Investigating the innovation process as influencing factor on creativity

A case study in the manufacturing industry

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Abstract

The purpose of this thesis is to fill a research gap in the understanding of the involved mechanisms between the innovation process and creativity in a manufacturing company. In particular focus are the two innovation process interfaces between the technology development, product development and production departments and their influence on creativity and information flow. A conceptual framework is proposed, based on the combination of previous research in individual creativity and innovation process, to assess the influence via the innovation process interfaces on product knowledge and creative climate as creativity prerequisites. This study uses an explorative two single case study design with integrated triangulation and an abductive approach to fulfilling the research aim. These case studies took place in two Swedish manufacturing companies with a complete in-house innovation process using semi-structured interviews, two questionnaires and focus groups. The findings imply that the innovation process affects the basic prerequisites of individual creativity knowledge and creative climate due to its structural, strategic and physical implementation. Furthermore, the interfaces between the innovation sub-processes technology development, product development and production mediate the exchange of information between the involved departments. The results of this study adding valuable insights in this research field and propose further research including systems theory to achieve further in-depth understanding.

Keywords
Innovation process, Creativity, Climate, Creative Climate, Culture, Technology Development, Product Development, Production, Interface aspects
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I Introduction

This chapter introduces the concept for this study, investigating the mechanisms involved between innovation process interfaces and creativity in production systems. A brief introduction about the theoretical background of the subject is given followed by practical implications. The structure of the finding is also introduced in this chapter.

1.1 Background

In a rapidly evolving global economy manufacturing companies are challenged to be innovative in order to stay competitive and ensure their existence.

A key factor for organisations to adapt and renew themselves in this environment is innovation (Tidd et al., 2005; Eisenhardt & Tabrizi, 1995) as it provides competitive advantages and substantial growth (Spithoven et al., 2012; Trott, 2008). Innovation is considered a primary driver for economic development, combining existing resources in new ways. Within the context of production systems, innovation is understood as the implementation, adoption or creation of new ideas, which leads to new products or processes (Rogers, 2003). In a more process-oriented view, innovation is the “successful implementation of those novel, appropriate ideas” (Amabile, 1997, p. 40). This definition consists the aspect of “novelty” which is essential and delicate at the same time as it depends on an individual’s perception if something is new or already existing (Rogers, 2003). A new idea should involve a significant recombination of existing materials, fit the situation or the problem, and provide a useful result or fulfil a need to be considered revolutionary new (Amabile, 1997; Ford, 1996; Oldham & Cummings, 1996). Furthermore examining the definition of novel ideas involves inevitably creativity as the raw material for “creating” new ideas (Amabile, 1997).

Creativity sometimes is defined as a mystical ability; a complex individual mental process that connects or combines previously unlinked knowledge elements to a novel idea (Ford, 1996). The two key influencers of creativity are an individual’s knowledge and the individual’s environment. Knowledge is a human faculty resulting from an individual’s interpretation of information, facts and skills acquired through experience or education (Turnbull, 2012). Information, more so than knowledge is acquired through information exchange with other individuals or in written form (ibid). In a company context the individual’s environment is represented by the organisation’s culture and the embedded organisation’s climate. Climate describes the summary of peoples’ impressions about an organisation and culture represents the underlying assumptions and values (Ekvall, 1997). Creativity provides the “spark” for a novel idea and is essential for every innovation but creativity by itself is not sufficient to ensure the realization of an idea (Paulus & Nijstad, 2003; Amabile et al., 1996). For successful implementation of an idea, the combination of resources and skills from a company environment is necessary (Fagerberg, 2004; West & Farr, 1990). The manifestation of innovation and creativity in the manufacturing context is the creation of new products (ibid).
A requirement for successful product realization is a clear and structured process covering all necessary activities within an organization (Roozenburg & Eekels, 1995). This innovation process can be characterized as a method embracing all activities that foster the implementation of a new product into a market. This method includes basic and applied research, design and development, market research, marketing planning, production, distribution, sales and after-sales service (ibid). In practice and academia, the innovation process is divided into three and in some cases overlapping sub-processes: 1) technology development, 2) product development and 3) production, as depicted in Figure 1 (Lakemond et al., 2007).

The separation of the three sub-processes is caused by organisational structures such as location, aspects and activities (Drejer, 2000). These separations create interfaces in-between the sub-processes and with them challenges to establish a successful cooperation between the sub-processes (Kahn, 1996). The two interfaces 1) “technology development - product development” and 2) “product development - production” are uniquely different in their nature and their challenges, based on the different characteristics of the sub-processes (Figure 1). In this context an increasing amount of studies (e.g. Lakemond et al., Nobelius, Daim) show that with improvements in these diverse factors the complete innovation process becomes more efficient. The investigated factors in the first interface were categorized as technology scope, transfer management, strategic and operational factors (Nobelius, 2004). The categories of the second interface were involvement, resources and time, communication and product manufacturability (Daim et al., 2009; Lakemond et al., 2007).

![Innovation Process](image)

**Figure 1: Innovation process**

In research about organisational conditions for creativity and innovation, several studies (e.g. Amabile, Ekvall, Fagerberg) have been undertaken on aspects of leadership, values and creative climate as well as on hard qualities of the organisation such as strategies and structure for innovation (Ekvall, 1991). The wide range of those studies focus on how to cultivate creativity and how it affects innovation. However, to our knowledge there is no investigation of how the
innovation process affects creativity in organisations, therefore, this study explores
the involved mechanisms in this respect. Due to the absence of a natural connection
between innovation process and creativity, the study proposes the following
substitution: the two interfaces of the innovation process are investigated how they
influence knowledge and the creative climate as creativity prerequisites. To further
narrow down the influence of the two interfaces, the categorized factors are used to
structure and specify their influence on knowledge and the creative climate. The
information exchange between the three sub processes is also investigated to
increase the insights about phenomenon.

Based on the explorative nature of this research endeavour, the phenomenon was
studied in two Swedish case companies who shared the same interest in this subject.

1.2 Aim and research questions

The aim of this study was to explore the mechanisms involved between the
innovation process interfaces and creativity in two manufacturing companies. In
particular the influence of the two interfaces on the product knowledge and creative
climate as prerequisites for creativity was investigated. The following research
questions are answered:

1. How does the innovation process affect the human creativity in a
manufacturing company?
2. How do the innovation process interfaces affect information exchange be-
tween the involved departments?

1.3 Delimitations

Exclusions include particular aspects of leadership, values or qualities of an
organisation like strategies and structure that influence creativity (Ekvall, 1991).
There is a need to limit the potential influencers of creativity and focus the attention
on the innovation process; especially leadership practices involving a high amount
of management and motivational theories that would go beyond of the scope of this
study. In the theoretical sub-section 2.3, an elaboration of the chosen approach is
presented, and the developed conceptual framework is built to ensure the focus on
innovation process relevant findings.

1.4 Disposition

In chapter one, the introduction to the research is shown including the motivation
to why this particular topic is of interest. The problem description, purpose,
research questions, and limitations are also stated in the chapter.

The second chapter includes the theories used within this study. The two theoretical
“pillars” of the innovation process and creativity are presented, and the conceptual
framework is built to structure the following fieldwork and analysis.
To give a better understanding of how the research has been carried out the methodology is outlined in chapter three. Chapter three also provides an explanation of what data is relevant and how the data has been analysed. A subsection with a discussion regarding the expected validity and reliability of the research ends the chapter.

The result of the empirical data collected from the case companies is outlined in chapter four and five. The chapters are following the structure given by the conceptual framework and according the used methodological instruments.

In chapter six the analysis and discussion of the findings are presented to fulfil the research aim. The research as a whole is further summarized at the end of the chapter, outlining the conclusions and practical implications.
2 Theoretical background

In this chapter, the theoretical background of this study is presented. Due to the absence of a natural connection between the innovation process and creativity both concepts and related research fields of climate and culture are divided into two “pillars”. Figure 2 is used to visualize the relationship between the concepts and the structure of the theoretical framework. The first sub-section 2.1 introduces innovation in organisations to create an overall understanding and entry into the topic of this study. Theories about the innovation process and sub-process interfaces follow this introduction. The second sub-section 2.2 introduces the theoretical pillar of creativity and related topics of climate and culture. Within the last sub-section 2.3 a connection is made between the two pillars and the resulting conceptual framework for the fieldwork is shown.

Figure 2: Structure of the theoretical background
2.1 Innovation in organisations

One example of successful innovation is comes from the Sony Corporation. In 1978 the Tape Recorder Division of Sony attempted to re-design a small portable voice recorder with stereophonic sound as output. The project ended up being a failure after a lot of time, money, and effort had been invested. The aim of reducing the size of the recording device significantly was not achieved, and the project ended up with a prototype that was producing stereophonic sound, but it could not record anything. After the project had been stopped, the engineers used the prototype to play their favourite cassettes while they were working. One day the chairman of Sony made a visit to the engineers’ office and found the engineers listening to music. When he saw the prototype, he remembered a project that was on-going in another department about lightweight portable headphones. Asking the simple question “what if we combine those two projects?” which started a revolutionary project. The combination of these two projects created the product that brought a revolution to the market and Sony Corporation, the famous Walkman (Nayak & Ketteringham, 1994).

The Walkman example shows how essential innovation can be for an organisation’s renewal and adaptation to a changing environment; it provides the organisation with a competitive advantage and secures their growth (Tidd et al., 2005; Eisenhardt & Tabrizi, 1995; Trott, 2008; Spithoven et al., 2012). Early innovation literature (e.g. Eisenhardt & Tabrizi) considered innovation as the primary driver for economic development combining existing resources in a new way and focused on individual entrepreneurs. Over time, the focus changed towards organisational innovation and created a broad range of research fields with various definitions accordingly to the researchers’ purpose. There are two viewpoints on organisational innovation; the first one considers the outcome (product) and the second one, the actual process to achieve the outcome as organisational innovation (Rogers, 2003). In this thesis, the process view on organisational innovation is adapted. Organisational innovation is the successful implementation, development, adoption, or creation of novel ideas, which ends in new products or processes (Amabile, 1997; Amabile et al., 1996; Damanpour, 1991; Isaksen & Ekvall, 2010).

