technology Development (TD) becomes obvious.

In recent years, there have been many studies investigating the relations in the Front-End of Innovation (Van den Ende, et al., 2015; Frishammar, et al., 2011; Reid & de Brentani, 2004). The headline of Eling and Herstatt’s (2017, p. 864) paper “Managing the Front End of Innovation—Less Fuzzy, Yet Still Not Fully Understood” describes the insufficient understanding in this field. This can be seen in relation to the major challenge of balancing R&D long- and short-term objective (Innovation Research Interchange, 2018). Already in 1995, Bower and Christensen identified the struggle of large organizations to staying ahead of the competition, when new technologies evolve or markets are changing (Bower & Christensen, 1995). Such transforming markets are bringing up the need for scrutinizing products-, processes- and technology strategies. Prior to development processes, firms need to decide whether their new product features are built on known technologies or require further TD. In consequence, a firm either identifies a matching technology for a defined problem or is trying to discover TD demands, which will support the business of tomorrow. In the context of TD, large organizations often tend to follow exploitational initiatives, due to the pressure of sustaining revenue and profit performance (O’Reilly & Binns, 2019). This often leads firms to neglect the uncertain potential of new TD ideas. Because of this Benner and Tushman (2003) claim the need for finding the right balance between the utilization of existing technologies and new TD. One way to approach this challenge is a well-structured reviewing process for TD ideas that investigates the potential of the aspired technology. This enables comparability between the TD idea and the existing technologies and in consequence can lead to a well thought out decision.

In front-end decision-making, Idea Management (IM) is a proven innovation activity that structures the processes between the idea or opportunity recognition and their transition into a formal development process (Eling & Herstatt, 2017). IM thereby focusses on the generation, evaluation, and selection of ideas (Brem & Voigt, 2007). Alexe, et al (2014, p. 144) describes IM as a formal and structured process for the “systematically gathering of business ideas”. According to Gerlach and Brem (2017), the IM process consists out of six main phases namely preparation, idea generation, -improvement, -evaluation, -implementation and -deployment. Furthermore, topics like the IM frameworks (Gerlach & Brem, 2017; Brem & Voigt, 2009; Nilsson, et al., 2002), success factors (Van den Ende, et al., 2015; Kock, et al., 2015; Heising, 2012), ideation (Gurtner & Reinhardt, 2016; Van den Ende, et al., 2015; Kelley, et al., 2013) and evaluation criteria (Magnusson, et al., 2014; Soukhoroukova, et al., 2012) have been addressed. Despite extensive research, these studies have failed to consider the different contexts, in which IM can be assessed. While most studies generalized IM as a tool that
can be used in every innovation context, others directed their research towards IM for New Product Development (NPD). Since already the Stage-Gate models for NPD and TD deviate from each other, the differences between IM and NPD and TD are deviating (Cooper, 2006). Blitzer et al. (2014) attributes this to the different abstraction levels which are required when looking at products or technologies. Caused by this, Höorman and Johannesson (2013) are stating the importance of managing TD in a more flexible way to not limit the creativity in this early stage. As a result, no comprehensive studies appear to exist that relates IM to specific industries, the development of services, capabilities or technology (Gerlach & Brem, 2017; Kock, et al., 2015; Kelley, et al., 2013; Eling & Herstatt, 2017). Therefore, this study is trying to bridge this chasm by investigating evaluation criteria in IM, applied in the rather unexplored context of TD.

Evaluation criteria as a substantial part of idea evaluations and selections have been extensively investigated in the IM literature (Soukhoroukova, et al., 2012; Magnusson, et al., 2014). The research focus was rather on how to apply evaluation criteria most efficient. While for example, Magnusson et al. (2014) investigates if idea screening should be done by intuitive or formal criteria, while Soukhoroukova et al. (2012) examined the performance of evaluation criteria organized in form of idea markets. The IM literature covers the timing of when evaluation criteria need to be applied by referring to the IM process and in specific to the idea evaluation phase. This might be reasonable for NPD ideas but is, in my opinion, questionable when adopted to a TD context. I manifest this based on the TD literature, which is stating that TD needs to be conducted differently than NPD (Högman & Johannesson, 2013; Cooper, 2006; Blitzer, et al., 2014). Cooper (2006) for example attributes evaluation initiatives to all three stages of his TD Stage-Gate process, which can be seen as a contradiction to the one-step evaluation in IM. In summary, TD is commonly seen as an enabler for NPD but not as a context, in which IM needs to be applied. The relation between evaluation criteria, IM and TD is in consequence not comprehensively understood. Hence, I argue that IM for TD requires further research to fully understand the evaluation criteria under which technological ideas can be sufficiently evaluated (see Figure 1). Furthermore, the timing of when evaluation criteria should be applied for the assessment of TD ideas is not covered by recent literature.

**Figure 1 - Thematic focus of the study**
Against this background, the aim of this master thesis is to investigate which evaluation criteria are pertinent for each phase of IM, when applied for TD. To address this, I conducted 17 semi-structured interviews, participant observations as well as two focus groups at a large multinational firm that faces a technological transformation and therefore invests heavily in TD. The findings illustrate how organizations can evaluate TD ideas by following dominant evaluation dimensions, which are pertinent for each phase of the process. Specifically, my results reveal that a one-phase evaluation process is insufficient when addressing TD. In consequence, I present a generic evaluation framework for TD ideas, that leads organizations through the assessment process by using established phases as a guideline. I found conformity within my empirical data that the generic perspective of this framework can be adjusted to most TD use cases in the investigated industry sector.

The present study makes two contributions. First, it advances the understanding of IM in the context of TD by responding to the question raised by Eling & Herstatt (2017, p. 871) concerning which factors are important for internal idea evaluation. Specifically, I show that firms recognize the need for distinguishing between evaluation criteria for NPD and TD but still struggle when defining them. In particular, this study reveals that evaluation criteria for TD can be differentiated into strategical-, technological- and value proposition criteria. Thereby the perspective of value proposition criteria is significantly deviating from the determination of value or benefits in the IM literature regarding NPD. While this perspective in NPD usually tries to determine the value for the customer or market (Martinsuo & Poskela, 2011), this study suggests to determine value by evaluating the value proposition a technology entails for the firm’s own business. This means the focus is thereby rather internally use-oriented than externally customer-centric. Second, in contrast to one-phase evaluations applied for NPD ideas, this study contributes to the IM literature with a stepwise approach following the IM phases idea generation, idea improvement, and idea evaluation. My results suggest that such sequential evaluation complies best with the uncertain and unpredictable nature of TD ideas. Furthermore, by considering previous literature (Ajamian & Koen, 2002; Cooper, 2006; Martinsuo & Poskela, 2011) this study contributes with the suggestion to attribute a focus evaluation dimension to each IM phase. This allocation of evaluation criteria to IM phases is providing knowledge about the right timing for the use of each evaluation dimensions.

1.1 BACKGROUND AND SIGNIFICANCE

For being able to understand and consider the contextual circumstance of IM, when applied in TD, the Swedish firm Scania has been chosen as the research environment. Scania is a world-leading manufacturer of trucks and buses with a market share of 16.2% in 2017 (Scania AB, 2018). The firm is known for high-quality products and services as well as for being a pioneer in pushing technological boundaries. For example, in 2017 Scania’s innovativeness led to 243 patent applications in Sweden, which is a share of 11% of all national applications (Swedish Patent and Registration Office, 2017). Scania as part of the transport industry is currently facing a transformation from a combustion engine dominated industry to an ecosystem of sustainable transport solution provider. This sophisticated challenge is caused by the diverse use cases in which trucks and buses, depending on industry and environment are used. While electric- or hybrid driven busses or trucks can be used in urban areas
the rather tough non-urban application areas mostly do not supply a charging infrastructure for electric vehicles. Because of this, Scania is forced to diversify their product portfolio based on innovative solutions and technologies. In order to supply digital tools and systems for these various use-cases and applications, Scania pursues new technology developments for short- and long-term.

On this background, Scania founded the Smart Engineering Laboratory in August of 2018. Since then, a small number of TD projects has been conducted. Based on the first experience, Scania realized the necessity to enhance their decision-making processes, before initiating new TD projects. The need for transparent and consistent evaluation criteria was identified as critical in order to guide the IM process from the preparation phase to the final decision of which project idea to implement next. Purpose of these evaluation criteria is to guide the decision-making group towards the selection of the most promising and valuable idea for a new TD. This master thesis intends to gain knowledge of which and when evaluation criteria in this Laboratory should be used. It will furthermore assist R&D managers to create a Scania own Lab onboarding process by structuring evaluation criteria along the phase’s idea generation to idea improvement and idea evaluation.

1.2 PURPOSE AND RESEARCH QUESTION
The purpose of this thesis is to investigate evaluation criteria for Idea Management in a Technology Development context. Thereby, it examines:

Which evaluation criteria are pertinent for each phase of Idea Management, when applied for Technology Development?

1.3 THESIS LAYOUT
The following parts of this thesis have the following order and content:

THEORETICAL FRAME OF REFERENCE – this chapter presents in-depth knowledge about previous research in the field of IM. This implies how IM models are structured and how idea evaluations are conducted. Furthermore, this chapter describes the characteristics of TD projects and how they deviate from projects in NPD.

METHOD – this chapter provides an understanding of how the research approach has been chosen and also justifies why the methodological choices suite this kind of research project.

EMPirical FINDINGS – this part of the study presents the collected data from various perspectives, describing how IM criteria should be used when evaluating TD ideas.

ANALYSIS & DISCUSSION – this chapter presents a framework that has been established on proven IM phases as well as evaluation perspectives, enriched with technology-specific evaluation criteria.

CONCLUSION – lastly this section summarizes the major results of the study as well as states managerial implications and proposals for future research.
2. THEORETICAL FRAME OF REFERENCE

This chapter aims to describe the frame of reference for this study with the terminology crucial to understand for this field of research. A tentative analytical framework has been built to provide a foundation for this study. The framework is created to comprehend the elements of IM when applied to a TD context. It furthermore highlights the process deviations between TD and classical NPD to be able to address IM accordingly. The representative studies of Idea Management for Technology Development are presented in Table 1. Table 1 - Representative studies of Idea Management for Technology Development

2.1 IDEA MANAGEMENT

Idea Management is a proven innovation tool for almost 150 years that originated from the manufacturing industry (Thom, 2015). Gerlach and Brem (2017, p. 145) define IM as “subprocess of innovation management” that aims to capture, examine, nurture and develop ideas within a firm (Nilsson, et al., 2002). Gerlach and Brem (2017) describe IM as “an important pillar of corporate management, positioned at the forefront of innovation management”.

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<table>
<thead>
<tr>
<th>Author(s), year, and journal</th>
<th>Type of study and sample</th>
<th>Key insights relating to idea management</th>
<th>Insights on managing technology developments</th>
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<tr>
<td>Gerlach and Brenn (2017), Int. Journal of Innovation Studies</td>
<td>Literature review</td>
<td>The research on idea management created a variety of different models focusing on different aspects of the field. This paper presents a holistic conceptual framework that has been built on the key elements of 15 idea management models and their underlying success factors from recent literature. The presented framework consists of into six main phases namely, preparation, idea generation, improvement, evaluation, implementation, and deployment, which are linked to eight groups of success factors.</td>
<td>The study presents characteristics most suitable for the idea management in NPD. Beside this, the study also outlines the limitations and deviations regarding contexts and technology and therefore can be seen as call for future research in the context of TD.</td>
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<td>Eling and Herstatt (2017), Journal of Product Innovation Management</td>
<td>Literature review</td>
<td>This paper draws the linkages between the different aspects of the front-end of innovation and thereby also on idea identification and evaluation, which can be attributed to the phases of IM. Thereby it enables an overview of the related aspects.</td>
<td>The study the FEI is conceptualizing the back end as the fundament of technology research and therefore happens even before a product innovation is recognized. Furthermore, this paper calls for a more detailed investigation if opportunity identification as such needs to be organized differently depending on whether the company conducts fundamental technology research.</td>
</tr>
<tr>
<td>Gurtner and Reinhardt (2016), Journal of Product Innovation Management</td>
<td>Comparative Performance Assessment Study</td>
<td>Ambidextrous idea generation has a significant influence on the success of NPD. However, it only affects self-referenced NPD program success, competitive-or financial success remains unaffected. In addition, customer orientation provides a significant inverted u-shape effect on ambidextrous idea generation.</td>
<td>Even though customer orientation significantly contributes to the success of NPD, balancing idea-generation for radical and incremental innovation requires more than one source for novel ideas. Emerging technologies or even technology development can be seen as the counterpart to customer orientation and thereby widen the cognitive lens of the organization’s idea generators.</td>
</tr>
<tr>
<td>Van den Ende et al. (2015), Journal of Product Innovation Management</td>
<td>Qualitative comparative study</td>
<td>Innovation management is a balancing act between the creation of a supporting context and while setting direction. This can be applied to Idea Management when considering the tension between the objective to collect/create more ideas and at the same time increase the average quality of an idea. In consequence, the first objective aims to increase the quality and novelty of an idea, the second aims to reduce the number and simultaneously increase the usefulness for the firm’s strategy.</td>
<td>The paper calls for further research regarding a process understanding from idea generation activities to implementation. Since TD is an early phase in the innovation management process it is crucial to consider the aspects of quantity and quality when gathering and evaluation technological ideas.</td>
</tr>
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<td>Kock et al. (2014), Journal of Product Innovation Management</td>
<td>Double-informant design for a cross-industry investigation of 175 medium-sized and large firms</td>
<td>Ideation strategy, process formalization, and creative encouragement are independently and significantly contributing to front-end success. Front-end success can be seen as the mediator in the relationship between the elements of ideation portfolio management and project portfolio success.</td>
<td>This contrast to most papers, this study incorporates the role of managers regarding the handling of ideas regardless of an NPD or TD context. Furthermore, the presented insights regarding an ideation strategy are creating awareness of the important role of strategy in the early phases.</td>
</tr>
<tr>
<td>Magnusson et al. (2014), Technovation</td>
<td>Mixed-method approach considering 83 ideas from 47 idea providers</td>
<td>Intuition in idea screening can be seen as an appropriate way when conducted by experts of the context in which the innovation happens. Considering this the creation of scenarios which cause a certain context to enable the direction towards either more radical or incremental ides for NPD.</td>
<td>Considering intuition as an appropriate method for idea screening for NDP. How does this change when creating the context of TD with experts who know the fuzziness of the TD process? Is intuition then even more appropriate and valuable or does it just add on the level of fuzziness?</td>
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<td>Alexe et al. (2014), Network Intelligence Studies</td>
<td>Literature study</td>
<td>Idea Management Systems as a tool for collecting, distributing, managing and evaluating ideas are proven in the field of NPD when used as a circle of continuous communication and feedback scheme. Nevertheless, their approach is rather formal by using predefined criteria for reviewing the ideas.</td>
<td>Emerging or new technologies might require different characteristics of the used criteria than the ones targeting NPD.</td>
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Kelley et al. (2013), *Journal of Product Innovation Management*  
Analysis of a sample of 298 patents  
The breakthrough of technological inventions is based on accumulated knowledge. This means learning effects need to occur before criteria’s can be set to identify the most promising ideas and technologies.  