According to Rogers (2003) the idea attribute “novelty” is an essential element in innovation as it is a subjective individual attribute if something that is perceived as new or an imitation. Ford (1996) and Oldham & Cummings (1996) define a novel idea as a significant recombination of existing material or something entirely new that fits a particular situation or problem and is useful. This definition does not include how novel ideas are created; these various processes are described under the term creativity.¹ Creativity is the “spark” at the very beginning of innovation and considers the complex individual mental process of the novel idea generation (Ford, 1996). Creativity is seen as the individuals’ raw material of “making” new ideas (Oldham & Cummings, 1996).

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¹ A more in depth definition of creativity is given later in sub-section 2.2.1.
Based on those distinctive definitions creativity is an essential part of innovation, (Paulus & Nijstad, 2003) but not sufficient to ensure the implementation of a new idea (Amabile et al., 1996). Implementation to be successful, the combination of knowledge, resources, and skills of a company environment are necessary and known as innovation process (Fagerberg, 2004; West & Farr, 1990).

2.1.1 The innovation process

In manufacturing companies, the output of innovation is a product (Fagerberg, 2004; West & Farr, 1990). Through product innovation organisations can adjust themselves to their markets, technical conditions and ensure their survival (Eisenhardt & Tabrizi, 1995). A prerequisite for successful product innovation is a clear and structured process that is covering all necessary activities. This innovation process embraces all activities that foster the adoption of a new product into a market. This includes basic and applied research, design and development, market research, marketing planning, production distribution, sales, and after-sales service (Roozenburg & Eekels, 1995). Even if it is an internal process, it is an open system influenced by various environmental factors (Trott, 2008).

Both in practice and academia, the innovation process is divided in three, and some extend parallel sub-processes (Lakemond et al., 2007). The definitions of the shown parts in Figure 1 are as follows:

“Technology development is investigations undertaken to acquire new knowledge, though directed primarily towards a specific practical aim or objective” (Nobelius, 2002, p. 10). Characteristics of this process are a high degree of uncertainty, unclear time frames and a strong focus on research (ibid).

“Product development is the systematic work using existing knowledge gained from research and practical experience towards producing new material, products, processes, systems or services” (Nobelius, 2002, p. 10). It faces a higher time pressure, but there is less uncertainty (ibid).

Production refers to the process of producing products and services with support from different production factors such as labour, machinery, and raw material (Bellgran & Säfsten, 2010). This process faces the tightest deadlines, lowest uncertainty and focus on efficiency (Vandevelde & Dierdonck, 2003).

In reality, the separation or isolation of the processes are caused by organisational structures like location, aspects and activities (Drejer, 2000). For example technology development is performed in the research and development (R&D) department, while product development is done in separated projects, and production in the production area. This separation of the three processes grows the need for integration between them. Integration according to Khan (1996) comprises interaction and collaboration to a multidimensional activity, whereby interaction stands for all structural activities between the departments like meetings, calls or exchange of documents. The collaboration focuses more on mutual understanding, shared goals, and resources.
Drejer (2000) proposes three integration dimensions as a way to approach the challenge of sub-processes integration. With the integration of activities, all activities and tasks within the innovation process are seen as a chain to generate the final product. A way to improve the chain of these activities is to understand all the involved technologies and their effect on the product. The dimension of integration of aspects takes into account that product and technology development departments speak different languages. It aims to combine customer needs with the functions provided by the product and with the current technology available in the company. The last dimension is the integration of time horizon, this considers the differences between product and technology life cycle. Development and alignment of products and used technology takes into account scheduled time, specifications and expected level of performance (ibid). All those considerations point out the importance of the actual interfaces between the sub-processes in the innovation process.

2.1.2 Technology development – product development interface

As mentioned in the previous paragraph the sub-processes of technology development and product development are in reality often separated (Drejer, 2000). This increases the need for integration and creates an interface between the two sub-processes (Nobelius, 2002). This interface is affected by numerous factors and it has received great attention the recent years. Many scientists (e.g. Iansiti, Eldred and McGrath, Daim et al.) are considering this interface as an essential element for successful product innovation.

Eldred and McGrath (1997) propose a technology transfer step between the two processes as a bridge for better integration. In their view, a successful technology transfer requires three central elements: program synchronization, technology equalization, and technology transfer management. Program synchronization refers to the readiness of the technology to be transferred and the readiness of product development to receive the new technology. A careful synchronization will have a critical impact on the successful transfer. The role of technology equalization is to broaden the scope of used technologies. Technology development focuses on the development of one core technology while product development needs more than one technology to achieve their goals. Technology transfer management address the necessity of a structured transfer management process that ensures an efficient resource allocation and that all involved members are aware of the goals and their roles (Eldred and McGrath 1997).

Iansiti (1995) points out the importance of combining knowledge of new technology or processes with existing knowledge in order to achieve a more efficient product development process. A similar view as Eldred and McGrath (1997) is represented by Nobelius (2004). According to him, three aspects must be taken into consideration: strategic and operational synchronization, transfer scope and transfer management (ibid). Strategic synchronization deals with the issue of matching the technology to the product development strategy while operational synchronization is dealing with the proactive actions for initiation of a product development project. Transfer scope refers to the technology width and depth, in
other words, what kind of knowledge needs to be transferred and what its complexity is (ibid). The transfer management deals with the actual process and the management of technology transfer. There is a need for transferring verified technologies into product development projects where the separation between the processes is necessary (Lakemond et al., 2013). To ensure the quality of the transferred technology, a clear hand-over between technology and product development is crucial.

Daim et al. (2009) presented a number of aspects for a successful internal transfer of technology:

- **Communication channel:** A right communication between departments can decrease the time and the money spent on technology transfer. A communication channel between technology development and product development will improve the integration of those two.

- **Single point of contact:** A single point of contact between technology department and product development department will accelerate the decision-making process. This practice enables the ownership of technologies, clear structure and better management of resources.

- **Technology readiness:** Technologies need to be available and mature in order to integrate into products. It will prevent the development of technology inside the projects and will enhance the technology integration.

- **Technology portfolio:** A technology portfolio can help companies to keep track of all the internal developed technologies. An efficient use of technology portfolio can reduce the overlapping on the product development process and fastens the technology selection at a beginning of a project.

- **Consistent criteria and metrics:** A consistency in measures and metrics helps the creation of homogenous understanding and enables a comparison basis for technology and product groups.

- **Incentive structure:** An incentive structure creates a collaborative environment that enhances the collaboration between groups and departments.

- **Consistent decision-making:** The complexity of decisions made by managers can be very high and especially in high technology projects. Consistent decision-making will enhance the integration between departments.

- **Long-term strategy:** A long-term strategy supports the decision-making in a company and enables the linking of technologies with future products. Furthermore, it steers technology and product development in the same direction and results in a smoother and better integration of technology into new products.
Summary
The various described factors related to the interface technology development / product development can be categorized for a better understanding according their familiarities.

- The *Technology scope* category contains factors related to the development of technology as long as to knowledge development. Specifically this category contains the following factors: Knowledge accessibility, knowledge complexity, technology readiness, and technology portfolio.

- *Transfer management*, contains factors related to the transfer knowledge and technology, and the smooth transition from the technology development phase to the product development phase. Included factors are: clear hand-over, communication channel, and single point of contact.

- *Strategic and operational factors* are related to managerial and organizational factors that affecting the interface such as: Incentive structure, consistent criteria, decision-making and long-term strategy.

2.1.3 Product development-production interface

The second interface between product development and production has the same root cause as the first interface and is dealing with tight time schedules and limited uncertainty (Lakemond et al., 2007). Since cost and time are the primary focus, the process integration needs to be efficient. Cooperation and coordination are essential to overcome the interface-related problems and achieve a proper integration (ibid).

Adler (1995) proposed three coordination possibilities: the *pre-project coordination*, the *design-phase coordination* and the *manufacturing phase coordination*. Pre-project coordination refers to the stages before starting a development project where tools like CAM or CAD can be used to ensure integration of the activities involved in developing a new product and consequently for reducing the time-to-market. Design-phase coordination refers to stage concerning product and process definition where different techniques can be adopted to achieve coordination. The establishing of standards is a valid way to reach integration among the activities performed by designers without compromising the manufacturing phase. A possible approach to ensure integration is a sign-off procedure: the manufacturing department has the responsibility to declare if the project developed in the design phase, with the relative specifications, is feasible or not. In the manufacturing phase coordination the production operations takes place. With Engineering Changes (ECs) a powerful tool for proper coordination is introduced whereby the designers first send a rough version of the project to production. The production engineers respond with a list of necessary changes in order to make the product feasible (ibid).

In addition to the coordination aspects, there is a need to consider communication methods to ensure the cooperation between product development and production. Wheelwright & Clark (1992) use four interaction modes to improve communication. The first mode *serial mode* interaction has the manufacturing phase start after
designers have completed their work and send the final design to production, which represents a typical one-way communication. The early start in the dark mode uses another approach whereby the design department and the manufacturing unit are working in parallel to meet the deadline. Nevertheless, there is no effective communication in place before releasing the product for production. Potential adjustments may take longer time caused by the serial mode interaction. Early involvement modes are described as situations where design and manufacturing roughly share information in a two-way communication. However, they do not work concurrently, and, therefore, the problem-solving activity is happening in production only after releasing the detail design. Finally in the integrated problem-solving interaction mode, which refers to the design and the manufacturing work in parallel has a two-way continuous communication flow.

Closely related to integration in the product development-production interface is the concept of Design for Manufacturing (DFM), (Herbertsson, 1999). There are four levels with different scope and objective to perform DFM (ibid). The first level is the company level, which aims to achieve economy of scale benefits through types of standardization effort. Secondly there is the product family level, which has as objective the coordination among product variants in order to achieve economy of scale advantages. The third level, the product structure level, aims to design an overall product structure that enables effective and efficient design of variants, efficient flow in the production system and easy assembly. Finally, the fourth level is the component level, which has as primary objective to design parts, which can be fabricated efficiently.

In practice, these four levels are often difficult to separate (ibid), and when applying DFM, four types of factors must be considered for a successful implementation. Managerial factors refer to elements, related to goal setting and development strategies. Organisational factors concern the way of organising product development and project teams including training, skills and knowledge of the involved members. Methodical factors are used for design methodology and decision-making principles during the product development phase. The fourth factor to be considered how to apply and implement the DFM tools (Herbertsson, 1999).

While the previous paragraphs contain comprehensive theory about the product development production interface the following paragraphs focus more on specific factors and barriers. Lakemond et al. (2007) provide six additional critical factors for the product development-production interface.

- Analysing product manufacturability with methods as Design for Manufacturability (DFM) and Design For Assembly (DFA).
- Early involvement of production in the product development project.
- Dedication of specific resources for production to participate in the product development process.
• Continuous communication between production and product development project teams.
• Active involvement of production in the product development process.
• Shared vision between product development and production.

Vandevelde & Dierdonck (2003) use a different approach to achieve full integration of the two processes. They suggest that overcoming significant barriers will lead to success, and they relate those barriers to the following aspects:

• Personality differences are referred to, as the agreement, trust and the level of the relationship between the employees.
• Cultural differences strongly depend on the employees’ background, experiences and training, since these factors affect their way of viewing and understanding reality.
• Language barrier is more related to different departments within a company rather than the different nationalities of the employees. Slang and technical languages hamper communication between the departments.
• Organisational barriers focus on department goals interfering with the company goals. Moreover, senior management should support the product development and ensure clear goals, responsibility, and roles.
• Physical barriers relating to the physical distance could separate different departments. This kind of distance is an apparent obstacle to reach a clear and detailed communication and in considering the other departments as parts of a whole.

Summary
The various described factors related to the interface product development / production can be categorized for a better understanding according their familiarities.

• Involvement category contains factors regarding the participation of production in the innovation process. The specific factors are: Early production involvement, and active involvement.

• Product manufacturability category is related to the collaboration between product development and production departments, as long as the effective knowledge exchange, concerning product-manufacturing aspects. The related factors are: Knowledge exchange, feedback from production and DFM/DFA.

• Resources and time category, considers the available resources and the time pressure, specifically: sufficient resources, dedication of resources, time pressure and work overload.

• Communication category contains communication related factors in this interface. These factors are: Continuous communication, physical barriers and language barriers.
2.1.4 New Product Development (NPD)

After defining the innovation process and the interfaces between the sub-processes, there is a need to introduce the related and synonymously used concept of new product development (NPD). The concept of NPD is a process equal to the product development and production process of the innovation process. Technology is incorporated into new concepts, and the NPD is the process that transforms those concepts into products (Clark & Fujimoto, 1991; Adler, 1995). As a part of organisational projects, the NPD process faces numerous internal and external influences and challenges (ibid). Lakemond et al. (2013) provides a structure for assessing the challenges in a systematic perspective considering three different interfaces as shown in Figure 3.

**Contextual Interfaces**
The contextual interface links the two contextual perspectives of technology and market uncertainty (Lakemond et al., 2013). Market uncertainty refers to unknown customer demands and needs or competitor’s actions and sales strategies (O’Connor et al., 2004; Souder & Moenaert, 1992). Technology uncertainty refers to the “uncertainty regarding whether a new product is technologically feasible and whether it will perform as expected, given clear and valid product specifications” (Darian & Eppinger, 2009, p. 384).

**Technical System Interfaces**
The technical system interface, addresses the complexity of technical problem-solving is addressed and divides it into product and production complexity (Lakemond et al., 2013). Product complexity refers to the number of combinations between the different parts of a product, the functions of a product or the incorporated technologies (Griffin, 1997; Swing, 2003). Production complexity is related to the product complexity but also refers to the originality or the changes made on the design of the production system (Säfsten et al., 2014).
**Organisational Interfaces**

The organisational interface considers the circumstance that inside an organisation many activities are running in parallel and the difficulties to integrate them into the project (Lakemond et al., 2013). A primary reason for these obstacles is organisational and geographical separation of the involved units. Organisational and geographical dispersion relates to the separation between technology development, product development, and production (ibid). Also, cultural differences, physical distance or language barriers can increase the effects (Vandevelde & Dierdonck, 2003).

### 2.2 Creativity and climate concepts in organisations

This section and the subsections introduce the second theoretical pillar of this research, namely an orientation of the concepts of creativity, climate, culture, organisational climate and creativity climate.

#### 2.2.1 Creativity

The term creativity covers a broad range of aspects beginning from an individual’s mental processes of creativity to creativity in an organisational context. A start to understand creativity is to understand its importance for the society and organisations. In ancient Greece, Socrates and his associates recognised that the survival of a culture depends on the abilities of their leaders. Particularly, a leader should be able to solve upcoming problems with the support of their subordinates (Plato, 1946). The subordinates need support for this through a certain level of freedom and independence to be able to create ideas and solutions. An example might be the rise of the Roman Empire; their leaders used the full potential of their subordinates and achieved excellence in many areas. This finding of Socrates is also applicable to modern organisations where managers are representing the role of the leaders (Popenoe, 1980). Without cultivating and honouring creativity, the chance for the organisation’s survival is limited (ibid).

However, considering this deduction it needs to be clarified: *What is creativity and what is necessary to cultivate creativity?* The subject of creativity is not easy to grasp because it is observable as an ability, a behaviour and a phenomenon.

*What is creativity?*

Plato (1946) proposed the idea that creativity is an act of the gods or muses who momentarily graced a mere human with their powers to create. Recent research concluded in a less mystical way that creativity is a commonly distributed capability of most healthy people, who create something new and useful that others judge as creative (Isaksen, 1987). It is defined as a combination of thought processes, personal experience, knowledge, social interactions and environmental influences (Ford, 1996; Isaksen, 1987). All of those components are needed to interact to make an individual capable to be creative (Amabile, 1997). Moreover, special field knowledge and intrinsic motivation are necessary prerequisites for the thought
process that allows the individual to be creative with a full range of alternatives (Amabile, 1998). These thought processes are part of the psychological aspects of individual creativity (ibid).

The psychological description of individual creativity is according to Ghiselin (1963), found in (Ekvall, 1997), “a new configuration or” “formulation of meaning” and “a new structure of the mind” (p. 195). Ekvall (1997) reformulated this definition that a creative output requires a new combination of knowledge elements and principles. Researchers like Ford (1996) and Drazin et al. (1999), point out the importance of time for individual creativity and consider the actual act of human creativity as a complex individual mental process. Both descriptions are supported by brain science that expose the lateral thinking process of the mind to be the source of creativity, where lateral thinking is a process in the brain that cuts existent information clusters and rearrange them (De Bono, 1995).

Summarising the given definitions about creativity lead to the definition of creativity used in this study. “Creativity is the individual’s process of producing new and useful ideas”.

It needs to be mentioned that the presented theories cover a limited part of individual psychological aspects of creativity, and are restricted to the “Western” definition of creativity. “Eastern” definitions are considering creativity as a self-growth process (Lubart, 1990). Creativity prerequisites have also been simplified in terms of the individual process and the right environment (Ekvall, 1997). To answer the question “what is necessary to cultivate creativity?” creativity in an organisational context needs to be understood.

2.2.2 Organisational creativity and problem-solving

Studies about creativity in organisations distinguish between individual, group and organisational creativity (Drazin et al., 1999). A definition of organisational creativity is “The creation of a valuable, useful, new product, service, idea, procedure, or process by individuals working together in a complex social system” (Woodman et al., 1993, p. 293). Particularly important in this definition is that the creative ability of the individual becomes a valuable resource in the complex social system of an organisation, as the individuals need to work together to turn new ideas into profitable innovations for the organisation (Cook, 1998; Oldham & Cummings, 1996). This process of cooperation is influenced by various factors as type of task, organisational culture and climate, bureaucracy, and leadership style (Amabile & Khaire, 2008). Special attention is given to leadership, because managers need to challenge, motivate, decrease the fear of failure and give enough time for own projects. Likewise, climate and culture are considered to have a big impact on individual creativity; what makes it necessary to present those two concepts first (Ekvall, 1987). Before continuing with the concepts of climate and culture, there is a need to introduce a creativity related concept with similar meaning.
**Problem-solving**  
Problem-solving is often mentioned in creativity studies (e.g. Drazin, Ghiselin, Hall) and is sometimes put together as “creative problem-solving”. This is not correct, as creativity needs to be perceived as a part of problem-solving not as a combination (Matlin, 1989). The reason for this differentiation is that creative thinking is not logical and rational based; the involved process is dynamic, complex and chaotic and ends in a new idea for an unknown problem. For creativity the problem is unknown till the solution is found (Torrance, 1979).

Problem-solving is, on the other hand, logical, ordered, rational, easy replicable and searches for a new idea for a known problem. Figure 4 visualises the difference between creativity and problem solving based on the described circumstance.