Technological knowledge, as well as TD, are the base for the successful discovery of a high-potential innovation. A positive relationship between breakthroughs and recent technological developments, technological diversity and geographic proximity has been identified. Thereby this paper is significant since it is outlining the relation between TD and the emergence and selection of high-potential inventions.

Shoukhoroukova et al. (2012), *Journal of Product Innovation Management*  
Field study with more than 500 participants from 17 countries  
Idea Markets can be seen as a feasible and promising method when using a formal process to capture select and distribute ideas in an organization. Thereby its principle is built on the “wisdom of the crowd” and therefore depending on the believes and trust of many and their widely distributed knowledge.

Can idea markets, the “wisdom of the crowd”, be an aspired way to select the most promising technologies for the company when seeing technology as an enabler for various tools and products in different functions and departments?

Heising (2012), *International Journal of Project Management*  
Mixed-method approach considering a literature review confirmed by 10 interviews  
Ideation for NPD should not be seen as a single project management task. Even more, the earlier stages should be used to consider the perspective of a product- or project-portfolios targeting the next innovation.

Portfolio management is crucial for idea management in TD. New technologies as base for NPD require a proper technology portfolio management. Considering the portfolio perspective when evaluating TD ideas, provides the IM process with a rare dimension which is crucial for understanding technological synergies and strategical advantages.

Brem and Voigt (2009), *Technovation*  
Single case study  
While many scholars differentiating in the field of IM between ideas for radical and incremental ideas, this paper is highlighting the importance of the origin of an idea. Therefore, it introduces a theory-based conceptual framework regarding innovation impulses.

In contrast to many papers, technological knowledge and TD is seen as the origin of many NPD projects. Considering this, IM for TD is appropriate when conducting it with foresight as an enabler for future NPD. Therefore, IM in TD is a pre-requisite to achieve strategical alignment in NPD.

Nilsson et al. (2002), *International Journal of Technology Management*  
Multiple case study – investigating 3 Swedish, well known and innovative firms  
IM systems can follow different objectives by targeting a different kind of ideas. While some systems are made for realizing good ideas, others are aiming to identify wild and inspiring ideas or even have the purpose to capture knowledge in a certain area. This forces the awareness that IM systems, as well as their underlying evaluation criteria, need to be chosen by knowing the aspired outcome.

Similar than in NPD an IM system for TD requires a set focus. This can be also done by capturing knowledge, by targeting a specific end product or even by a special target group of customers.

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As the name hints, Innovation Management aims to manage the performance of innovation initiatives towards new Profit Models, Networks, Structures, Processes, Product Performance, Product Systems, Services, Channels, Brands and Customer Engagements (Keeley, et al., 2013). Table 2 provides an overview and description of these different types of innovation.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Category</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Configuration</strong></td>
<td>• Profit Model</td>
<td>• New ways of making money</td>
</tr>
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<td></td>
<td>• Network</td>
<td>• New ways of co-creation</td>
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<tr>
<td></td>
<td>• Structure</td>
<td>• New ways of aligning assets and talent</td>
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<td></td>
<td>• Process</td>
<td>• New ways and methods to do your work</td>
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<tr>
<td><strong>Offering</strong></td>
<td>• Product Performance</td>
<td>• Distinguishing new between feature and functionality</td>
</tr>
<tr>
<td></td>
<td>• Product System</td>
<td>• New ways to create complementary products and services</td>
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<tr>
<td><strong>Experience</strong></td>
<td>• Service</td>
<td>• New ways to support and amplify your offerings value</td>
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<td></td>
<td>• Channel</td>
<td>• New ways to deliver your offerings</td>
</tr>
<tr>
<td></td>
<td>• Brand</td>
<td>• New ways of representing the business/offering</td>
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<td></td>
<td>• Customer Engagement</td>
<td>• New ways to foster compelling interactions</td>
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Table 2 - Ten types of innovation according to Keeley et al. (2013)

Innovation Management as such is an ambidextrous approach targeting to create a supporting and stimulating context to fertilize, capture and mature ideas and at the same time set direction and focus by evaluating and selecting ideas (Birkinshaw & Gibson, 2004; Van den Ende, et al., 2015). Handling both, a supporting and stimulating context as well as setting direction and focus is creating a tension that properly managed and balanced will boost an organizations innovation capacity. Direction and focus are highlighting the significance of IM for the corporate management to make innovation initiatives aligned with the corporate strategy.

Idea Management, also called the idea stage or pre-development stage refers to a set of activities between the idea or opportunity recognition and her transition into a formal NPD process (Eling & Herstatt, 2017). This early phase of innovations is often attested as fuzzy because of its highly informal, knowledge-intensive, uncertain and unpredictable characteristics (Frishammar, et al., 2011). Addressing this fuzziness, IM is considered as a formal and structured process for the “collection, handling, selection and distribution” of ideas (Alexe, et al., 2014, p. 144).

### 2.1.1 Idea Management Models

This section gives a brief overview of the components of IM models. Gerlach and Brem’s (2017) generic model of the IM process, which represents a merger of 15 IM models, is the chosen model of this paper (see Figure 2). This model has been chosen since it has been published in the most recent literature review focussing IM models. The fact that the model is built on prior models from research with different
perspectives on IM validates its holistic nature. It, for example, considers the integration of market pull and technology push aspects (Brem & Voigt, 2009) or the perspectives of innovation value chains (Hansen & Birkinshaw, 2007). The model itself consists out of six main phases namely preparation, idea generation, improvement, evaluation, implementation, and deployment (Gerlach & Brem, 2017).

Figure 2 - The generic model of the idea management process (Gerlach & Brem, 2017)
2.1.2 **IDEA MANAGEMENT PHASES**

The *preparation phase* represents the first step of each IM initiative. In this phase, the key conditions for the IM initiatives, like through which communication channels ideas can be submitted, are planned. Furthermore, this phase defines the search field as well as the types of ideas requested by the IM program (Gerlach & Brem, 2017). The defined rules of the preparation phase can be seen as the first of various filters on the long way to a successful commercialization on the market (Alexe, et al., 2014). The preparation phase can also be seen as the phase where a firm plans how to generate, improve and evaluate ideas. Because of this, the preparation phase can have a strong impact on the design and selection of evaluation criteria. If the setup of this phase is strategically planned and operated, the IM can contribute long-lasting to a firm’s success. This can contribute to the earlier described direction and focus aspects and aim to reduce the numbers of ideas, increase the overall idea quality and usefulness for the organization. Gerlach and Brem (2017, p. 151) namely describe this defined field of focus as problem types, which can address for example “customer needs for technical solutions, new technologies looking for a new application or new applications of old products”. Such clear focus is important to help R&D managers with the creation of matching ideas and at the same time avoids time and other resources spent, when considering ideas which are out of scope. Van den Ende et al. (2015) conceptualizes this by distinguishing among three types of managerial activities within the preparation phase. In particular, the authors define IM as the formulation of an ideation strategy, the determination of the process formalization as well as creative encouragement. Even though the first two managerial activities are control-oriented while the last is support oriented, Van den Ende et al. (2015) highlights the importance of managing them dynamically balanced. To give these first conditions a comprehensive platform, Soukhoroukova et al. (2012) suggest the use of *Idea Markets*, an IM system which is based on the principle “wisdom of the crowd”. Such software-based platform, made for submitting, discussing, refining and evaluating ideas can incorporate such guidelines by designing the settings and input masks accordingly.

*Idea generation*, as the second phase, is the first time, where proactive actions within the field of IM are required. While the preparation phase determined the rules of the game the idea generation phase represents the first play. Ideas are crucial for each firm, independent if they centre new technologies or products since the idea itself can be seen as the initiator for the process of new development initiatives (Nilsson, et al., 2002). This phase centres the ideator, a person with an idea of how to address at least one of the ten types of innovations. Nevertheless, the ideator does not necessarily have to be an individual, it can also be a group who have been collaboratively working on the idea. Gerlach and Brem (2017) even stated that a commonly generated idea is most likely more thought through and mature. Furthermore, a group consisting out of ideators from diverse positions and with different perspectives will achieve a highly varying idea generation which in consequence will lead to a higher success rate of the IM program (Gerlach & Brem, 2017). Considering the change of the past 20 years, organizations are also generating ideas in a more open manner by either following an *inside-out* or *outside-in* strategy (O’Reilly & Binns, 2019). This means that firms are more receptive and open for external ideas (outside-in) or actively sharing and jointly working on ideas with external parties (inside-out). According to Nilsson et al. (2002, p. 501), the generation of ideas can be separated by the “identification of a need, an idea of what can be done and an idea of how something can be done”. Based on Burgelman and Sayles (2004) three enduring linkages between technology push and market pull.
aspects, Brem and Voigt (2009, p. 357) define the emergence of ideas as either technology-competence-driven, market-need-driven or corporate-interest-driven. Considering the different triggers for ideas as well as the different ideators involved in the generation process, ideas can describe new technologies, business ideas, productivity issues, safety and many more (Gerlach & Brem, 2017; Sandström & Björk, 2010). Ideas that originate from different sources often deviate in their degree of maturity, therefore the idea improvement phase is necessary to rework and clarify ideas (Nilsson, et al., 2002). Heising (2012, p. 585) states that an organization has to ensure “that efficient processes are in place to advance and develop these ideas” to a mature level. In consequence, this phase needs to investigate the root causes of an idea independent of its origin. Thereby stakeholder workshops, scenario planning or discussion groups can be used for investigating the unknown weaknesses and their counteractions (Brem & Voigt, 2009; Gerlach & Brem, 2017). In other words, this phase is a data collection phase that aims for a deeper understanding of the context, trigger, aim, advantages and disadvantages of an idea.

The evaluation phase proceeds with filtering and assessment processes to identify valuable and promising ideas. Gerlach and Brem (2017, p. 152) describe “the selection of ideas from a large pool” as a key issue for “the future success of an organization”. The selection of the right mature idea is, for example, determining the resulting costs during development or production. According to Shields and Young (1991), the production costs of a product are dependent from 75% to 90% on the efforts and definitions in the early concept phases. The importance of idea validation is also highlighted by O’Reilly & Binns (2019) who described this as the second of three distinct and necessary steps to grow a new successful business. The difficulty of evaluating an idea can be seen in the lack of background information of the ideator or examiner when describing or assessing the potentials or limitations of an idea (Nilsson, et al., 2002). For mastering an information extensive evaluation process, suitable evaluation criteria are crucial to ensure reliability. The criteria represent guiding factors that can enable transparency, comparability, and repeatability. The selection of evaluation criteria is dependent on the context of the organization and the pursued IM purpose. This is in line with Sandström and Björk’s (2010) which call for differentiation of IM models for technologies from the ones targeting business ideas.

The two remaining phases, of Gerlach & Brems (2017) generic model of the IM process, are called implementation- and deployment phase. Since these phases are going beyond the scope of this thesis, they will not be further described.

### 2.2 Technology Development

According to Ajamian and Koen (2002), the overall innovation process consists out of three sub-processes, namely fuzzy front end (FFE), new product development, and commercialization (see Figure 3). Nevertheless, NPD projects only require TD projects, when existing technologies are disregarded. Comparing the time when TD- and NPD processes are initiated, we can see that TD projects are set in action in the early phases of the FFE. In contrast, traditional Stage-Gate processes, which are designed for the development of products are starting in the final phase of the FFE and last until the closure of the NPD. Even though both processes exhibit an overlap, it still shows significantly where the focus of each process is. Ajamian and Koen (2002) overall
innovation process model shows that four out of 5 process phases of the TD Stage-Gate belong to the fuzzy front end while the traditional Stage-Gate only attributes one out of six phases to this segment.