![Figure 4: Visualisation of the difference between creativity and problem solving](image)

**2.2.3 Climate**

Within the previous section 2.2.1, environment was identified as an essential condition for creativity to appear. The investigation of environmental factors in this respect started with the Hawthorne experiments, initiated in 1920 by Elton Mayo. These tests and their interpretation are the earliest humanistic approaches in organisational psychology. The findings showed the relation between manager’s interest in their human subordinates and the increase of productivity. This conclusion shifted the paradigm towards the importance of social environment, beyond financial rewards for the employees (Morgan, 1988). It took another 60 years before climate was incorporated into management practices, mostly based on misinterpretations of approaches like Taylor’s (1911) scientific management (ibid). The human aspect was completely forgotten by the managers, who put the theories into practise and just focused on the structural boundaries. Organisational climate research became a method to understand the individual behaviour in an organisation (ibid).

Historically climate research is built on different group and organisational studies, which helped to develop the perspective of how individuals interact with their environment (Lewin, 1951). The inclusion of researchers as Lewin and their psychological orientation improved the understanding of the interactional perspective of climate. Lewin (1951) discovered that there is a function between an individual’s behaviour and a situation.
The individual interprets the situation based on psychological factors, and creates “his/her” individual climate and react accordingly. Lewin’s function applied to an organisation, all members of the organisation acts as one collective in the same way as one individual and creates their “climate”. Organisational climate is the summary of the individual’s perceptions of the situation in an organisation (James & Sells, 1981).

This view of climate in an organisation makes it feasible that climate influences individual climate through the perception of the climate itself (Schein, 1990). Not all of those perceptions are observable; some of them are deeper and mystical and are studied in culture research.

2.2.4 Culture

According to Schein (1990), culture and climate are closely related or even depending on each other. Culture has its roots in sociological studies and plays a central role in societies as it represents a “system of values and meanings shared by a group or society including the embodiment of those values and meanings in material objects” (Popenoe, 1980, p. 128). The culture’s development is based on other sociological concepts as climate, society, individuals, groups and organisations. After the culture is established, to a certain extent, those concepts lose their influence and culture starts influencing them (ibid). More so, culture is considered a stable and unique construct, and its members learn culture by observation of other members. However, culture is not a closed system; it evolves over time as the surrounding environment changes. Those external influences are not the only source of cultural change; the most common reason for this change is innovation. New ideas created by the members can change the shared values and meanings (ibid).

In organisations, culture is represented on multiple levels (Schein, 1990). There is a high possibility that every geographically separated factory, building or even department can develop their own sub-social systems and therefore, own cultures (Ekvall, 1987). Those subcultures are not entirely different to the main culture of the organisation since they share a common history based on the founder’s goals and values that are embedded in the company’s culture (Schneider, 1987). However, there is a possibility that the subcultures might be in conflict with each other or existing entirely independent (Schein, 1990). The study of culture is a newer research field and covers aspects left open by climate studies (ibid). Combining culture and climate, climate is the observable manifestation of the deeper basic culture. Typical manifestations are behaviours, attitudes and feelings of the organisation members (Ekvall, 1991).

It has been stated in the previous paragraphs that climate is the observable manifestation of the deeper values and assumptions based culture of the organisation. Climate has the tendency to influence the individuals in the organisation through the summarised perceptions of the climate, but all those findings are still not sufficient to answer the question: what is needed to cultivate creativity?
This is because they are describing how climate and culture influence the individuals, but not which particular perceptions of climate are influencing individual creativity and how to change those perceptions. Studies in creative climate research are trying to answer those questions.

### 2.2.5 Creative climate

Similar to climate studies most of the involved researchers in creative climate studies have their roots in social psychology and investigating the influencing factors on the organisational members (Hall, 1980). The research started on the individual level as identification of common factors, the assessment and the cognitive abilities of creative people and the influence of training. After this period, the focus changed towards group, societies, families, classrooms and organisational environments. Creative climate research acknowledges a complex interaction between the individual's capability and the environment's resources to support these, based on Lewin's behaviour function theory (Amabile, 1997; Stein, 1986). Furthermore, the creative climate research focuses on the observable aspects of the climate and culture construct. The deeper values and meanings are not directly measurable and capable of being influenced (Amabile, 1997).

Orpen (1990) identified the underlining aspects as supportive leadership, ownership, diversity norms, continuous development, and consistency. Ekvall (1997) presents similar findings; he considers the larger environment, resources, strategic position, architecture and leadership practises as the major dimensions. Those dimensions or aspects indicate to the employees what is important within the organisation. These dimensions can be influenced by rewards, support and expectations.

Different instruments have been developed for assessing the creative climate. These instruments measure the respondent’s perception of their environment within a unique setting such as a department of an organisation (Ekvall & Arvonen, 1984). Based on his long research experience Ekvall created the creative climate questionnaire Creative Climate Questionnaire (CCQ) 2, which had 50 questions covering ten different scales with five items each. The resulting scores represents the organisation’s creativity based on the answers of the members of the organisation. This instrument allows measuring the creative climate in a quantitative way and allows ranking the organisations innovation capability either as “innovative” or “stagnated” (Ekvall, 1997).

“What is necessary to cultivate creativity?”

After the elaboration of the right environment for creativity and the definition of the individual prerequisites, the answer what is necessary to cultivate creativity is the following:

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2 Within this study, the creative climate questionnaire is used for triangulation of the findings to answer the research aim how the innovation process affects creativity. For the assessed dimensions and their definition see Appendix 8.7
Theoretical background

• To cultivate creativity, the prerequisites of the individual process and the right environment need to be present. Whereby the individual process includes the individual’s ability, personal experience, motivation, and knowledge.

• Furthermore, it was found that climate and culture are representing the organisational environment and climate is the observable manifestation of the deeper culture.

• The observable aspects of climate are capable of being influenced and, therefore, the only way to influence the environment.

The following Figure 5 displays the relations between creativity, culture and climate elaborated in this subchapter.

Figure 5: Visualization of the relation between creativity, culture and climate.
2.3 A conceptual framework

This section connects the two theoretical pillars of this study towards a conceptual framework in order to support the aim and the answers of the research questions. To link the theories together, potential connection points are evaluated and presented. Also, the way of using the conceptual framework for the fieldwork and analysis is elaborated.

2.3.1 Creativity influencers

To recap the aim of this study it was to unveil the mechanisms between the innovation process creativity, and in a manufacturing company. Due to the different nature of both concepts and no obvious connection points, there is a need to create a framework that presents links between the innovation process and creativity.

Within the literature enablers and prerequisites for creativity were found in the previous subchapter. Examples for enablers were collaboration and diversity in teams, reduced bureaucracy, allow the employees enough time for personal projects, and leaders need to challenge, motivate and decrease the fear of failure (Amabile & Khaire, 2008).

Reconsidering the basic theory in the literature review above, creativity is a combination of thought processes, personal experience, motivation, knowledge, social interactions, and environmental influences (Ford, 1996; Amabile, 1998). Alternatively, more simplified creativity prerequisites are the individual process and the right environment, whereby process stands for the new combination of knowledge elements and principles (Ekvall, 1997).

The environment is represented by the climate that is embedded in the organisational culture (Schein, 1990). As mentioned in the theoretical background, the climate is represented in the behaviours, attitudes and feelings of the organisations members and is considered as a part of the culture. Culture characterizes believes, values, assumptions on a preconscious level, the things in the “walls” (Schein, 1990). This inclusion of climate within culture makes climate the observable manifestation of the deep-rooted culture and furthermore an intervening variable within the organisation, their operations and processes (Ekvall, 1991). “The climate has this moderating power because it influences organizational processes such as communications, problem-solving, decision-making and the psychological processes of learning and motivation” (Ekvall, 1991, p. 74).

These considerations lead to the awareness that creativity is influenced by knowledge and creative climate. The two influencers could be the interaction points to connect creativity with the organisation and the innovation process. Support for this assumption is presented within Ekvall’s (ibid) model Figure 6 where he describes the relationship between creative climate and the organisation. Operations and processes are making use of the organisation's resources like people, money and machines and creating different kinds of effects. These effects are visible in the
outcomes, such as products or services of high or low quality; adjusted or entirely new products; company profit or loss. The climate has an indirect influence on the effects, but the effects in return a direct influence on climate and resources as depicted in Figure 6.

Knowledge is a human faculty resulting from interpreted information, facts and skills acquired through experience or education (Turnbull, 2012). In the context of a production system knowledge is related to product knowledge how to produce or develop a product. Therefore, in this study knowledge is related to knowledge used by the involved individuals in the innovation process to develop and produce a product. Based on all those considerations this study uses product knowledge and creative climate as interaction points to assess the influence of the innovation process on creativity. For the evaluation of the influence of the innovation process on those interaction points, assessable properties of the process itself need to be found.

![Figure 6: Ekvall’s causal relationship model of climate. Source: (Ekvall, 1991, p. 75)](image)

### 2.3.2 Innovation process interface factors

Within the theory background, the interfaces between the three sub-processes of the innovation process, according to Figure 1 in section 1.1 and subsequent elaboration in section 2.1.1, were emphasized. Those interfaces are caused by the integration of the sub-processes in the organisation and mediate the entire innovation process. The ability to influence the innovation process predestines the interfaces as
potential interaction points towards creativity. In previous studies, specific factors were identified within the two interfaces that are accountable for influencing the corporation between the departments involved in the innovation process. This study proposes the use of the same factors to assess their influence on product knowledge and creative climate.

Considering the theory found in the literature and the high amount of studies investigating those factors creates the need for summarizing and categorizing them. The factors described in section 2.1.2 and 2.1.3 were categorized depending on their occurrence in the literature in regard to the two interfaces and their thematic familiarities. This categorisation is not aiming to be error free; it should give the research the needed focus and structure. Following the categorisation is shown according the two interfaces depicted in Figure 7 and further described:

**Interface: Technology/Product Development interface**

The three categories made in this interface containing the factors identified by Eldred and McGrath (1997), Daim et al. (2009) and Nobelius (2004) as presented in section 2.1.2.

- The category *Technology scope* contains factors related to knowledge accessibility and complexity as long as technology readiness and technology portfolio.
- In *Transfer management*, factors are included concerning the smooth transition from technology development and product development.
- The last category *Strategic and operational factors* contains factors related to organisational strategy, decision-making and structure.

**Interface: Product Development/Production interface**

For the second interface four categories were created based on the factors identified by Adler (1995), Vandevelde & Dierdonck (2003) and Lakemond et al. (2007) described in section 2.1.3.

- The *Involvement* category contains factors related to the early and active involvement of production during the development phase.
- Within *Product manufacturability*, factors are included concerning the effective collaboration and knowledge exchange between product development and production.
- *Resources and time* considers factors of resource allocation and time pressure.
- The *Communication* category contains communication and physical barrier factors.
2.3.3 A conceptual framework

After elaborating of the interaction points between creativity and innovation process, Figure 7 visualizes the proposed conceptual framework used in this thesis. Creativity is placed in the centre surrounded by the three sub-processes of the innovation process. Organisational climate is building the outer ring of the framework, and the two interfaces are indicated as well as the categories made.

To summarize, the way to assess the influence of the innovation process on creativity in the production system is the following: As there is no possibility to influence creativity directly, creativity is substituted by product knowledge and the creative climate as elaborated in 2.3.1. The investigation of the influence of the innovation process interfaces as visualized in Figure 7 on product knowledge and creative climate will allow assumptions how the entire innovation process affects creativity.

To ensure the focus on the innovation process the factors presented in subsection 2.3.2 were used as the guideline for the fieldwork, and structure the investigation of the interfaces, findings, and analysis. The following Table 1 shows the proposed structure of the investigation whereby every category is investigated for their influence on product knowledge and creative climate. Furthermore, the creative climate within the companies and how the product knowledge is maintained is evaluated for connections towards the innovation process.
To support this intention the departments involved in the innovation process are studied in two case companies to find the needed evidence.

Table 1: The categorisation for guiding the fieldwork and analysis

<table>
<thead>
<tr>
<th>Creativity interaction points</th>
<th>Interface 1</th>
<th>Interface 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Technology/Product Development</td>
<td>Product Development/Production</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Technology scope</td>
<td>Involvement</td>
</tr>
<tr>
<td></td>
<td>Transfer Management</td>
<td>Product manufacturability</td>
</tr>
<tr>
<td>Creative Climate</td>
<td>Strategic and operational factors</td>
<td>Resources and time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Communication</td>
</tr>
</tbody>
</table>
3 Method and implementation

This chapter focuses on the methodology in this study, including the research design, the chosen methodological instruments, the research process and the case companies as a resource for the data collection.

3.1 Research design

This section describes the underlying methodological considerations for this study.

3.1.1 Two single case studies

The research approach used in this thesis is a two single case study design (Eisenhardt, 1989; Yin, 2009). The following considerations led to the chosen research strategy.

Within the previous chapters, it was argued that the dependencies between the innovation process and creativity are not well explored. In particular the influence of the interfaces between the sub-processes remain a black box which provided the base for the aim and research questions of this study which were:

1. How does the innovation process affect the creativity in a manufacturing company?
2. How do the innovation process interfaces affect information exchange between the involved departments?

This research endeavour has a partly explorative nature and tries to contribute to a new perspective on the mechanisms between the innovation process and creativity. Miles and Huberman (1989) suggest that qualitative data analysis is powerful in assessing causality, exploring “black box” phenomenon and explaining the mechanisms involved. They go on to state those explanations of good “why” and “how” questions requires going beyond sheer association to see the real mechanism of influence in a particular setting. The reasons to apply a single case design in two companies are the following: Firstly, the research ambition is the understanding of the interaction between innovation process and creativity by explaining the mechanism of the innovation process interfaces - creativity relationship (Eisenhardt, 1989). Secondly, the study is explorative aiming to develop theory rather than generalization (Yin, 2009). In this thesis, the research was conducted in two manufacturing companies with complete in-house innovation process where each company represents one case. The application of a comparative strategy was regarded helpful to understand the phenomenon in two different environments and the possibility of polar results (Eisenhardt, 1989).

The unit of analysis used is the innovation process. However, the innovation process could not provide the explicit knowledge needed to fulfil the research aim. For this study the unit of observation has the higher importance and is represented
by the key individuals identified according the research purpose (Grünbaum, 2007). Those key individuals are the “heart” of the case and are directly or indirectly involved in the innovation process and creative work. These persons can provide information about the investigated phenomenon.

3.1.2 Case selection

Based on chosen case study research method, two companies, Kongsberg (Driveline) AB and Fagerhult AB, were available for the intended research. Both companies were located in Jönköping County, Sweden, had different historical backgrounds, and faced different external challenges. In addition to that, they were mature manufacturing companies with a complete in-house innovation process and had approximately the same amount of employees. They faced the same wider industrial context, had similar core production capabilities and organisational structures. Furthermore, the job roles were comparable, and they were fostering innovation with distinctive processes. A particular and unique similarity was that both companies performed technology development, product development and production in the same local area, Fagerhult especially even in the same building complex. Another fact was that the employees had been working for many years in the respective company or beforehand in the other firm.

The two case companies fulfilled the need to control the “extraneous variation” (Eisenhardt, 1989, p. 573) because the investigated phenomenon was a part of the organisations’. Furthermore, they provided samples of polar types as they operated in different markets with particular products and strategies (Pettigrew, 1990). Therefore, their organisational cultures varied and influenced people's view of innovation and creativity as well as the companies’ innovation initiatives. Based on those differences divergent results were expected (Yin, 2009). Moreover, the similarities in their organisation setup ensured the balance between the cases (Stake, 1995).

For a detailed comparison of the companies see Appendix 8.1

3.1.3 Case companies

Two Swedish manufacturing firms were the case companies, one in the automotive industry and the second in light solutions. For a better context understanding both firms are briefly introduced.

*Kongsberg Automotive (Division Driveline)*
Kongsberg was one of the leading subcontracting companies in the automotive business. The company had its origins in Norway, a defence and weaponry company, which began producing brakes and drive shafts for Volvo in the late 1950’s. Those days the company operated in four different business areas: Vehicle interior, Driveline, fluid transfer and driver control. This study focused on the company’s facilities located in the Jönköping area that hosted a part of interior and driveline business. Furthermore, Global Tech centre for the business areas Driveline
and Interior (EU) was located there. The revenue of the plant was exceeding the 100 million Euro, had 550 employees and the product range included gear shifters, head restraints, and injection moulded parts, crash brackets, stamped parts, expansion tanks and on-board chargers. Since 2013, a new innovation process called Knowledge Building Development (KBD) was implemented, and a strategy change towards driving the market instead following it has taken place.

**Fagerhult**
Fagerhult was a core member of the Nordic Region’s largest lighting group and one of Europe’s leading players in the industry. The company had a 70-year-old history with headquarter in the wider area of Jönköping and operated in more than 20 countries. The group had 2300 employees whereby approximately 700 were working in Habo the actual Fagerhult AB. Within Fagerhult AB, the main product areas were indoor, retail and outdoor lighting solutions. New products were introduced twice a year as end user catalogue products specialized customer orders for large projects. A recent investment has been made into the new LED technology with an own production of LED strips for various product applications. Fagerhult AB was maintaining a close relationship with several universities and actively promoted new technologies; the internal high-tech laboratory for testing and developing lighting solutions supported this also. The internal innovation process was considered as mature and stable but was facing continuous challenges with newly introduced technologies or changing market requirements. Within this thesis, Fagerhult AB in Habo was studied, not the entire group.

### 3.1.4 Choice of methodological instruments

The selection of the methodological instruments was based on the chosen case study design and the case companies. To strengthen the construct validity of the study multiple data sources were used to “triangulate” the results (Yin, 2009). Moreover, with the usage of different methodological instruments a wider understanding of the cases could be expected. According to Williamson (2002) different data collection methods are suitable for case studies. In this study, the chosen methods were interviews, questionnaires and focus groups.

**Questionnaires**
The reason for choosing questionnaires was to describe the context of the cases, add further evidence to the findings and compare the status of both firms. Also, there was a need to collect a larger amount of data in a short time within a wider range of employees. The questionnaires were chosen based on their acceptance in research papers and the actuality in the particular research topic. With the Creative Climate Questionnaire (CCQ) the organisational creative climate was assessed. The questionnaire contains fifty questions based on a ten-dimension model of climate; “Challenge, Freedom, Idea Support, Trust/Openness, Dynamism/Liveliness, Playfulness/Humour, Debate, Conflicts, Risk-taking and Idea time” (Ekvall, 1997, p. 86). One five-question block represents one climate dimension. The second questionnaire the “interface assessment tool” (IAT) was used to identify the challenges “technological and market uncertainty, product and production complexity, and
geographical and organizational dispersion” (Lakemond et al., 2013, p. 40). This tool covers the whole new product development process (NPD) and offers advice on improvements. It furthermore provides insights on the status of a project and delivers measurable data to trigger improvements and the identification of their root causes.

**Interviews**
The unit of observation of this case study is the explicit knowledge gained from the key individuals identified according to the research purpose. To access this knowledge, interviews were chosen because they allowed collecting the individuals experience working in the innovation process, in a richer and more complete way (Williamson, 2002). The interviews were more suitable to control the environment as required for case studies (Eisenhardt, 1989). While, for the orientation study (Table 2), unstructured interviews were chosen to get an overview of the case companies and identify the key individuals for the main study. Within the main study (Table 2), semi-structured interviews were used to get in depth knowledge about the targeted specific research field but still give room for additional information. Additionally, it was necessary to have the possibility of adjusting the questions during the interviews if unexpected facts appeared and further clarifications were required (Williamson, 2002).