The term fuzzy describes something that is “difficult to perceive, indistinct or vague” (Oxford University Press, 2019). In the context of the front end, this means that this “portion of the innovation process is mysterious, and this attitude often results in a lack of accountability and difficulty in determining who is responsible to manage the activities in this area” (Koen, et al., 2016, p. 46). Furthermore, this segment of the innovation process has been also described as uncertain, high-risk (Ajamian & Koen, 2002), fragile (Cooper, 2006) chaotic, unpredictable and unstructured (Koen, et al., 2016). The uncertainty is thereby usually related to the target market or the technological context of a firm (Frishammar, et al., 2011).

Blitzer et al. (2014) describe a chasm between the product-oriented and technology-oriented dimension. Thereby product-oriented describes an innovation impulse for new- or improved product offerings while technology-oriented describes activities and methods form making a certain technology usable (Blitzer, et al., 2014). Thereby both dimensions can initiate TD within organizations or industries. Nevertheless, the outcome of TD projects is more uncertain than projects targeting NPD. Traditional NPD processes are designed for projects which are well-defined and predictable, whereas TD processes are made for projects with high risks, unknown variables and great technical uncertainty (Cooper, 2006). In this context, Frishammar et al (2011) is stating two reasons why fuzzy front end projects are critical. “First, the foundation for success or failure is often established before a new concept enters the subsequent “formal” development process. Second, many firms lack proficiency in the way front-end activities are executed” (Frishammar, et al., 2011, p. 551). Another aspect that needs to be considered is the level of detailedness when specifying the contribution of a project to business success. Cooper (2006) argues that in the case of NPD processes it is required to present a full business case and a financial analysis before commitments are made. In contrasts, he describes the commercial prospects of TD projects as highly unclear when making the commitment decision. This uncertainty requires a significantly higher degree of creativity and flexibility in handling high-risk TD projects (Ajamian & Koen, 2002). In summary, TD- and NPD projects are very different and in consequence require a specific way of handling.
Technology has been defined as “the use of science-based knowledge to meet a need” (Bigwood, 2004, p. 39). Similarly, Burgelman et al. (2004) describes technology in the context of innovation and engineering design as a facilitator for knowledge, skills and other artifacts that can lead to the development of products and services. In other words, “Technology Development projects are the foundation or platform for new products and new processes” (Cooper, 2006, p. 23). Because of this, the concept of technology can be seen as the interface that connects the world of science with new products (Bigwood, 2004; Markham, et al., 2010).

Unlike product development, TD are inventions and discoveries that aim for a transformation into practical use (Burgelman, et al., 2004). These statements are highlighting the prominent role of TD for organizations. Nevertheless, projects involving TD represent only a minor percentage of all development initiatives of an organization (Cooper, 2006). TD is a special issue since its outcome is “new knowledge, new technology, a technical capability or a technological platform” (Cooper, 2006, p. 23). Because of this Ajamian and Koen (2002, p. 3) characterize TD as “new, different, and unpredictable”. In consequence of its numerical under-representation firms often struggle when managing TD projects (Gama, et al., 2017). TD contains numerous challenges for an organization as well as for the employees. Typical challenges are according to Cooper (2006) unclear commercial prospects, that the technological solution cannot be envisioned and the fear of employees to make decisions in such an uncertain context. Furthermore, the risk that a technological discovery may not occur and old structures or outdated work practices are used, have been mentioned (Ajamian & Koen, 2002). For overcoming these challenges and especially for decreasing the fear of employees to make bold decisions, appropriate evaluation criteria for TD ideas are required. If mismanaged, those criteria might lead to TD that does not meet the desired specifications, prevents creativity and flexibility for an in-depth exploration of the technological potential, can cause delays, even higher levels of uncertainty or the non-consideration of ideas (Ajamian & Koen, 2002; Cooper, 2006). Therefore, evaluation criteria in IM also require adaption to the characteristics of TD process.

THE TECHNOLOGY DEVELOPMENT PROCESS

Classical project management processes, such as Stage-Gate, created for NPD have proven their ability to shorten development cycle times and improved efficiency (Cooper, 2006). This means that classical process management approaches are made to optimize the outcome of classical development tasks. While NPD projects are considered as ordinary, projects for TD have been described as a “special class of development projects” (Cooper, 2006, p. 23). In consequence, if “traditional management techniques” are applied “to non-traditional projects, much damage is done” (p. 24). When this relation has been discovered, specialized processes, like Coopers TD Stage-Gate, have been developed to enable a process- and project management. Coopers TD Stage-Gate (see Figure 4) is the chosen process model for this study since it has been successfully established in many leading organizations (Högman & Johannesson, 2013).
The TD development Stage-Gate process consists of three stages and four gates. TD projects have to be moved from the discovery to final decision where R&D managers decide if the TD project will be developed or not. Each stage of Coopers (2006) model presents a collection of best practices that the project team needs to consider. The gates between each stage are decision points where the decision-makers judge about further funding for the project (Cooper, 2006). The aim of each stage is generally the compilation of data used for the actual development work or decision making. Since TD ideas are highly uncertain, each stage needs to reduce the uncertainty for sufficient levels. In the following, the gates and stages will be described more in-depth to advance the understanding of the process.

The initiating action for a TD idea is either technology-competence-driven, market-need-driven or corporate-interest-driven (Brem & Voigt, 2009). The idea generation for TD projects is thereby highly focused on the quality of the idea. The quality of an idea has been described as “a single dimension of merit” (Girotra, et al., 2010, p. 597), which can be seen as the best-identified opportunity in a TD context. In the field of innovation, average quality ideas do not bring significant advancement. Therefore Girotra et al. (2010) describes competitive advantage bringing ideas as extreme. In consequence, the introduction of a non-qualitative, unfeasible technological idea might cause a high risk that the technology will never meet the desired specifications or business value (Ajamian & Koen, 2002). The described first action is called as Discovery and initiates Coopers (2006) TD Stage-Gate process. This is followed by the first gate which represents a first screening of the idea. The purpose of this first screening is to determine if the idea is even worth to be followed up.

The first gate is done in a gentle and highly qualitative manner to appropriately handle such uncertain ideas (Ajamian & Koen, 2002). The evaluation criteria in this step are rather of generic nature with a rather low degree of detail like the strategic fit, -impact or -leverage as well as the likelihood of technological- and commercial success (Cooper, 2006, p. 26). When passing this first gate the TD idea is entering the first stage. This stage aims to scope the project including the generation of a project plan. This still implies the consideration of the idea fuzziness by not defining each followed process step in detail. Planning activities in the TD process are rather an act of giving the project a rough direction by describing crucial conceptual steps which need to be defined, clarified and resolved along the way. A “scheduled technology discovery” as
well as a “detailed overall project planning is therefore impractical” (Ajamian & Koen, 2002, p. 3). Furthermore, activities like preparation work, technical literature search, resource gap identification or competitive alternatives have to be carried out.

The second gate represents an evaluation of the knowledge gained in the first gate. The criteria for this gate are still rather gentle by assessing if the TD idea is sufficiently achievable to be followed by experimental tasks. Based on the decision of the second gate, the TD is pushed forward to the second stage. The second stage aims for technical clarification by conducting preliminary experiments that investigate the technical feasibility under ideal conditions in a laboratory.

The third gate aims for detailed investigations while the most previous investigations were of non-detailed nature. The third gate decides whether the TD idea is promising enough to invest resources into detailed investigations. The criteria for this gate involve the same dimensions as stated at the first gate but differentiate in the way they get applied. Evaluation criteria in this gate are more rigorous applied and contain more detailed sub-set of criteria (Cooper, 2006). In the third stage, the TD idea undergoes an in-depth exploration, considering the technological feasibility, the value for the company, significant expenditures, focus activities as well as market-, manufacturing- and impact assessments. To have guidance in this most decisive phase of the process, Cooper (2006, p. 28) defined five best practice groups which should be investigated most extensively. These groups are namely “Business Strategy Fit, Strategic Leverage, Probability of Technical Success, Probability of Commercial Success and Regards”.

The Fourth gate intends to review the gained data and knowledge with criteria designed for determining a TD ideas applicability, scope and value from a technological as well as from an organizational perspective (Cooper, 2006). This gate also called the Application Path Gate, is the final step of the TD Stage-Gate process representing the interface to follow-up new-product or process development projects. Therefore, the challenges at this gate are the simultaneous final evaluation of the idea and the technological transition into follow-up processes like NPD projects.

2.3 EVALUATION CRITERIA FOR TECHNOLOGY DEVELOPMENT

The term evaluation refers to “a systematic process by which one deliberately assesses a piece of work using preformulated external standards or criteria with the goal of judging whether a piece of work adequately meets specific criteria or expectations” (Morse, 1994, p. 98). A criteria is, according to Romero & Rehman (1989, p. 12) “a general term comprising… the attributes, objectives or goals to be considered relevant for a criteria decision-making situation”. The conglomerate definition of evaluation criteria is defined as “a benchmark, standard, or yardstick against which accomplishment, conformance, performance, and suitability of an individual, alternative, activity, product, or plan, as well as of risk-reward ratio is measured” (businessdictionary.com, 2019). In the context of IM, evaluation criteria are required for the formal screening and evaluation of an evident assumption by providing consistent knowledge (Martinsuo & Poskela, 2011). Moreover, evaluation criteria enable a transparent comparison of aspects and expectations, which are of interest in a firm’s decision making. Using criteria for the comparison of ideas are common practice in product development. Defining criteria is setting a direction to align ideas to
“eventually select the most promising” (Van den Ende, et al., 2015, p. 483). Even though the evaluation of ideas with the help of evaluation criteria is common practice, Magnusson et al. (2014) has been investigating the relationship between assessments based on intuition and the assessments with formal criteria. They conclude that intuition can be a valid evaluation method when the expertise of the assessor is proven. However, there is more than one way to assess ideas in a sustainable way, evaluation criteria are indispensable for the process of selection.

For this study, I am following the definition of businessdictionary.com (2019) by only considering evaluation criteria, which help to benchmark ideas characteristics regarding their accomplishment, conformance, performance, and suitability.
3. **METHOD**

This chapter outlines the method adopted to answer the stated research question. It specifies in detail the design, process, and transparency of the research approach to ensure the best outcome (Bryman & Bell, 2011). The method can be categorized into empirical research and a systematic literature review.

3.1 **METHODOLOGICAL CHOICES**

This study follows the methodological choices suggested by Saunders, Lewis, and Thornhill (2009) visualized in the “research onion” model, presented in Figure 5. It is illustrating the structure and underlying methodological choices of the research process. In order of an outside-in approach, every following subchapter is describing one layer of the model.

![Figure 5- Research methodology choices based on Saunders et al. (2009) “research onion” model](image)

**RESEARCH APPROACH**

The research method can be divided into two general types of approaches, deductive and inductive. The difference between deduction and induction can be found in the relation between theory and research. While an inductive approach describes the theory as the outcome of the research, a deductive approach uses theory as a guideline for the research (Bryman & Bell, 2011). Means a deductive approach can follow the research strategy of testing existing theories with hypotheses in the research case (Saunders, et al., 2009). In contrast, an inductive approach is allowing theory “to emerge direct from the data” (Fereday & Muir-Cochrane, 2006, p. 83). Even though there is no strict separation, the inductive approach can be rather associated with qualitative research while the deductive approach is closer related to quantitative research (Bryman & Bell, 2011).

The purpose of this thesis is to contribute with new knowledge to the understanding of IM in the context of TD. Because of this, an inductive approach is necessary to be able
to learn from empirical findings. Nevertheless, this paper is conducting a hybrid process of inductive and deductive analysis. The fuzziness of this research area justifies this choice. While most literature in IM targets the front-end of innovation as a whole, I argue that there is a difference between IM for NDP and TD. Because of this, the inductive approach targets the empirical investigation of IM in the context of TD while the deductive approach is used to investigate key parameters of IM in NPD of past research.

The comparison of the inductive and deductive generated data is underlining and specifying the need for differentiation in IM for NPD and TD. Thereby I am integrating data-driven codes from an inductive, bottom-up data collection, with theory-driven (deductive) arguments from the literature. This way of doing research is also called systematic combining (Dubois & Gadde, 2002) or abductive approach (Peirce, 1931). This enables to consider the firm's context and proven approaches but also reflects and scrutinizes upon them when comparing with best practices from academia. The advantage of such “spiral movement lies in its involving a great level of sensitivity to the empirical material” (Blomkvist & Hallin, 2015, p. 48).

Thus, I argue that a hybrid process of inductive and deductive elements is most suitable for interpreting the raw data of this study. Dubois and Gadde (2002) argue that by “going ‘back and forth’ from one type of research activity to another and between empirical observations and theory,” the researcher will improve his understanding in theoretical and empirical aspects. Considering that I pursue to reconsider the generic IM theory for the application in TD, my approach is in line with Dubois and Gadde’s (2002) suggestion of theory development, rather than theory generation. The focus of systematic combining is therefore to refine existing theories for a divergent context.

3.2 Research Strategy and Research Choice

Research strategies are made to describe the way how a researcher plans to answer the defined research question(s). The research strategies stated in Saunders, Lewis, and Thornhill (2009) are experiment, survey, case study, action research, grounded theory, ethnography, and archival research. Thereby each strategy can be conducted in an exploratory, descriptive and explanatory way. Means that exploratory approaches are rather investigating ongoing procedures, descriptive approaches sketch current states of persons or events and explanatory studies are focussing on “causal relationships between variables” (Saunders, et al., 2009, p. 140).

I have chosen to conduct a single case study, which is one of the most common research strategies (Yin, 2003). Case studies as such are providing unique means for the development of theories by gathering deep insights of empirical phenomena in their contexts (Dubois & Gadde, 2002). Using this insight, the purpose of this study is to investigate IM in the context of TD. In detail, this is done by: (1) investigating how criteria of IM differ between TD and NPD, and (2) identifying key criteria which enable a successful selection and evaluation of ideas for TD. This complies with Yin (2003), who describes a case study approach as suitable when exploring how or why a phenomenon happens. Furthermore, the decision for using a single-case study approach is based on Yin (2003) who stated the five principles that justify the focus on a single case: critical case, unique case, representative/typical case, revelatory case, and longitudinal case. Four out of the five principles can be fulfilled when conducting this
study. This case can be seen as unique (1) since it is a rare opportunity that a firm is opening up for external research directly after establishing a new laboratory. Thereby the research is not done in form of a consultancy work before launching the TD, nor when facing problems with the innovation process. The uniqueness of this case is that the case company is willed to learn by simultaneously running the TD and conducting the research. By giving the researcher access to the lab it is possible to investigate and identify potential improvements while continuing TD projects as usual. Furthermore, the case company is well known as a supplier for premium products, premium quality but also premium prices and thereby is having a unique market position at the upper end of the truck and bus industry (Kenny, 2004). In 2017, Scania was ranked first for patent registrations in Sweden (11% of all national patent registrations), which can be seen as an indicator for a strong innovation capability (Swedish Patent and Registration Office, 2017).

The second aspect to justify a single case-study is that the case itself is representative/typical (2) for such circumstances. In Innovation Lab Excellence, Richard Turrin (2019) states that most innovation labs fail because they do not meet the expectations of the management. Similarly, Foden and Berends (2010) describe the failure of meeting managerial expectations is often caused by the mismanagement of TD projects. To prevent such failure the contribution of this study can help firms to successfully integrate and direct TD innovation labs within large organizations. In addition, Turrin (2019) describes that the failure of innovation labs has been common since firms were aiming for innovation by launching a lab but at the same time ignored the needed integration and adjustment of processes. Because of this, I would claim that this study as a critical case (3) for Scania to not waste resources and at the same time make a profit. Furthermore, this research as a single-case study approach is revelatory (4) because it is among the first studies in the field of TD and requires a high contextual understanding. In summary, conducting a single case study is the way to make the best use of empirical data and existing theory.

This thesis aims for “valuable means of finding out what is happening; so seek new insights; to ask questions and to assess phenomena in a new light” (Robson, 2002, p. 59). Nevertheless, for understanding the history of the IM processes of the case laboratory, the explorational part of this study will be compared with a descriptive investigated of the current state.

### 3.2.1 Case Selection

To be able to answer the research question of which evaluation criteria are pertinent for each phase of IM when applied for TD, I selected my case company for several reasons. First, a broad dataset and perspectives are more likely to find, when working with a well-established large organization. This does not imply that it wouldn’t be possible in a small or medium-sized enterprise context but the number of experts to talk to would be most likely smaller than in large organizations. Secondly, the industry of the selected case company is currently transforming technologically from a traditional combustion engine-driven industry towards sustainable transport solutions using electrified vehicles (International Road Transport Union, 2018). These circumstances ensure that the firm is forced to accelerate their TD output by increasing the process efficiency of generating, evaluating and developing new technological ideas. Third, the case company was actively seeking academic support in this field of work. This pro-
active behavior shows the willingness of the organization to contribute to the study in order to achieve the best result. To ensure alignment, I have discussed the objective of this study with the case company and found a direction which creates a win-win situation for both parties. This complies with the Van de Ven (2013) who describes the importance of a both-sided engagement, from the researcher as well as the practitioners involved in this study. Fourth, by selecting Scania as the case company I am following Brem and Voigt (2009) who requested further research in the corporate front-end the by the means of an extreme case. Since Scania is known for its very high performance in product development, this study can contribute with contextual understanding.

3.2.2 CASE COMPANY

The Scania CV AB with its headquarters in Södertälje, Sweden is the focus of this thesis. Scania founded in 1891 is one of the world’s leading manufacturers of heavy-duty trucks, buses as well as industrial marine engines but also offers vehicle financing, insurance, and rental services. As a multinational corporation, Scania is employing 49,300 people in about 100 countries and belongs to the TRATON Group. The TRATON Group owned by Volkswagen covers the brands Scania, MAN and Volkswagen Caminhões e Ônibus (Scania AB, 2019).

Scania’s R&D is mainly located in Sweden and covers a headcount of about 4200 people. The Smart Engineering Lab (SEL), which will be the context of this study is located within the Product Description Development Department. Even though the Lab belongs to the line organization, it is also cross-functionally linked to the Chief Digital Office which is fostering the digital acceleration within Scania. The Product Description Development Departments aims to support the R&D processes with documentation, tools, and software to increase efficiency and to shorten development times. The SEL has been newly established in September 2018 with the focus on software development for process support. So far it has not been specified if the Lab is rather focussing on current needs, which cannot be solved by the line organization, or on the technological exploration for tomorrow’s business.

With this action research, I will examine how evaluation criteria in IM influence the direction of TD in the Smart Engineering Lab. In detail, we aim to design an onboarding process for ideas coming from within the Scania organization. The challenge here is to ensure strategical alignment, objective idea prioritization and at the same time keep the process time short and agile. When designing the idea prioritization process a combination of adjusted Scania own best practices, recommendations from academia and empirical findings will be considered.

3.3 TIME HORIZON

When planning and conducting a study the researcher needs to be aware of the circumstances under which he is investigating. One major factor that limits and, in many cases, even determinates the choice of methods is the available time. When planning the time horizon Saunders et al. (2009) suggest the differentiation between a cross-sectional- and a longitudinal-perspective. The differentiation between these methods can be seen in its lengths and the predetermined timeframe for the planned research. Cross-sectional research represents the study of a specific phenomenon in a given time and thereby can be seen as a “snapshot”. Considering the time constraints of a “snapshot”, cross-sectional research is suitable for investigating the relations and
connections between different organizational factors. In contrast, longitudinal research is looking at the development of phenomena during a longer period or even an open-ended time horizon (Saunders, et al., 2009). Van de Ven (2013) points out that the investigation of change processes over a longer period of time can be attributed to longitudinal studies.

Considering that this study investigates evaluation criteria that are pertinent for each phase of IM in the context of TD, a cross-sectional study was considered as the more suitable method. In addition, a limited amount of time confirms this decision.

3.4 DATA COLLECTION

When choosing the way of doing research, it is important to consider the different types of data on which the research is build up upon. Data gathering can be done in form of qualitative and quantitative research. When doing quantitative research, the researcher “emphasizes quantification in the collection and analysis of data” through predefined concepts to adequately measure the results (Bryman & Bell, 2011, p. 26). In contrast, qualitative collection techniques and analysis procedures are used for processing non-numerical data. Qualitative data can, for example, refer to words, pictures or video clips (Saunders, et al., 2009). The researcher is thereby not limited in deciding for one way (mono method) of collecting and analyzing data. Combinations in form of multi-method or mixed-method research are also common. Yin (2003, p. 97) even highlight the importance of multiple data sources, since the “major strength of case study data collection is the opportunity to use many different sources of evidence”.

For this thesis, the data collection of primary as well as secondary data were conducted in a qualitative manner as described in the following sections.

3.4.1 PRIMARY DATA

The methods of choice for the primary data collection have been semi-structured interviews, focus group and participant observations. While all interviews, as well as the focus group, have been conducted in April and May 2019, the observations were made in the timespan between January and May 2019. For ensuring high data quality, the interviews were done with R&D experts from the field of innovation and development as well as with high-level managers to consider various perspectives on how to evaluate technological ideas. The focus group has been used to review and refine the collected data. For being able to interpret the collected interview data, the participant observations provided the contextual understanding of the research environment. The primary data collection methods are presented in Table 3. Furthermore, Table 4 describes the three phases in which the data have been collected.

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<th>Semi-structured interviews</th>
<th>Focus group</th>
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<td>13</td>
<td>17</td>
<td>2</td>
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Table 3 - Primary data sources
3.4.1.1 SEMI-STRUCTURED INTERVIEW

According to Saunders et al. (2009), interviews are a primary tool to collect valid data in a *structured*, *semi-structured* or *unstructured* manner. When doing qualitative research, *semi-structured* and *unstructured* interviews are the most common choices to collect the data. Qualitative research is most interested in understanding the opinion and ideas of the interviewee and hence required a higher degree of freedom for the researcher (Saunders, et al., 2009). *Structured* interviews, in contrast, are more commonly used in quantitative research since they are more suitable for maximized reliability (Bryman & Bell, 2011).

Since this thesis is a qualitative study, I have conducted *semi-structured* interviews. The reason for this choice is based on the topic complexity for many interviewees. Since IM is commonly used in NPD, most interviewees would also answer from this perspective. Evaluation criteria for IM in the uncommon context of TD, therefore, require a higher degree of interview guidance from the researcher (Saunders, et al., 2009). *Structured* interviews, in contrast, are more commonly used in quantitative research since they are more suitable for maximized reliability (Bryman & Bell, 2011).

The 15 of 17 interviews have been conducted face-to-face to ensure the best possible knowledge exchange. The other two interviews were conducted via Skype due to distance. All interviews have been digitally recorded to ensure reconsideration as well as an iterative data analysis. Another reason for this was the opportunity for me to actively participate in the discussion since I did not have to make notes about every detail mentioned. Two of the interviews have been conducted in German, wherefore the data has been translated to English when doing the data analysis. The interviewees, as well as some interview details, are presented in Table 5.

### Table 4 - Description of the three phases of data collection

<table>
<thead>
<tr>
<th>Phase A</th>
<th>Phase B</th>
<th>Phase C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period</td>
<td>January – March 2019</td>
<td>April – May 2019</td>
</tr>
<tr>
<td>Purpose</td>
<td>Understanding the empirical context of technology development</td>
<td>Explore key criterions for idea management in technology development</td>
</tr>
<tr>
<td>Data collection</td>
<td>13 Introduction meetings and participant observations</td>
<td>17 semi-structured interviews</td>
</tr>
<tr>
<td>Key secondary data sources</td>
<td>Internal documents (e.g., presentation material)</td>
<td>Internal documents (e.g., process charts)</td>
</tr>
</tbody>
</table>
### Table 5 - Semi-structured interviews, conducted for empirical data collection

<table>
<thead>
<tr>
<th>Interview</th>
<th>Date</th>
<th>Title</th>
<th>Location</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respondent A</td>
<td>05-apr-2019</td>
<td>Developer</td>
<td>Scania, Södertälje</td>
<td>40 min</td>
</tr>
<tr>
<td>Respondent B</td>
<td>05-apr-2019</td>
<td>Developer</td>
<td>Scania, Södertälje</td>
<td>40 min</td>
</tr>
<tr>
<td>Respondent C</td>
<td>05-apr-2019</td>
<td>Developer</td>
<td>Scania, Södertälje</td>
<td>40 min</td>
</tr>
<tr>
<td>Respondent D</td>
<td>09-apr-2019</td>
<td>Innovation coach</td>
<td>Scania, Södertälje</td>
<td>55 min</td>
</tr>
<tr>
<td>Respondent E</td>
<td>09-apr-2019</td>
<td>Senior Business Consultant</td>
<td>Scania, Södertälje</td>
<td>78 min</td>
</tr>
<tr>
<td>Respondent F</td>
<td>10-apr-2019</td>
<td>Research Director</td>
<td>Scania, Södertälje</td>
<td>40 min</td>
</tr>
<tr>
<td>Respondent G</td>
<td>11-apr-2019</td>
<td>Head of Research and Innovation</td>
<td>TRATON, Södertälje</td>
<td>50 min</td>
</tr>
<tr>
<td>Respondent H</td>
<td>15-apr-2019</td>
<td>Manager Digital Factory</td>
<td>Scania, Södertälje</td>
<td>40 min</td>
</tr>
<tr>
<td>Respondent I</td>
<td>17-apr-2019</td>
<td>Engineering Director</td>
<td>Scania, Södertälje</td>
<td>60 min</td>
</tr>
<tr>
<td>Respondent J</td>
<td>18-apr-2019</td>
<td>Agile Coach</td>
<td>Scania, Södertälje</td>
<td>60 min</td>
</tr>
<tr>
<td>Respondent K</td>
<td>26-apr-2019</td>
<td>Strategist Foresight</td>
<td>Skype</td>
<td>65 min</td>
</tr>
<tr>
<td>Respondent L</td>
<td>26-apr-2019</td>
<td>Director Shared IT</td>
<td>Scania, Södertälje</td>
<td>40 min</td>
</tr>
<tr>
<td>Respondent M</td>
<td>30-apr-2019</td>
<td>Chief Digital IT</td>
<td>Skype</td>
<td>55 min</td>
</tr>
<tr>
<td>Respondent N</td>
<td>02-may-2019</td>
<td>Design Engineer</td>
<td>Scania, Södertälje</td>
<td>35 min</td>
</tr>
<tr>
<td>Respondent O</td>
<td>02-may-2019</td>
<td>Business Analyst</td>
<td>Scania, Södertälje</td>
<td>60 min</td>
</tr>
<tr>
<td>Respondent P</td>
<td>02-may-2019</td>
<td>Business Architect</td>
<td>Scania, Södertälje</td>
<td>35 min</td>
</tr>
<tr>
<td>Respondent Q</td>
<td>06-may-2019</td>
<td>Digital Architect</td>
<td>Scania, Södertälje</td>
<td>15 min</td>
</tr>
</tbody>
</table>

**3.4.1.2 PARTICIPANT OBSERVATION**

Observations are data collection methods, mainly used for qualitative research. Participant observations consider a rich set of data, wherefore the researcher integrates into a “group for an extended period, observing behavior, listening to what is said in conversations both between others and with the fieldworker” (Bryman & Bell, 2011, p. 444). I have chosen this data collection method because of the complexity of the case firm as well as TD as a complex field of research. The participant observations in this study enabled a rich contextual understanding, which is required when investigating common theory in a new context. This contextual knowledge made me understand the case firms challenges in the research field as well as their previous measures to deal with it. One major challenge is, for example, the decision whether the TD ideas should be evaluated with criteria for the prospective electrified vehicle market or if the evaluation should be rather generic for both todays and tomorrows business. Furthermore, by participating in meetings, discussions, and workshops I have been able to compare statements with defined work processes and employee actions. The
participant observation therefore also revealed that spoken statements and observed behavior can significantly deviate.