**Focus groups**
Using focus groups in the main study (Table 2) had three particular reasons. First, to collect additional knowledge about the main topics found during the semi-structured interviews. Second, there was a need to have a further source for data triangulation (Yin, 2009). Third, to compare individuals’ opinions with opinions made within a group for correlation. All those requirements could be covered by a focus group, and it provides enough room to adjust the group interview based on the situation (Bryman & Bell, 2007).

**Overview table of the used methodological instruments**
The table below shows the methodological instruments used in this study and the number of executions. Further details will be presented later in this chapter.

<table>
<thead>
<tr>
<th>Data collection tool</th>
<th>Kongsberg Respondents</th>
<th>Fagerhult Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploratory unstructured interviews</td>
<td>n = 10</td>
<td>n = 8</td>
</tr>
<tr>
<td>Questionnaire 1 (CCQ)</td>
<td>n = 22</td>
<td>n = 29</td>
</tr>
<tr>
<td>Questionnaire 2 (IAT)</td>
<td>n = 23</td>
<td>n = 27</td>
</tr>
<tr>
<td>Semi-structured interviews</td>
<td>n = 8</td>
<td>n = 7</td>
</tr>
<tr>
<td>Focus groups</td>
<td>n = 6</td>
<td>n = 12</td>
</tr>
</tbody>
</table>
3.2 Research process

The whole research process can be divided into two phases; orientation study and the main study. During the orientation study the development of the conceptual framework including conducting the literature research was done.

3.2.1 Orientation study

Before the main study started, 18 exploratory interviews with company employees were conducted to get an overview of the companies and their innovation processes as depicted in Table 3.

<table>
<thead>
<tr>
<th>Role</th>
<th>Kongsberg</th>
<th>Fagerhult</th>
<th>Role</th>
<th>Kongsberg</th>
<th>Fagerhult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstruct. Int.</td>
<td>Location</td>
<td>Duration (approx)</td>
<td>Unstruct. Int.</td>
<td>Location</td>
<td>Duration (approx)</td>
</tr>
<tr>
<td>Role did not exist</td>
<td></td>
<td></td>
<td>Role did not exist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R+D manager</td>
<td>1</td>
<td>Silver</td>
<td>1 hour</td>
<td>1</td>
<td>Lux</td>
</tr>
<tr>
<td>Design engineer</td>
<td>2</td>
<td>Silver</td>
<td>2 x 1 hour</td>
<td>1</td>
<td>Lux</td>
</tr>
<tr>
<td>Plant manager</td>
<td>1</td>
<td>Silver</td>
<td>1 hour</td>
<td>1</td>
<td>Lux</td>
</tr>
<tr>
<td>Production engineer</td>
<td>1</td>
<td>Silver</td>
<td>1 hour</td>
<td>1</td>
<td>Lux</td>
</tr>
<tr>
<td>Product manager</td>
<td>Role did not exist</td>
<td>1</td>
<td>Lux</td>
<td>1 hour</td>
<td></td>
</tr>
<tr>
<td>Project leader</td>
<td>2</td>
<td>Silver</td>
<td>2 x 1 hour</td>
<td>1</td>
<td>Lux</td>
</tr>
<tr>
<td>Category Manager</td>
<td>1</td>
<td>Silver</td>
<td>1 hour</td>
<td>1</td>
<td>Lux</td>
</tr>
<tr>
<td>Innovation Manager</td>
<td>1</td>
<td>Silver</td>
<td>1 hour</td>
<td>1</td>
<td>Lux</td>
</tr>
<tr>
<td>Process Manager</td>
<td>Role did not exist</td>
<td>1</td>
<td>Lux</td>
<td>1 hour</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>10 hours</td>
<td>8</td>
<td>8</td>
<td>8 hours</td>
</tr>
</tbody>
</table>

* The interviews were held in the same meeting rooms in the companies with the mentioned names.

The supervisors allocated by the case companies made the initial contact with the employees. In case of Kongsberg, the supervisor was the LEAN Champion and for Fagerhult, the industrialization manager. During the interviews the topic was introduced, our personal backgrounds presented and it was assured that it was in the companies’ interest to participate. To identify further interviewees, a snowball principle was used. This approach allowed acquiring a general understanding of the company and how the innovation process works in reality. Interviews in this phase were held completely unstructured aiming to collect as much information as possible. The only limitation was given by the topic of the research and the intended outcome.

These interviews helped to identify the key individuals for the further semi-structured interviews in the main study. It was important to choose people directly involved in the innovation process, as they have the specific knowledge about the desired topic. Therefore, the key individuals included both management positions and employees with functional roles (e.g. development, design, production etc.).
Other job functions were considered as well, to increase the potential for further findings based on an outside view on the innovation process (e.g. purchasing, market management). Besides the job role considerations the choice of the respondents also followed the idea to have all parts of the innovation process represented. Moreover, it was possible to experience the different working environments and compare the existing job roles in the companies.

### 3.2.2 The literature overview

During the initial phase of the study, the exact field of research was decided, and the research questions were defined. Due to the sheer endless existing theories about creativity, innovation, innovation processes a conceptual framework was needed and developed. It was used to guide the data collection, the structuring and analysis of the findings. The sources for the framework were mainly books and academic reports accessed through the University of Jönköping databases ABI/INFORM Global and Scopus. For identification of relevant sources, the following keywords were used: `creativity`, `creativity climate`, `innovation process`, `new product development`, `enhancing creativity`, and assessing creativity restricted between 1970 and present day. The sources were accessed between January and April 2015, and approximately 40% of the articles could be used after a surface screening. Another applied criterion was the amount of citations by other research papers.

Within the first phase of the literature review, the topics of creativity, innovation and innovation process were in focus. The main output was the awareness that all these topics were not clearly specified and needed some further research. Regarding the topic of creativity, a basic theory about climate, organisational culture and creative climate had to be included. Within the literature research about the innovation process, the attention shifted towards the innovation process interfaces and new product development process (NPD). In combination with the exploratory interviews, the final research questions were defined, and the main study was initiated.

### 3.2.3 The main study

On March 15 the main study was started after the initial orientation interviews, the parallel-executed literature research and creation of a conceptual framework. During this phase, the “Creative Climate Questionnaire” was answered by 51 respondents, the “Interface Assessment Tool” was answered by 50 respondents, 15 semi-structured interviews and two focus groups embracing 18 respondents were conducted. The total fieldwork in the main study took five weeks caused by the availability of the key persons. Following the conducted methods are chronologically listed and explained.

**Creative Climate Questionnaire (CCQ)**

Within this thesis, the CCQ was used to assess the creative climate of the two case companies, add further evidence to the interview findings and compare the two firms. The questionnaire contains 50 questions based on a ten-dimension model of
climate; “Challenge, Freedom, Idea Support, Trust/Openness, Dynamism/Liveliness, Playfulness/Humour, Debate, Conflicts, Risk-taking and Idea time” (Ekvall, 1997, p. 86). One five-question block represents one climate dimension. All questions were put into an online survey tool in the Swedish language to assure understanding of the questions, as they consider soft factors/feelings. To reach all relevant employees, the previously identified key-persons were asked to distribute the link to the questionnaire via email to their peers. This way of distribution created a high response rate (Kongsberg 85%, Fagerhult 90%) and the ensured the significance of the respondents.

**Interface Assessment Tool (IAT)**

Within this thesis, the Interface Assessment Tool was used to assess the challenges of the innovation process in the two case companies, add further evidence to the interview findings and compare the two firms. The questionnaire contains 24 questions to discover challenges in “technological and market uncertainty, product and production complexity, and geographical and organizational dispersion” in NPD projects (Lakemond et al., 2013, p. 40). In this study, the questionnaire was used to assess challenges the case companies were facing in their innovation process and not specifically in one NPD project. All questions were put into an online survey tool in English language to assure understanding of the questions. To reach all relevant employees, the previously identified key-persons were asked to distribute the link to the questionnaire via email to their peers. This way of distribution created a high response rate (Kongsberg 88%, Fagerhult 84%) and the ensured the significance of the respondents.

For both questionnaires the email content described the intention of the questionnaire and included instructions on how to answer the questions. The complete anonymity was ensured as well, and the closing date was mentioned. After ten days, a reminder was sent out to achieve a higher response rate. The assessment of both companies was independent, and no other information about the respondent was collected to ensure anonymity. After 15 days, the online questionnaire was closed, and the results were evaluated according to the key provided by the CCQ and IAT. An overview about duration and respondents according to the case companies is given in Table 4.

<table>
<thead>
<tr>
<th></th>
<th>Kongsberg</th>
<th></th>
<th>Fagerhult</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Questionnaires</strong></td>
<td><strong>Respondents</strong></td>
<td><strong>Duration</strong></td>
<td><strong>Respondents</strong></td>
<td><strong>Duration</strong></td>
</tr>
<tr>
<td>Creative Climate (CCQ)</td>
<td>n = 22 (N = 26)</td>
<td>15 days</td>
<td>n = 29 (N = 32)</td>
<td>15 days</td>
</tr>
<tr>
<td>Interface Challenges (IAT)</td>
<td>n = 23 (N = 26)</td>
<td>15 days</td>
<td>n = 27 (N = 32)</td>
<td>15 days</td>
</tr>
</tbody>
</table>

3 The CCQ was originally developed in Swedish and used in various studies (Ekvall, 1997).
4 The IAT is developed in English and no official Swedish translation was available.