3.4.1.3 Focus Group

Focus group interviews are a data collecting strategy with the purposeful use of the interaction between the participants to generate data (McLafferty, 2004). In the definition of Carey (1994, p. 226) it has been described as “using a semi-structured group session, moderated by a group leader, held in an informal setting, with the purpose of collecting information on a designated topic”. Focus group interview aim for the collection of peoples experience, meanings, understandings, attitudes, opinions, knowledge, and beliefs in accordance with a certain subset of phenomenology (McLafferty, 2004). Thereby “focus groups may pay explicit attention to consumers rather than professionals, with the consumer being regarded as the expert” (McLafferty, 2004, p. 188). This means that focus groups have a high potential for rich data when conducted with people who are actively engaged in consuming or using a phenomenon. This complies with the selection of participant for this study. The participants have been engaged or aware of the TD procedures of the case firm. The purpose of conducting focus group interviews in this study is to validate initial findings. Both focus group interviews were done with four participants and took about one hour. While one focus group has been done with participants having the development perspective, the other focus group was done with senior R&D manager who worked with TD from a strategical point of view. By capturing both perspectives I have been able to validate the evaluation criteria and their time of application from a practical as well as from a conceptional perspective. One intention of these focus groups has been to review and discuss the findings regarding their match to TD. Since one challenge during the semi-structured interviews has been to keep the respondents focus on TD and not generalize NPD with TD, the focus group interview has been used to scrutinize statements and criteria from a TD perspective. In my opinion, this choice is beneficial since the data is analyzed on a latent level and therefore complex to interpret. In this sense, the focus group interviews can be seen as a control measure.

3.4.2 Secondary Data

As a supplement to primary sources, secondary data is often used for complementing the data set in order to sufficiently answer the research question. According to Saunders et al. (2009, p. 258), secondary data can be divided into three main groups, namely documentary data, survey-based data, and multiple source data. The secondary data used for this study belongs to documentary data like internal process charts, workflows, decision making templates and other documents. These documents were used to capture knowledge regarding the multiple dimensions of the current decision-making processes.

3.5 Data Analysis Method

The purpose of this thesis is to identify evaluation criteria for TD ideas, which can be used as guidance for the selection of new technologies. Therefore, I investigate which perspectives are important to consider when assessing TD ideas. The collected data is analyzed by following the thematic analysis method inspired by Braun & Clarke (2006). The thematic analysis is a method for processing qualitative data in a systematic but also accessible and theoretically flexible way (Braun & Clarke, 2006). This flexibility
is providing the researcher with theoretical freedom to identify, analyze and report patterns within the collected empirical data (Braun & Clarke, 2006). Since this study is built on qualitative data from interviews, focus groups and observations the thematic analysis is providing adjustable guidance for analyzing the collected data best. Thereby the procedure is of recursive nature by constantly moving back and forward between the data set, the coding and the analysis part (Braun & Clarke, 2006). Because of this non-linear approach, the writing, coding and analyzing of data is happening in a reoccurring and simultaneous manner. Since the data collection with 17 interviews happened in a time span of 8 weeks some coding, writings, as well as analyses, are conducted simultaneously in the described reoccurring way.

The kind of thematic analysis can be determined by a set of decisions which are required to considered and discussed by the researcher before the analysis starts. Thereby it needs to be clarified whether the researcher is “aiming for an overall or detailed analysis, are searching for latent or semantic themes, or are data- or theoretically-driven” (Braun & Clarke, 2006, p. 87). In this study, I am conducting a detailed analysis since the thematic analysis is closely linked to the research question of: which evaluation criteria are pertinent for each phase of IM when applied for TD? Furthermore, this research question can be only linked to some specific information of the data and therefore supports the choice for a detailed analysis. Even though Braun & Clarke (2006) call for a decision between an inductive or deductive analysis of the data, I decided for conducting an abductive approach (see 0). This decision is grounded in the existing relatable literature for evaluation criteria in NPD and the new set of data for evaluation criteria in TD. Doing an abductive approach enables the inductive analysis of the new data in TD and is simultaneously relating and comparing the data to the existing theory of evaluation criteria in NPD. Lastly, I chose to conduct a thematic analysis at a latent level. This is caused by the complexity of the data set, collected from participants whose answers showed influences of an NPD perspective. Means that the interpretation of this data requires a depth of analysis that goes beyond the semantic content of the data.

Following Brown & Clarke (2006), the thematic analysis is guided through six phases, namely: familiarization yourself with your data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report (see Table 6). I started into phase one, the familiarization phase, with the prior knowledge of the data, since I collected the data myself. In the following, I conducted “repeated listening” to the audio files of the interviews as well as “repeated reading” of interview and presentation notes, focus groups summaries and secondary data like workflow and process documents. For a more in-depth familiarization of the data, a partial transcription of the data has been conducted. Due to the combination of data volume and time constraints, I limited the transcription to interesting- and significant valuable statements. This complies with Braun and Clarke (2006, p. 88) who stated that “there is no one set of guidelines to follow when producing a transcript”. Phase two focusses the generation of initial codes. This means to organize your data into meaningful groups of interesting aspects (Braun & Clarke, 2006). I did this by adding tags to the transcribed statements, describing my interpretations and links to the IM and TD literature. By doing so, I have been able to group different data across their sources. Initial codes within this study have been for example idea screening, long-term criteria, and short-term criteria. With these codes, I tried to differentiate criteria for the clarity of an idea from the ones investigating the time when an idea will have an impact on a firm’s business. This initial reorganization of codes can be attributed to phase three, which happens when all data have been coded and collated. Braun and Clarke (2006)
describe the purpose of this phase with re-focussing the analysis at a broader level to be able to see emerging themes across the codes. However, not all codes, generated in phase two, can be set in relation to a theme or sub-theme. Following the suggestion of Braun and Clarke (2006), I conducted this work by visualizing codes, themes and their relation on a whiteboard. This way of flexible organizing the initial codes into themes helped me to recognize emerging patterns or so far non-relatable data. The outcome of this visual analysis was a list of recognized themes and sub-themes which I analyzed more in-depth in phase four.

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

Table 6 - Phases of the thematic analysis (adopted from Braun & Clarke (2006))

Phase four can be summarized as the phase of iteration and reconsideration around the in-phase three identified themes. The themes identified are value proposition criteria, technological criteria, and strategical criteria. Even if done properly, phase four scrutinizes the identified themes or subthemes in a two-step approach. Aim of this is to sort out whether an initial theme is matching, needs refinement, collapses with other codes or themes. Step one at this phase is to review if the identified theme fully complies to the collected group of codes. Recognized deviations can cause a rework of the theme, refine the coding or the creation of new themes. To proceed to step two in this phase, it is required to be confident and satisfied that the identified themes adequately represent the coded data. The second step of analysis in this phase is scrutinizing the themes in the context of the other themes. This means the analysis focusses on the relation of a theme to the entire data set. Furthermore, this step includes the consideration if data that has not been coded or attributed yet can be set in relation to the theme. In other words, it is a process of selective screening whether some data have been missed to consider. I have conducted this fourth phase by iterating between my initial codes, themes and research question, whereby I realized that some codes and themes were vaguely defined or not clear attributable. This two-step approach helped me to reach a higher level of understanding for the patterns and relations of my data and in consequence refined and streamlined my codes and themes into a coherent thematic map. After being satisfied with the fit of my themes I moved in phase five, which is focusing on defining and naming the themes. Braun and Clarke (2006, p. 92) described this as the way for “identifying the essence of what each theme is about […] and determining what aspect of the data each theme captures.” When doing this I tried to find the right balance of staying close to the data and generalizing the data. By doing so I aim to help the reader to understand the data in the context of the case firm as well as describe it in general terms for IM and TD. The sixth and last phase of Braun and Clarke (2006) guideline for a thematic analysis is the phase of producing the report.
The complexity of this phase is to convince the reader that the previously described thematic analysis created a reliable and valid result. This is also why it was important for me to stay close to the data. In my opinion, this demonstrates best, that my results are not too much aggregated and therefore transparent and plausible. (Braun & Clarke, 2006)

3.6 TRUSTWORTHINESS

When conducting a qualitative study, it is the responsibility of the researcher to make sure, that the research design is planned and executed in a high-quality manner to answer the research question in a reliable way. Furthermore, it demonstrates the researcher’s awareness of its responsibility (Shenton, 2004). With this chapter I would like to demonstrate, that trustworthiness has been a crucial element throughout my entire thesis work for me. Because of this, the following chapter is structured with accordance to Bryman and Bell (2011), which are stating the importance of trustworthiness, as an interplay between equivalent criteria: credibility, transferability, dependability, and conformability.

3.6.1 CREDIBILITY

According to Bryman and Bell (2011), the credibility of findings is linked to a research process of good practice and by submitting the findings for verification and confirmation to an expert of the field. This helps to prevent the misunderstandings of data and results (Saunders, et al., 2009). For ensuring credibility in my work I have been in frequent contact with my supervisor, who helped me throughout the process. Thereby we discussed the work process, as well as the how to approach the subject and academical procedures. In a few short sessions with my examiner as well as with my supervisor I got valuable feedback about my flaws or weaknesses of my manuscript. This provided me a new perspective that I have not considered before.

In addition to a frequent exchange with my university, I have been working closely with the case firm. By being present at the case firm’s facility I have been able to understand early the practical context in which the research will occur. Therefore, I participated in several meetings and presentations. This complies with Shentons (2004, p. 65) call for “the development of an early familiarity with the culture of [the] participating organizations.” For establishing a relationship of trust, I have been in contact with many of the interviewees even before the data collection happened (Shenton, 2004). This helped me to get honest and reliable answers, even to complex topics. Another way to support the honesty of interviewees is to give them the freedom to refuse to answer a question, which they do not feel comfortable with. Furthermore, the possibility of answering anonymous was beneficial.

Another strategy that increases the credibility of the findings is triangulation (Shenton, 2004). The idea of triangulation is to use multiple methods “in order to improve our confidence in the findings” (Bryman & Bell, 2011, p. 140). In my familiarization with the case firm as well as during my data collection I have chosen the interviewees and other secondary data sources that can describe the same aspects from different points of view. By doing so I have been able to compare statements and understand their meaning in the correct context.
3.6.2 Transferability

According to Bryman and Bell (2011), qualitative research focusses on studying a small group of individuals. In contrast, transferability deals with the question if the findings of a study can also be applied to other situations (Shenton, 2004). Since this thesis is a single case study, I collected a rich amount of data for enabling the reader of this study to determine whether these findings are transferable to his or her contexts. By doing so, I am following the request of Lincoln & Gauba (1985) who requested sufficient contextual information.

3.6.3 Dependability

Dependability refers to the possibility of repeating the conducted research in the same context and same methodical choices. The researcher grants dependability if he provides detailed information about all methodical choices as well as about contextual information. Shenton (2004, p. 71) described this by stating that “the processes within the study should be reported in detail, thereby enabling a future researcher to repeat the work, if not necessarily to gain the same results”. To ensure dependability, this study documents all decisions made as well as provides a rich contextual base of data. Especially the data collection provides dependability since all interviews have been digitally recorded and therefore enable reconsideration.

3.6.4 Confirmability

“The concept of confirmability is the qualitative investigator’s comparable concern to objectivity” (Shenton, 2004, p. 72). This means that the findings of a study should be based on the experiences and ideas of the informants and not related to the wishes and preferences of the researcher (Shenton, 2004). Bryman and Bell (2011) describe it as the responsibility of a researcher to demonstrate that he or she have acted in good faith. In this study, I tried to work as objective as possible. As mentioned, the recorded interviews enabled a word-by-word transcription of the important statements and therefore are absolutely objective. Furthermore, the two focus groups conducted in this study have been used to validate my initial findings and interpretations. This validation showed that the data I collected was understood and interpreted in the right way.