Interviews
The semi-structured interviews were used in the main study as the primary data source to collect the targeted knowledge about the specific research field. According to the unit of observation the respondents’ descriptions about what they experienced during creative work was an important source of information. Further allowed interviewing the key individuals in a structured way but still letting them enough room to add further information. The interview questions were following the logic to cover all parts of the theoretical framework, especially considering the interfaces and creativity (see Appendix 8.2). One of the ideas behind structuring the questions as visible in Appendix 8.3 was to provide themes for discussions rather than ask for direct answers from the respondent and act as a guide during the interviews. This kind of construct allowed us to adjust the interviews depending on the flow and other points of interest. The question topics were sent beforehand via email to the interviewees to give them an idea about the upcoming interview.

All the interviews with the key individuals were organised individually in the companies’ premises in the same meeting rooms; “Lux” in Fagerhult and “Silver” in Kongsberg (for further information see Table 5). Using the question guideline the interviews started with the main questions and when necessary the more detailed sub-questions were asked as depicted in Appendix 8.3. Depending on the flow of the on-going interview, the questions were varied to not interrupt the interviewee. During the interviews one of us asked the questions, while the other one took notes, in order to not distract the respondent and ensure that all questions from the guideline were covered. Then we asked for real life examples about what they did, or what the company did in specified experiences to reduce the risk of standardised answers. All interviews were recorded, with a mobile device in MP3 format, for later transcription and analysis. The transcription was done after the interview on the same day and sent to the interviewee for approval. The interviews had an average duration of 45 minutes. Based on the evidence from these interviews the topics for the focus groups were determined.

Focus groups
To validate the accounts given during the semi-structured interviews, a one-hour focus group in each case company was held with in Kongsberg 6 and Fagerhult 12 participants and we acted as moderators. The participants were predominately the same key individuals as during the semi-structured interviews, but other employees were invited as well. The groups were equally divided into two sets and supervised by one of us. They were asked to discuss three significant findings of the interviews “being creative”, “being involved” and “information exchange”. Next, they had to give an account what restricts and drives them to be “creative, involved or exchange information”. This way of discussion concluded in a simple force field analysis based on Lewin (1951) for every topic what provided additional insights. After 30 minutes, the two groups’ findings were presented to each other and discussed in the whole group.
Main study overview
The table below shows the job roles of the interviewed persons and the participants of the focus groups.

Table 5: Main study overview about conducted semi structured interviews (n = 15) and focus groups (18 respondents)

<table>
<thead>
<tr>
<th>Role</th>
<th>Kongsberg</th>
<th>Fagerhult</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Semi-struct. Int.</td>
<td>Duration</td>
</tr>
<tr>
<td>R&amp;D manager</td>
<td>1</td>
<td>44 min</td>
</tr>
<tr>
<td>Design engineer</td>
<td>1</td>
<td>52 min</td>
</tr>
<tr>
<td>Plant manager</td>
<td>1</td>
<td>51 min</td>
</tr>
<tr>
<td>Production engineer</td>
<td>1</td>
<td>43 min</td>
</tr>
<tr>
<td>Product manager</td>
<td>Role did not exist</td>
<td></td>
</tr>
<tr>
<td>Project leader</td>
<td>2</td>
<td>2x45 min</td>
</tr>
<tr>
<td>Category Manager</td>
<td>1</td>
<td>40 min</td>
</tr>
<tr>
<td>Innovation Manager</td>
<td>1</td>
<td>41 min</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>361 min</td>
</tr>
</tbody>
</table>

3.2.4 Data analysis

The approach used for the data analysis was divided into three steps; first the transcribed interviews were summarised and combined according the categorisation in chapter 2.3.3. The summaries were created by reading the transcripts several times and using the conceptual framework to identify the for the aim relevant answers. Answers given by the majority of the interviewees where no contradictions could be found were considered representative. Then, the interview summaries containing illustrative quotes were used to back up the connection to reality. All results gained from the semi-structured interviews are presented as case findings in combination with the questionnaire and focus group results in the two case chapters 4 and 5. The results gained from the focus groups were not further summarised and representing the status what the group agreed on.

Secondly the in-case data gained from the interviews, focus groups and questionnaires were combined and analysed for reoccurring patterns (Eisenhardt, 1989). The start for identification the patterns was the previously made categorised case summaries of the semi-structured interviews. In order to identify patterns, the summaries were further condensed, and statements created, every statement was checked for his occurrence in both cases as agreement or polar finding. Furthermore, the patterns were in the next step checked for support in the results of the questionaries’ and the focus groups to increase their validity (triangulation). Case specific statements without the support of the other instruments were checked for their relevance to the aim and either excluded or
added. The results of the second step are presented in this report in the Appendixes from 8.4 till 8.6.

Thirdly, the patterns were analysed and discussed according to the theory and the proposed conceptual framework in subsection 2.3.3 to answer the research questions. The identified patterns in the categories product knowledge and creative climate were analysed for connections towards the innovation process and discussed in relation to theory. Every pattern identified in the interfaces was checked for their influence on either creative climate or product knowledge and their support in the theory. The results of this third step were directly used to answer the research questions.

3.2.5 Summary research process

Summarising the above-described research process, the research questions and the conceptual framework were developed along with the collection of data and their qualitative analysis. This way of study is known as abductive approach (Alvesson & Sköldberg, 2009) in which theory is adjusted according to empirical findings (Dubois & Gadde, 2002). The reason to use the abductive approach was that preconceptions had to be made for the first orientation study. During the orientation study evidence was found that helped us to narrow down the literature review and confirm the presumed literature gap. The theory interpretation started based on the identified literature gap and the presumed underlining causal mechanism (Haig, 2008). As a starting point, the existing theories about innovation process and creativity were explored to understand and explain the mechanisms behind the phenomena.

An initial conceptual framework was built based on the literature review in order to narrow down the key elements to assist the data collection in the main study (Miles & Huberman, 1994). Moreover, the concept was used to structure the case findings and the following analysis.

The findings from the questionnaires, semi-structured interviews and focus groups of the main study are presented in the next two chapters.

3.3 Expected reliability and validity

The question of the reliability and the validity of this study is the question of its trustworthiness. For increasing the trustworthiness, all research steps are described in Chapter 3, which allows repeating the study under similar conditions. Additionally, the chosen methodological instruments of questionnaires, interviews and focus groups were considered suitable for the explorative nature of this study.

Based on the suggestions of Yin (2009) for improving the internal, construct and external validity of the study, various actions have been taken. To increase the construct validity the conceptual framework was used to keep the collected data consistent, and the evidence is triangulated from different sources with the target of
corroboration. The internal validity was secured with the abductive approach of this study where existing iterative theory was compared with theory emerged based on the empirical findings (Silverman, 2006). Due to the explorative approach of this study and the lack of similar research the external validity was improved by comparing the findings with related theories and research.

Summarized, the expected reliably and validity of this study is high as all actions were taken to improve both aspects. Therefore, the results should be used as “tendencies” and not as generalizable results as the study is explorative and just to a limited extend theory building. Companies in a similar situation might have a more valuable use of the results. The final discussion will be presented in chapter 6.
4 Findings Case Kongsberg

This chapter contains the findings of the case company Kongsberg. The way of presenting follows the chronological order of the used instruments. Furthermore, the interview findings are organised according to the categorisation described in chapter 2.3.3.

4.1 Questionnaires

Following this subsection contains the results from the questionnaires.

4.1.1 Creative climate questionnaire (CCQ)

The CCQ was used to assess the creative climate of the case company, to add further evidence to the interview findings and compare the two firms. The questionnaire contains fifty questions based on a ten-dimension model of creative climate; “Challenge, Freedom, Idea Support, Trust/Openness, Dynamism/Liveliness, Playfulness/Humour, Debate, Conflicts, Risk-taking and Idea time. (Ekvall, 1997, p. 86) One five-question block represents one climate dimension. The respondent should answer each question choosing from a scale of 0 to 3, whereby 0 stands for “in alls” (not at all) and 3 stands for “i høg grad”(highly). For further explanations about dimensions see Appendix 8.7 and continuative interpretations the paper published by Ekvall (1997).

Table 6 shows in the first row the according to the key interpreted answers of 22 participants from Kongsberg. The second row displays the average score of other Swedish companies. This average is based on research made by Ekvall (1997) in his studies about creative climate. A low score indicates less support for creativity in this particular dimension. Only in the dimension conflict, a lower score indicates a better result. If all dimensions are lower than the average the company can be considered as uncreative.

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Freedom</th>
<th>Idea support</th>
<th>Trust/Openness</th>
<th>Dynamism/Liveliness</th>
<th>Playfulness/Humour</th>
<th>Debate</th>
<th>Conflict</th>
<th>Risk-taking</th>
<th>Idea time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Res.</td>
<td>1.45</td>
<td>1.6</td>
<td>1.5</td>
<td>1.3</td>
<td>1.3</td>
<td>1.45</td>
<td>1.5</td>
<td>1.35</td>
<td>1.35</td>
</tr>
<tr>
<td>ø</td>
<td>1.9</td>
<td>1.74</td>
<td>1.64</td>
<td>1.6</td>
<td>1.55</td>
<td>1.69</td>
<td>1.28</td>
<td>0.88</td>
<td>1.12</td>
</tr>
</tbody>
</table>
4.1.2 Interface Assessment Tool (IAT)

The questionnaire contained 24 questions to discover challenges in “technological and market uncertainty, product and production complexity, and geo-graphical and organizational dispersion” in company’s innovation projects. Each of the statements describes a circumstance that may represent a challenge that could threaten the project’s success. Each person should rank each statement on a scale from 1 to 6, while 1 indicates “completely disagree” and 6 indicates “completely agree” with the statement as it applies to the project.