3.6.5 Scope of Access

Saunders et al. (2009) describes physical access to a group or organization as one of the difficulties a researcher is facing. In this study, I did not face this difficulty since the research topic was partly initiated by the case firm. This means that the organization itself had an interest in sharing the data to enable high qualitative results of the study. The scope of access thereby contained secondary data like documentation about workflows as well as dedicated time for interviews, introduction meetings and other initiatives providing contextual information.
4. EMPIRICAL FINDINGS

This chapter presents the empirical data that has been collected in this study. The data has been sourced via participant observations, semi-structured interviews, a focus group as well as through document readings. The analysis identified the evaluation criteria named value proposition criteria, technological criteria and strategical criteria as main themes for the assessment of TD ideas. The findings are presented in the following sections and have been visualized in Figure 6.

4.1 VALUE PROPOSITION CRITERIA

The data analysis reveals that the case firm applies value proposition criteria for the evaluation of the desirability and expectable benefits of an idea for TD. Value Proposition Criteria refer to a set of principles intended to determine the alignment of new TD ideas against the acknowledged value of a firm. The respondents pointed out that value proposition criteria are used by the firm to lower the degree of uncertainty of ideas regarding their estimated value. By doing so, value proposition criteria help to consider appropriate data for creating a base of knowledge that helps a firm to make the right choices for gaining a technological competitive advantage. When choosing or applying value proposition criteria incorrect, the outcome of TD evaluations will cause misperceptions and in consequence, lead firms to implement the wrong TD idea. Wrong TD ideas in this context are ideas that do not significantly contribute to a firm’s technological transformation towards at least one of the described 10 types of innovations (see Table 2). Especially the categories profit model, process and product performance are important aspects for the value proposition assessment. In this analysis, the magnitudes for value proposition criteria were identified: value-in-use and value-in-exchange.

The value-in-use perspective applies to the evaluation of value propositions, which emerge out of internal processes and the consumption of own resources. According to many respondents, a value proposition assessment of a TD idea requires the consideration of opportunities as well as aspects that can impact the value proposition negatively. The following first-order concepts describe such situations: idea descriptions based on customer problems and customer behavior, risk identification for technological idea failure and hypothesis-driven idea evaluations.

Idea descriptions based on customer problems and customer behavior refers to the way of handling the idea evaluation in a rather observational- than in an inquiring way. This means that value proposition criteria for TD should assess how an idea addresses a self-identified customer problem or contributes to more efficient customer behavior. The focus of these criteria is to assess whether an idea rather follows a self-identified opportunity or the articulated wish of a customer. This can take the form of customer discussions about process inefficiencies to jointly elaborate its root cause. Additionally, observations of emerging patterns in workflows can expose TD opportunities worth trying. For example, Respondent L described the circumstances under which value evaluations are most valid:

We create the most value by “go and see” in several places and by listening to existing problems. Furthermore, it has been most promising to get to someone when we think he could have a problem. (Respondent L, Director Shared IT)
<table>
<thead>
<tr>
<th>First-order concepts</th>
<th>Second-order concepts</th>
<th>Evaluation dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea description based on customer problems and customer behaviour</td>
<td>Value-in-use</td>
<td>Value proposition criteria</td>
</tr>
<tr>
<td>Risk identification for technological idea failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD requires a hypothesis driven idea evaluation</td>
<td>Value-in-exchange</td>
<td></td>
</tr>
<tr>
<td><strong>TD evaluations requires a high abstraction thinking beyond one-dimensional use cases</strong></td>
<td>Technological novelty</td>
<td></td>
</tr>
<tr>
<td>TD evaluations should focus on a &quot;use oriented&quot; value determination perspective</td>
<td>Technological viability</td>
<td></td>
</tr>
<tr>
<td>Differentiation if the TD solves a new problem or a known one in a better way</td>
<td>Business strategy fit</td>
<td></td>
</tr>
<tr>
<td>TD is a driver for disrupting or incrementally improving products and processes</td>
<td>Strategic leverage</td>
<td></td>
</tr>
<tr>
<td>Investigating the synergies and proximity to industrial trends</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technological evaluations decrease the expectations while increasing detailed knowledge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal goal is to visualize a future scenario in form of a prototype or MVP</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IM require a strategic direction to enable context driven evaluations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investing the proximity of an idea to the core business and related projects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investigating the alignment of an idea with the current business model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Having the believe that a Technology will grow into a solution of impact</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determining the synergies of an idea within the organization</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Risk identification for technological idea failure** refers to the evaluation of actions or circumstances, which can cause the failure of TD ideas. From a value-in-use perspective, this means that the risks emerge out of the used processes or resources. The respondents stated that value proposition criteria in this perspective evaluate the identified internal rooted risks regarding their severity, occurrence, and detectability. For example, Respondent K described risks for the idea as well as the idea as the risk itself:

> We need to consider risks at any time; this can, for example, mean to evaluate if an idea is already patented or if the idea itself is a risk for marketing issues. (Respondent K, Strategist Foresight)

**Hypothesis-driven idea evaluation** refers to a way of defining and applying value proposition criteria. According to the respondents, the value of a TD idea is hard to predict and highly uncertain. Because of this, it has been stated that evaluation criteria for a value perspective should be directed towards hypothesizes. For example, Respondent F explained why it is inevitable to follow such a hypothesis-driven idea evaluation:

> You need to follow a hypothesis of where you want to go – but you also don’t know if you will ever reach it. (Respondent F, Research Director)

The **value-in-exchange** perspective evaluates value propositions by juxtaposing the estimated benefits against the resource sacrifices which are necessary to realize an idea. For example, the respondents described TD evaluations as challenging, when the realization of the idea requires an upfront investment but the applicational details are still unclear. In such cases, it is hard to identify people who are capable of dealing with uncertainty by carefully weighing the potential benefits against the potential risks without being too optimistic or pessimistic. The respondents indicated that, if mismanaged, value proposition criteria with a high application focus can cause an unsatisfactory utilization of a TD ideas potential. The following characteristics such situations: **TD evaluations require a high abstraction thinking beyond one-dimensional use cases** and **TD evaluations should focus on a “use oriented” value determination perspective**.

**TD evaluations require high abstraction thinking beyond one-dimensional use cases.** This refers to the habit of employees to get bogged down in applicational details with considering the context or dimension of an idea. The respondents described such TD evaluation as one-dimensional and not expedient. In contrast, the purpose of TD has been attributed to an improved technical skill set of a firm that in consequence will support the creation of new- or better products and processes. For example, a Strategist Foresight described the required profile of an employee for TD evaluations:

> When evaluating technologies, I need people who are capable to think on a high abstraction level and will not automatically get bogged down in a product perspective. In my experience, it is hard to identify these minds within a firm. (Respondent K, Strategist Foresight)
TD evaluations should focus on a “use oriented” value determination perspective. This refers to the design of the evaluation criteria, which should support the employee to focus on the use of an aspired technology. The respondents indicated that most employees are used to the assessment of NPD ideas, which have been described as highly detail-oriented. In contrast, it has been stated that value proposition criteria for TD require a design that is rather use oriented. This deviation has been described with the opportunity to apply a certain technology in multiple use cases which can differ when looking into the details. For example, as an Agile Coach described the differentiation of these perspectives:

If we have an idea that is good for the customer, then it is also good for us as the supplier. This can be on a technology level, on which we don’t see the real customer function. But we have some kind of technology that we believe will grow into a solution that will have a good impact on the customer (Respondent J, Agile Coach).

4.2 Technological Criteria

The data analysis indicates that the majority of the interviewees rely on a set of criteria to evaluate TD ideas from a technological point of view. Technological Criteria refer to a set of principles intended to determine the technological novelty and viability of an TD idea. The respondents pointed out that technological criteria are used to selectively collect and evaluate data about aspired technology. Technological criteria, if applied correctly, enable firms to gain knowledge about the technological opportunities of an idea, exhibits challenges of the TD process as well as indicates potentials for an idea refinement. This knowledge is the base of the technological evaluation, which supports a firm to scrutinize, rate and prioritize ideas in TD. In this analysis, the magnitudes for technological criteria were identified as: technological novelty and technological viability.

**Technological novelty** can be seen from an industrial, corporate or use case perspective. According to many respondents, technological novelty is a key aspect for TD evaluation criteria. Considering the various perspectives of technological novelty, the following first-order concepts have been described: differentiation if the TD solves a new problem or a known one in a better way, TD is a driver for disrupting or incrementally improving products and processes, and investigating the synergies and proximity to industrial trends.

**Differentiation if the TD solves a new problem or a known one in a better way.** This refers to the purpose of a TD idea. The evaluation of the technological novelty distinguishes whether an idea aims for solving a newly recognized problem or for solving an already addressed problem in a better way. According to the collected statements of the respondents, this differentiation is crucial when evaluating a TD idea. Especially for the evaluation of the technological advantage have been set in relation to criteria like cost advantage, increased customer benefits, and increased efficiency. This has been specifically described by Respondent K:

When evaluating technologies, it is essential to investigate if the aspired technology solves a new problem or an existing one. Thereby the evaluation
should focus on the advantages in cost, customer benefit and efficiency that the novel technology brings along. (Respondent K, Strategist Foresight)

**TD is a driver for disrupting or incrementally improving products.** This refers to a mindset change of the employees in development departments. For example, with regard to the novelty of the technology, the respondents highlighted the potential of TD to inspire developers and business architects to enhance procedures and processes. Evaluation criteria for the novelty of a technology consider to which degree a TD idea could contribute to the incremental improvement of existing solutions or even disrupt known product offerings or processes. This has been especially emphasized by respondent B, who described one purpose of TD as following:

The R&D has been working so many years in the same way. A good example, therefore, is the use of Excel sheets. By not changing the way of working, this would mean that an aspired improvement would lead to a better excel sheet. The purpose of all digitalization is to get fresh insights, to see what is out there and afterwards bring it to the organization. TD can be seen as a challenger for the existing products and processes. (Respondent B, Developer)

**Investigating the synergies and proximity to industrial trends.** This refers to the perspective of changing markets or industries. According to many respondents, the technological analysis of a TD idea should contain criteria which are assessing an idea’s proximity to the dynamics of the market or industry. The focus of these criteria is to investigate if a TD idea is in line with current trends and if the aspired technology can gain positive synergy effects to the product portfolio or other technology- or business-related offerings. For example, respondent Q linked the proximity to industry trends in relation to the ability of a firm to react to emerging problems:

If we do not know which new technologies are around the corner, we will not be able to answer a question when a new problem arises. (Respondent Q, Digital Officer)

**Technological viability** refers to the evaluation of a TD idea’s complexity as well as uncertainty. According to the respondents, the assessment of a TD idea should include criteria that investigate to which degree an idea can lower the technological uncertainty for a firm. In addition, it has been stated that criteria for the technological viability should determine if the capabilities and the corporate set up of a firm are sufficient to at least visualize the idea in form of a prototype or minimum viable product (MVP). Based on this, the following first-order concepts are: technological evaluations decrease expectations while increasing detailed knowledge and the minimal goal is to visualize a future scenario in the form of a prototype or MVP.

Technological evaluations decrease expectations while increasing detailed knowledge. This refers to a high level of uncertainty in TD ideas. In this context, the respondents described the relationship between a high level of technological uncertainty and the high expectations of the employees. Because of this, it has been mentioned that evaluation criteria for the technological viability should describe to
which degree the uncertainty can be reduced. In other words, to which degree the expectations of employees and other stakeholders can be transformed into technological knowledge. For example, respondent K described this situation as following:

We need to investigate the complexity of the technological feasibility to be able to simultaneously lower the expectations towards an idea and increase the level of detail. (Respondent K, Strategist Foresight)

The minimal goal is to visualize a future scenario in form of a prototype or minimum viable product. This statement refers to the common opinion of the respondents that TD projects have to have minimum deliverables. According to the respondents, the minimum deliverables of TD projects are the visualization of a technological idea in form of a prototype or minimum viable product. Evaluation criteria for the technological viability, therefore, have to determine if the idea, as well as the corporate circumstances, enable the creation of such idea visualization. Respondent P describes this as following:

The minimal goal is to visualize a future scenario in form of a prototype or MVP. When visualizing a goal, you can believe that you can achieve it and then set the steps backward to define measures that are required for the achievement. (Respondent P, Business Architect)

4.3 STRATEGICAL CRITERIA

The data analysis reveals that the respondents highlighted the importance of applying strategical criteria for the evaluation of TD ideas. Strategical Criteria refer to a set of principles intended to simultaneously determine the conformance of an TD idea to the current strategy of a firm and the strategic leverage an idea bears. Strategical criteria are used to determinate, to which degree an idea complies with the strategical direction of a firm. If applied correctly, strategical criteria help firms to select and prioritize TD ideas that either fit best to the current business strategy or have the potential to pave the way for the business of tomorrow. Incorrect applied strategical criteria can cause the development of a set of inconsistent technologies and in consequence the waste of resources and potential competitive advantages. In this analysis, the magnitudes for strategical criteria were identified: business strategy fit and strategic leverage.

Business strategy fit refers to the alignment of an idea to the current strategy of a firm. For example, the respondents described situations of unclear defined innovation strategies, which do not point in an unequivocal manner the direction of focus initiatives. In such cases, it is hard to evaluate if an idea for TD is aligned with the strategy. The respondents indicated that well-defined evaluation criteria for a business strategy fit are inevitable prerequisites for a sustainable selection and prioritization of TD ideas. The following first-order concepts describe important aspects for the design of criteria regarding a business strategy fit: IM requires a strategic direction to enable context driven evaluations, investing the proximity of an idea to the core business and related projects and investigating the alignment of an idea with the current business model.
**IM requires a strategic direction to enable context driven evaluations.** This refers to the ability to attribute each TD idea to the strategical initiative of a firm. For reaching a business strategy fit, the respondents stated the importance of making clear to which strategical initiative an idea contributes. By knowing this, the employees working with the TD idea have a clearly defined context that refines the criteria for a business strategy fit evaluation. For example, respondent K described this aspect as following:

Idea Management [for TD] should be open for each and every idea. Nevertheless, firms need to define strategic focus areas which foster context-driven TD ideas. (Respondent K, Strategist Foresight)

**Investing the proximity of an idea to the core business and related projects.** This relates to the potential of a TD idea to contribute to the current core business of a firm. The evaluation of the proximity between the idea and the core business defines to which degree an idea is in line with the operational direction of a firm. Strategic business fit criteria are important to determine if and when an idea will contribute to the corporate success of a firm. Understanding this is helping firms to decide whether a TD idea that contributes to the competitive advantage, in the long or short term, should be prioritized. For example, the evaluation of the proximity between the TD idea and the innovation strategy has been described by respondent D as following:

We have been struggling with it when it comes to more radical ideas/projects. But we have the right evaluation criteria that are able to adopt the maturity of the idea or how close is it to our core business or how is it related to other projects. (Respondent D, Innovation Coach)

**Investigating the alignment of an idea with the current business model.** This relates to the alignment and potential of an idea to contribute to the existing business model. This also means to which degree a refinement of the current business model is required to be able to utilize the potential of a newly developed technology. According to the respondents, business strategy fit criteria concerning the business model of a firm need to determine if a TD idea, independent if explorational or exploitational, can contribute to the current business model of a firm. Ideas with a high degree of novelty that do not comply with the current way of making business require a different evaluation and handling than ideas aligned. This aspect, for example, has been described by respondent D, who pictured such a situation as following:

It is necessary to develop a process that at the same time can handle exploration & exploitation [ideas]. When considering new business models as the future of Scania we do not have a process that is fit for the future. (Respondent D, Innovation Coach)

**Strategic leverage** refers to the potential of an idea to pave the way for future success based on a strategical advantage. In other words, it describes the potential and contribution of an idea for a strategic leap. For example, the respondents described the scenario of the transforming transport industry and how an idea could internally
contribute to obtaining a competitive advantage in future markets. The respondents indicated the high complexity of defining evaluation criteria for strategic leverage, caused by a high technological as well as market uncertainty. Nevertheless, they pointed out that evaluating TD ideas regarding the predicted technological and market conditions are better than neglecting these evaluation criteria. This has been explained with the fact that most technologies are still adaptable enough to be applied in divergent use cases. Accordingly, the following first-order concepts describe characteristics of evaluation criteria for an idea assessment regarding strategic leverage: having the belief that a technology will grow into a solution of impact and determining the synergies of an idea within the organization.

**Having the belief that a technology will grow into a solution of impact.** This refers to the intuition of the assessor if a TD idea will have an impact on the future business of a firm. Thereby the respondents stated that this category of evaluation criteria does not determine the potential of having an impact. The potential is rather a prerequisite wherefore the criteria investigates the personal belief of the assessor. For the application of these criteria, it has been stated, that the managers who are conducting the evaluation need to have a high degree of technological- as well as market knowledge. For example, respondent J described this aspect as following:

> If we have an idea on a technological level, on which we do not see the real customer function yet. We have to have the belief that the technology will grow into a solution of good impact. (Respondent J, Agile Coach).

**Determining the synergies of an idea within the organization.** This refers to the holistic business leap, which a TD idea should entail. In other words, these evaluation criteria should investigate how a TD idea can gains advantages and synergies across departments, divisions or disciplines within a firm. The respondents stated that strategical leverage build on cross-functional synergies is having a higher success rate than TD ideas beneficial for only one part of an organization. Therefore, TD departments can be seen as a function for intra-organizational development. This has been described by respondent L as following:

It has been most promising for us to go to someone when we think the person/department could have a problem. In consequence, we created the most value by “go and see” at several places for listening to the existing problems. (Respondent L, Director Shared IT).
4.4 FRAMEWORK

Following the empirical findings and the reviewed literature, I have created a new conceptual framework, addressing the research question: which evaluation criteria are pertinent for each phase of Idea Management, when applied for Technology Development? This framework, called the generic evaluation framework for TD ideas, is presented in Figure 7.

![Diagram of the generic evaluation framework for TD ideas, considering the phases, evaluation dimensions and focus areas (dark)](image)

**Figure 7 - The generic evaluation framework for Technology Development ideas, considering the phases, evaluation dimensions and focus areas (dark)**

4.4.1 FRAMEWORK DESIGN

The generic evaluation framework for TD ideas consists out of the IM phases idea generation, idea improvement, and idea evaluation, as well as the evaluation dimensions, value proposition criteria, technological criteria, and strategical criteria. The IM phases are based on the frame of references and represent a well-known structure of the IM literature. Idea generation, idea improvement, and idea evaluation have been chosen for this analytical framework since these stages contain crucial IM decisions, which are specifically relevant for the idea evaluation process. While the idea evaluation phase represents the main stage of evaluation, where in-depth knowledge is required, the idea generation and improvement phases can be seen as pre-evaluation especially when assessing TD ideas. While the IM phases, used in this framework, can be seen as a process starting from idea generation to idea evaluation, the evaluation criteria stem from the empirical findings of this study and have been attributed cross-functionally. By having such matrix structure evaluation dimensions are connected to all three considered phases of the IM process. This means that all evaluation dimensions, and therefore all evaluation criteria, are considerable for each step of the process. Each group of evaluation criteria has been described with an abbreviation of two characters. Thereby the first character is representing the allocated IM phase (e.g. G – generation...
phase) while the second character describes the evaluation dimension (e.g. V – value proposition criteria). Together, abbreviations like G_V (value proposition criteria for the idea generation phase) indicates the relation between the affected evaluation dimension and IM phase.

This study revealed, that in each IM phase one evaluation dimension can be seen as decisive and therefore requires increased attention. These dimensions have been described as a focus- or dominant evaluation dimensions throughout this study. This is caused by the unequal level of uncertainty but especially the different level of knowledge in each phase. The dominant evaluation dimensions for each IM phase have been marked dark in the presented framework.

The presented generic evaluation framework for TD ideas visualizes the answer the research question: Which evaluation criteria are pertinent for each stage of Idea Management, when applied for Technology Development? The framework shows, that all evaluation criteria are considerable for each stage of the IM process. This means that in each phase all evaluation criteria can be applied. Nevertheless, not all criteria can be assessed sufficiently due to the limited amount of knowledge and data. Because of this, the framework highlights dominant evaluation dimensions (dark), which exhibit characteristics most suitable for an assessment. Means, that a dominant evaluation dimension provides most knowledge and data for the assessment of a certain IM phase. Therefore, the framework reveals which evaluation criteria are pertinent for each phase of IM.

The field of IM is large and considering the different contexts, under which evaluation criteria can be applied, also diverse. Thus, an analytical framework was required that visualizes the relations and focus dimensions in a TD context. Thereby, neither a one-dimensional process- nor a disciplinary perspective would fulfill the requirements to answer the stated research question. The presented matrix structure appears as most suitable, since it does not exclude evaluation criteria for each phase but still highlights the most important criteria to consider. Furthermore, this way of visualizing the findings underlines why an abductive approach was chosen. The framework shows the development and adaption of given theory by examining them with new empirical data. Considering this, the parameters of the framework are chosen to challenge existing theory through empirical data of a new context.

In sum, the IM phases and the evaluation dimensions, visualized in the presented holistic matrix structure, enable the allocation of evaluation criteria pertinent for each phase of IM.

### 4.4.2 Application of Evaluation Criteria

The generic evaluation framework for Technology Development ideas can be seen as a tool that enables firms to systematically structure the criteria used for analysing and assessing TD ideas. Thereby it is crucial to understand that not all criteria are suitable for all kind of TD ideas. Considering the varying contextual characteristics for example regarding industry or technological maturity firms need to scrutinize evaluation criteria
before applying them. Regardless the diverging contextual characteristics this chapter provides an overview of criteria used in the focus evaluation dimensions of the Technology Evaluation Canvas. The Technology Evaluation Canvas, presented in chapter 8.2, can be seen as the applied version of the generic evaluation framework for TD ideas, tailored for the use in an innovation laboratory of the case firm.

**Strategical Criteria for the Idea Generation Phase**

At this stage, the idea to be evaluated is new and unexplored. Considering this, the value proposition as well as technological characteristics of an idea have been described as uncertain wherefore the results of this study suggested to start with a strategically evaluation. Strategical evaluation criteria have been identified as most suitable for an early assessment since their characteristics are of rather generic nature. Criteria for a strategical evaluation can be divided into corporate strategic criteria and divisional strategic criteria. Corporate strategic criteria are assessing if an idea is in line with the overall strategy and vision of a firm. Strategical alignment is therefore a criteria that assesses to which degree an idea can contribute to a firms success in reaching the strategic targets. In contrast divisional strategic criteria are required to evaluate ideas regarding the fit to the TD environment. This means criteria like resources, capabilities or timing are assessing if the TD idea is suitable for the chosen TD environment. These early assessments of the fundamental strategic fit are crucial to sort out ideas with a low congruence with strategical conditions and targets. Furthermore, this study revealed that the measurement of the stakeholder engagement is a crucial part of the TD idea evaluation. Due to its uncertain nature, TD ideas require support either through high level managers or through internal customers who are willing to test and try the aspired technology. This support and engagement is crucial to be able to go protect uncertain or immature TD ideas against external impacts like cost-cutting programs. Another strategic criteria, used in the context of the case firm, has been the evaluation of success factors. This evaluation requires the assessment whether the success factors of an TD idea are realistic, achievable and beneficial at the same time. In sum, strategical criteria for the idea generation phase are enabling a firm sort out unsuitable TD ideas early by investigating the degree of strategical alignment.

**Technological Criteria for the Idea Improvement Phase**

The technological evaluation criteria, applied in the idea improvement phase, are made to scrutinize the TD idea from a broader perspective. This means that the criteria look beyond the described idea to identify opportunities for scaling, alternatives as well as maturity aspects. The data, collected in this study, suggested these kinds of criteria because of the necessity to understand if the TD idea is the only way to achieve the strategic goals. In consequence it is essential to evaluate if there is alternative technology that can be developed or is already existing and offers equal characteristics. Evaluating this widens the perspective and whether the TD idea is the only option to chose from. Another criteria to assess TD ideas is used to investigate the scalability of the aspired technology. Due to the resource intensive nature of TD projects, a newly developed technology should be preferably applicable in more than use case. Because of this the TD idea need to be assessed by evaluation criteria regarding scalability and multi applicable use. In this context it is furthermore important to apply evaluation
criteria that evaluate the technological maturity. Since most TD projects are build on fundamental research, a firm needs to understand how mature an aspired technology is. In sum, technological criteria for the idea improvement phase are crucial for understanding the implications that a TD idea brings along.

VALUE PROPOSITION CRITERIA FOR THE IDEA EVALUATION PHASE

Criteria for assessing the value proposition of an idea has been determined as focus dimension for the idea evaluation phase. The results of this study revealed the need to evaluate the value proposition of an TD idea last. This is due to the lack of knowledge in the idea generation and improvement phase. By having the strategical and technological knowledge gained in the earlier phases a firm is able to judge the value of an TD idea. In detail, value proposition criteria applied in this phase are evaluating TD ideas regarding the problem relevance, impact as well as the aspired improvements and effects. Problem relevance as evaluation criteria is scrutinizing the actual need for TD. Considering the gained knowledge about alternative solutions as well as the scalability of the technology, the criteria problem relevance is crucial for comparing the development expenditures of expectable benefits. To understand the benefits of a technology the criteria impact needs to assess the scope of impact. By understanding to which extend the aspired technology can be a leap or competitive advantage for a firm the prioritization between different ideas becomes easier. Lastly, the criteria improvement and effect are crucial for understanding the contribution of the technology. This means that these criteria are helping to answer whether a technology improves a process, product or service offering. In sum, the described value proposition criteria are essential for understanding the potential value and benefits a TD idea can imply.
5. **Analysis & Discussion**

Recent developments in the IM literature stress the importance of investigating which evaluation criteria are important for internal idea evaluations (Eling & Herstatt, 2017). This study contributes to the literature by investigating which evaluation criteria are pertinent for each phase of IM. Furthermore, a contribution is done by relating evaluation criteria, grouped in evaluation dimensions to the context of TD. Such concepts appear not to exist and therefore can be seen as an initiation for future research. Using a single case study, my results demonstrate the importance of attributing evaluation criteria to each phase of IM, when conducted in the context of TD. In particular, I found that all IM phases can be linked to a dominant evaluation dimension, which helps to evaluate a TD idea stepwise. Thereby, this study answers to the call for future research about an improved “understanding of the process from idea-generation activities to implementation” (Van den Ende, et al., 2015, p. 486). The findings are discussed in the following sections.

5.1 **TD Evaluation Dimensions**

This study presents detailed insight of how evaluation criteria can be attributed to proven IM phases, described for example in Gerlach & Brem (2017). These insights complement prior studies of evaluation criteria for IM and also opens new space for future research when attributing evaluation criteria to the IM phases in TD. For example, Martinsuo & Poskela (2011) proposed the use of market-, technical- and strategic criteria for the evaluation of NPD ideas. Despite the fact that these criteria sound similar to the ones identified in this study, the contextual differences between NPD and TD are significant. This complies with the study of Sandström and Björk (2010, p. 321), revealing the need to “treat different forms of ideas in different ways and that all ideas cannot go through the same funnel”. The present study investigates these contextual deviations and proposes to shift the focus when applying criteria for TD evaluations. In detail, while the IM literature for NPD is focussing on customer needs (Martinsuo & Poskela, 2011; Gerlach & Brem, 2017) or customer involvement (Florén, et al., 2017), the results of this study indicate the need for a strategical focus when assessing TD ideas. The insights are thus in line with Cooper (2006), who suggests an initial idea screening regarding strategic fit, -impact and -leverage. Moreover, the findings contribute to the IM literature by suggesting value proposition criteria as most suitable for the determination of TD value. Value proposition criteria, as a use-oriented way to determine the value of TD ideas are therefore in line with the TD literature (Bigwood, 2004; Burgelman, et al., 2004; Markham, et al., 2010) who describe TD as an interface between science and new products. This means, value proposition as evaluation dimension provides the required higher level of abstraction when looking at technologies. The call for a high level of abstraction for evaluation criteria in TD is thereby in line with Blitzer et al. (2014) who reflected on product-centric view and the required high level of abstraction for TD. Technological criteria as third evaluation dimension is completing the identified perspectives for TD assessments. The results revealed that the technological evaluation in TD as well as in NPD are rather similar. The divergence that has been identified, is the necessity for technological criteria to the reduction of expectations towards a TD idea while increasing detailed knowledge. This has been explained by the relation, that a high level of uncertainty causes unrealistic high expectations towards a new technology. Because of this, technological criteria should consider focus on the reduction of expectations by gathering knowledge and data about the aspired TD. It can be associated with the higher uncertainty and
unpredictability, described in the TD literature (Ajamian & Koen, 2002; Koen, et al., 2016).

5.2 EVALUATION CRITERIA PERTINENT FOR EACH IM PHASE

The IM literature focusing on idea evaluations often takes an extreme position by for example discussing if ideas need to be screened by formal or intuition criteria (Magnusson, et al., 2014). In contrast, the empirical data of this study reveals that none of the presented evaluation dimension is generally dominant in the IM process. Moreover, the findings suggest an evaluation focus for each phase of IM. This means that each evaluation dimension can be seen as dominant in one particular phase of IM in TD. The dominant evaluation evaluation dimensions for each IM phase are visualized in the-

The generic evaluation framework for Technology Development ideas, considering the phases, evaluation dimensions and focus areas (dark) (Figure 7). The framework thereby contradicts to the common evaluation processes in the IM literature. While existing IM models usually describe the idea evaluation to be done in a single phase (Gerlach & Brem, 2017; Soukhoroukova, et al., 2012), the results of this study suggest a stepwise evaluation during the phases idea generation, idea improvement and idea evaluation.

Caused by the high uncertain nature of TD ideas, an initial evaluation in the idea generation phase with an emphasizes on strategical criteria has been identified. Due to the lack of knowledge and idea maturity in this early stage, it is rather important to determine if the hypothesis of an idea is in-line with the firm’s strategic aims. This is aligned with Ajamian and Koen (2002), Alexe et al. (2014) as well as with the study of Kelley et al. (2013) describing the characteristics of high-potential innovations. Even though Ajamian and Koen (2002) describe strategical evaluations as crucial in the early stage, their technology review process just covers the stages of technology- and business review. Considering the results of this study, strategical criteria should be used as the dominant evaluation dimension for the phase idea generation. The second described evaluation dimension in this study, namely technological criteria, has been identified as most important in the phase idea improvement. This has been found based on the stated need to decrease the expectations of a firm by increasing their detailed knowledge about an aspired TD. The insights are thus in line with the idea improvement, the name of the phase, as well as with Ajamian and Koen (2002) whose process suggests to review the technology before looking at the business side. Following this, the evaluation dimension value proposition criteria, which Ajamian & Koen (2002) describe as business review, is allocated as dominant for the phase idea evaluation. The use of value proposition criteria as the dominant evaluation dimension in the phase idea evaluation has been confirmed by this study. This study shows that the value proposition of an idea can only be understood and in consequence evaluated when the idea reaches a sufficient degree of certainty concerning strategical as well as technical considerations. In sum, what emerges is that each phase of IM revealed pertinent evaluation criteria when applied for TD.
6. CONCLUSION

This chapter concludes the report by clarifying the answers to the research questions. Furthermore, implications, limitations as well as suggestions for future research are stated.

6.1 ANSWER TO THE RESEARCH QUESTION

This study represents a single case study that investigates evaluation criteria that an organization in the automotive industry should consider when assessing TD ideas. By conducting and abductive approach, existing academic theory has been challenged with new contextual requirements as well as new empirical data. The thesis was built around a primary research question that is answered subsequently.

RQ: Which evaluation criteria are pertinent for each phase of Idea Management, when applied for Technology Development?

The answer to this research question departs from the empirical data, presented in chapter 0, as well as from the reviewed literature (chapter 2). Based on the discussion in chapter 0 it has been confirmed that IM for TD needs to be conducted differently than suggested by existing literature. While existing IM models usually describe the idea evaluation to be done in a single phase, the results of this study suggest a stepwise evaluation during the phases idea generation, idea improvement and idea evaluation. In addition, the findings suggest focussing differently in each evaluation phase (see Table 7). The root cause for this can be seen in the relation between the degree of idea maturity and the simplicity of the evaluation dimension. While a strategical evaluation requires a rather a high level of abstraction with a rather small amount of detailed knowledge, the evaluation of the value proposition demands an in-depth understanding of the identified need or problem as well as the technological understanding of how to address it. In summary, this dynamic adaption of the evaluation dimensions, regarding the fuzzier context makes strategical criteria pertinent for the idea generation phase, technological criteria for the idea improvement phase and finally value proposition criteria for the idea evaluation phase. The described order and evaluation focus are thereby providing a theoretical as well as a practical guideline for the process of idea evaluations in a TD context.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Focus evaluation dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea generation phase</td>
<td>Strategical criteria</td>
</tr>
<tr>
<td>Idea improvement phase</td>
<td>Technological criteria</td>
</tr>
<tr>
<td>Idea evaluation phase</td>
<td>Value proposition criteria</td>
</tr>
</tbody>
</table>

Table 7 - The focus dimensions for each Idea Management phase
6.2 **Theoretical Contribution**

The present study makes two contributions to the literature. First, it advances the literature by contributing to an improved understanding of the evaluation process for TD ideas. While most prior IM literature has explored and suggested evaluation criteria for NPD ideas (Soukhoroukova, et al., 2012; Magnusson, et al., 2014), this study specifically contributes with insights about evaluation criteria applied in the rarely addressed context of TD. Thereby this study contributes to the suggestion of Sandström and Björk (2010), by investigating how different forms of ideas require a different treatment. In particular, this study reveals that evaluation criteria for TD can be differentiated into strategical-, technological- and value proposition criteria. Thereby the perspective of value proposition criteria is significantly deviating from the determination of value or benefits in the IM literature regarding NPD. While this perspective in NPD usually tries to determine the value for the customer or market (Martinsuo & Poskela, 2011), this study suggests to determine value by evaluating the value proposition a technology entails for the firm’s own business. This means the focus is thereby rather internally *use-oriented* than externally customer-centric. In consequence, this study also follows Eling & Herstatt (2017) call for further investigations about which evaluation criteria are important for internal idea evaluations.

Second, the findings advance prior research about evaluation criteria with the consideration of timing. The majority of prior studies either did not consider the timing for applying evaluation criteria or just to the extent that a single evaluation phase has been defined (Gerlach & Brem, 2017; Brem & Voigt, 2009; Nilsson, et al., 2002). This might be sufficient when evaluating NPD ideas, whereas my results of this study suggest a stepwise evaluation when applied for TD ideas. In detail, this study contributes to the IM literature by suggesting dominant evaluation dimensions for the IM phases idea generation, idea improvement, and idea evaluation. This allocation of evaluation criteria to IM phases is providing knowledge about the right timing of the use of each evaluation dimensions in consideration to the contextual characteristics of TD.

6.3 **Managerial Implications**

The presented study also offers relevant implications for managers and organizations. First, the findings suggest firms to conduct idea evaluations differently when applied for TD. The search and development for new technologies is an uncertain context, as for example described by Cooper (2006), and therefore requires management on a higher abstraction level (Blitzer, et al., 2014). The application of evaluation criteria with a wrong level of abstraction, can cause a misinterpretation of an idea’s potential in and consequence the implementation of the wrong TD idea. Because of this, the presented generic evaluation framework for Technology Development ideas can be seen as a systematic guidance for managers and firms. It prevents managers to conduct an instant in-depth value analysis and without having the technological and strategical awareness of the idea. In addition, the result of this study should advice managers and development teams to conduct wide-ranging evaluations by looking beyond the original TD idea to also investigate the scalability and applicability for more than one use case.

Second, the findings are relevant for the organization of the evaluation process. While many firms apply the same evaluation process for products and technologies, this study
invites managers to scrutinize existing processes and methods for the selection of TD projects. This study should also alert managers to conduct tailored evaluation processes to keep up with the speed of rapid technological progress and shortened times in product and technology to market. The findings of this study suggest that firms should evaluate TD ideas in three-step approach by applying pertinent evaluation criteria to each phase of the IM process. By following this, firms can gradually counter the uncertain characteristics of TD ideas and in consequence will have a higher accuracy when evaluating and choosing the next TD idea.

Third, this study particularly tries to make managers aware, that the determination of a TD ideas value proposition is complex and therefore should be done after the application of strategical and technological evaluation criteria. Doing this is helping to avoid the rejection of valuable ideas which are just too immature to be sufficiently rated.

6.4 LIMITATIONS AND FUTURE RESEARCH

Considering the findings and results, this study has limitations. The data were exclusively collected within one large technology-oriented firm in the automotive industry. For firms in other industrial contexts, with a different size or corporate culture, the outcomes might differ. Furthermore, this study has limits due to its generic case study approach. The applied method is rather exploratory than explanatory and in consequence primarily describes the process and criteria dimensions for TD idea evaluations without explaining every criteria in-depth. Because of this, the study provides room for detailed investigations regarding the criteria design in TD idea evaluations. Further studies could also examine the presented framework in differing conditions or contexts to verify its applicability. This would enable a better understanding of how dynamic the evaluation criteria for TD ideas are related to the contextual setup. Furthermore, the timing for the application of evaluation criteria requires further attention and research. While this study revealed insights about the timing of evaluation criteria regarding the phases of IM, future research could generally investigate the effect of timing in idea evaluations as well as in different contexts or industries.
7. REFERENCES


8. APPENDIX

8.1 APPENDIX A – INTERVIEW GUIDELINE

Background questions
a. Formal position
b. Academic training
c. Years of employment
d. Has experience/involvement with Idea Management?

Group A - Innovation strategy
a. How would you describe the innovation strategy of Scania?
b. How do you measure the success of the innovation strategy?
c. If you are involved in the processes around the Smart Engineering Lab (SEL), how would you describe its strategical objective?
d. Do you see a difference in Scania’s innovation process, when targeting new technologies instead of new products?

Group B - Idea Management
a. Is Scania following a certain method of how to conduct Idea Management?
b. Can you describe the measures, with which Scania is systematically collecting the ideas for a novel or improved technologies and products?
c. Which evaluation criteria would you apply to determine promising ideas?
d. How would you characterize both, a successful or unsuccessful Idea Management?
e. Which challenges/barriers does Idea Management need to overcome to become successful?
f. Does Scania proceed differently when conducting Idea Management for Products or Technologies? If so, please explain the differences?

Group C - Ambidexterity
a. Is the balance of the projects in the SEL rather towards the exploration or the exploitation of an idea’s potential? (value creation/value discovery)
b. How would you describe the best balance between long- and short-term opportunities/benefits?
c. How would you balance the idea evaluations between focusing on the potential for the portfolio and the single idea potential?

Group D - Learnings
a. Is there anything else you believe that I should have asked you during the interview and/or other knowledge you would like to share with me?
b. Who do you think I should interview in order to get additional insights into Idea Management in the context of Technology Development?
8.2 APPENDIX B – TECHNOLOGY EVALUATION CANVAS (FOR SCANIA)
<table>
<thead>
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<th>VALUE PROPOSITION</th>
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<td>TECHN. IDEA DESCRIPTION</td>
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<tr>
<td>WHO BENEFITS</td>
<td>INITIATOR</td>
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<td>EXPECTED IMPACT</td>
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**EXPLOIT**

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**RISKS**

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TECHN. MATURITY/SAFETY
Markus Dunstheimer, Master student in Industrial Management and Innovation at Halmstad University. Has a Bachelors Degree in International Production Engineering and Management.