The cumulative score for a given challenge indicates the risk that the challenge may disrupt the project. Lakemond et al., (2013) provides specific instructions for the interpretation of the result, which contains three scales. 1) If the cumulative score is equal or below 13, it indicates that no special attention is needed, 2) if it is between 14 and 19 active monitoring is necessary, and finally 3) if the score is above 20 preventive managerial actions should be taken. The results of this questionnaire and the interpretive instructions are presented below in Table 7. In total 23 employees answered the questionnaire.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market uncertainty</td>
<td>14</td>
</tr>
<tr>
<td>Technological uncertainty</td>
<td>16</td>
</tr>
<tr>
<td>Product complexity</td>
<td>17</td>
</tr>
<tr>
<td>Production complexity</td>
<td>16</td>
</tr>
<tr>
<td>Organisational separation/technology development and product development</td>
<td>15</td>
</tr>
<tr>
<td>Organisational separation/product development and production</td>
<td>15</td>
</tr>
</tbody>
</table>

Interpretation of Table 7 results

1. Score \(\leq 13\) = No special attention is needed
2. Score \(14 - 19\) = Active monitoring is necessary
3. Score \(\geq 20\) = Take preventive managerial actions.

4.2 Interviews

The interview findings are organised according to the categories described in Table 1 in chapter 2.3.3. Firstly the findings about the creativity interaction points, product knowledge and creative climate are presented. Secondly the findings of the interface technology development/product development are presented according to the categories Technology scope, Transfer management and Strategic and operational factors. Thirdly the findings in the second interface product development/production are
presented according to the categories Involvement, Product manufacturability, Resources and time and Communication. All information is purely based on the answers given by the interviewees in the eight semi-structured interviews of the main study.

Note: Because of confidentially agreements, no specific job roles or other personal information are mentioned, in order to avoid the identification of the specific respondent.

4.2.1 Creativity interaction points

Product knowledge
Knowledge building was a major topic within Kongsberg. The innovation process was foreseeing pre-creation of knowledge and concepts for later stage usage. Key persons for this knowledge building were the “knowledge owners”. Experienced senior employees specialised in a particular area held this particular role. They had to document core information for everyone understandable in the product life cycle management (PLM) system. They acted as single point of contact to collect new knowledge made during projects in their area of specialty. During the time of the interviews, this role was introduced two years ago, and the documentation process of existing knowledge was still in progress. Another attempt to enrich knowledge was a global manufacturing group, containing production experts from all sites of Kongsberg. The idea was to bring in experience from production into the early phases of the innovation process.

It is worth to mention is that Kongsberg was not aiming for completely new or radical ideas. They targeted an incremental approach that created small improvements, which could lead to a whole new product or solution (Product generation strategy). The underlining strategy was to invest money in pre-developments without concrete customer request rather than in complete new product solutions.

Creative climate
The opinions about the creative climate within Kongsberg were varied quite a bit between the interviewees. They perceived that the biggest restrictions for a creative climate were time pressure, not enough resources, high workload and too much stress involved during the projects. The variation of opinions was also visible in their view about Kongsberg’s ability to be creative. They saw Kongsberg as less creative in creating complete new ideas but as very good in problem-solving. This was furthermore distinguished between the departments and recently created market fields. The global development centre, also called Tech-Centre, was considered to be the heart of new idea generation and innovation. Other departments were higher rated in their ability to solve problems.

There were also positive thoughts about the creative climate. One thing in particular everyone positively agreed on was the newly introduced process for dedicated innovations was a step in the right direction. Within this process, new ideas could be proposed to a steering group that was authorized to invest money and time in promising projects. Those projects were offering a better opportunity to be creative.
as there was no actual customer request behind. Four of the interviewees experienced enough room to be creative and felt supported by the company or their managers in their ambitions. Moreover, it was mentioned that there were particular individuals who were the source of new ideas, inspired others and just knew what to do. Some of them had worked quite long in the organisation and built an extensive contact network. A manager mentioned in this context that those creative individuals worked best alone and were good in out of the box thinking:

“One designer is very creative and has an extreme quality in his work. One time I tried to control him in detail, which limited his performance. The only solution was to let him work alone and have trust in his work. The only problem was the lack of information flow towards the other team members; they could not continue working.”

A different aspect often mentioned, was the relationship between time pressure and the innovation process. Five respondents considered the predefined innovation process itself as a limitation on their creativity within the organisation. It highly depended on the person how to escape from the strict boundaries and find some time to be creative. Similar to this topic was a manager’s statement that it is very difficult to create a creative climate, space and protect the creative people under permanent time pressure.

4.2.2 Interface technology development / product development

Technology scope
The level of product knowledge within Kongsberg was considered by the interviewees to have an average level of complexity. It was focused on how to build products, create adaptations and solve product related problems. The respondents gave an account that the involved employees in a project owned the specific knowledge. Therefore, it was considered as important to identify those people and save their experience in case of them leaving the company. One attempt within Kongsberg to secure this experience was, those employees trained a newly entered employee. This approach had the further benefit that the new employees had the opportunity to build their own contact network. Such a contact network was considered as essential as there was no database or intranet page, which provided contact information to specific knowledge owners.

Most of the respondents had the opinion that the access to product knowledge in Kongsberg was difficult, especially when it was stored in the product lifecycle management system (PLM). The PLM system represented the core database for all product related information of Kongsberg. Not all employees considered the system as a splendid solution as it was perceived not easy accessible, restricted, not user-friendly and particular slow when used outside of the company. It needed a lot of experience to find project specific information because there were no guidelines in which way data had to be stored and organised in the PLM system.
The opinions about the benefit of introducing the role of a knowledge owner were consistent among the interviewees. They agreed that the information flow had improved, the last two to three years, based on the documentation work done by these employees. A particular improvement was that all the product knowledge was centralised stored in the PLM system. Before this reform, the exchange of product knowledge was based on the individual willingness to share.

Transfer management
Kongsberg’s innovation process was respected by the interviewees as a well-structured process and suitable for the company’s needs. It was targeting a multilevel strategy to foster new ideas and knowledge generation before the development started for an actual customer project. At the time of the interviews, this process view was new to the company, and most of the respondents admitted that they were still working with the old serial innovation process.

Specially mentioned by the respondents in Kongsberg’s case was the fact that most of their projects didn’t involve new technology development. Their concept phase was focused on open competitive biddings, were they created a customer specific solution in a very tight time frame. In this phase, all departments were involved, and every bidding was managed as a single project. The handover between the concept phase and the product development phase was not seen as critical as all engineers were working in both phases. Furthermore, 50% of the concepts had to be reworked after a project was won.

Within projects and daily business, the most used communication channels were email, telephone and meetings. The project leaders had the unique responsibility to distribute the project information and decisions among the involved members, due to the fact that the engineers continuously switched between the projects. They were responsible for organising how information was stored in the PLM system, as well. Most of the interviewees were criticising that the way of storing information in the system, was depending on the project leader and was not following any guideline. This situation caused problems with accessing information about a project at a later stage or when the project was finished.

Strategic and operational factors
Kongsberg was facing a change in their strategic orientation to be a pure customer follower towards a customer-proposing organisation. This particular ambition was not easy to achieve, as it required a mind-set change of the employees to think ahead instead of following customer specifications.

A few respondents mentioned that higher management levels were not providing their full commitment to the new company strategy. Therefore, some risks were not taken such as investing money into the development of new technologies or products usable in the future. Five also said, decisions were not transparently communicated, and innovation projects were often setback for an actual customer project. Another critique was the minimalistic actions taken to build knowledge and create concepts in advance.
The interviewees were describing Kongsberg as a traditional manufacturing company with strict rules and roles. This kind of structure was not perceived as very motivating and encouraging to collaborate with other departments. However, this account was partly neglected since they also mentioned to have a friendly and collegial environment.

4.2.3 Interface product development / production

Involvement
Most respondents had the opinion that Kongsberg’s innovation process was not explicitly stating at which status of the project each of the partaking departments had to be involved. They mentioned further that every project should independent on the progress; officially contains representatives from all the involved departments. At that time the situation within the projects was described differently by the interviewees as the involvement was partaking randomly and not in a consistent way. Especially the involvement of the production department was considered as to less.

Furthermore it was explained that there was no natural way of corporation between the involved departments as they still had the typical “island” thinking. A manager expressed this “island” thinking in the way “It is cold outside I am not going to the production”. Moreover, within the entire organisation the knowledge about how the other departments were working was absent.

The members of the product development department presented a slightly different view. They were arguing that during the first phases of a project the concepts were very vague, and an involvement of the production department would be too early. However, they also agreed that the cooperation should be improved and that many mistakes could be avoided. A further agreement among the interviewees was that the knowledge coming from the production department was usually used to solve customer problems and not in developing concepts. In this context, high hopes were set into the global manufacturing group to bring experience from production into the early phases of the innovation process.

During the interviews, there were other accounts given that time pressure and the daily operations were limiting an active involvement from the production department in the projects. Also, regular discussions were missing and in some stages there were too few resources available. Moreover, four of the respondents had the opinion that real technology development should use production processes as a base for their developments.

Product manufacturability
Eight interviewees agreed that getting feedback and information was problematic within Kongsberg as there was no official process of documentation and giving feedback. They mentioned that there was no feedback culture present in the company and the departments involved in the innovation process. This was further explained in terms that there was no information flow back to the development
department after a project was handed over to production. Possible improvements mentioned were job rotation models and that all members of the project teams should work at the same room, at least one day a week. Another suggestion was that the team members representing their department should be more related to the projects and share information between the innovation process departments.

Most interviewees were pointing out that there was no product responsibility in Kongsberg because all products were connected to one particular customer. This situation hindered the information flow after a product was released to serial production. Information about further improvements or changes in the production system was not communicated to the development department. The members of the production department had the opinion that the absence of a knowledge owner in the production could be the reason for this situation. The interviewees also mentioned that “the lessons learned meetings”5 were held in the departments and not in the cross-functional teams, which meant that there was no summarized report of the entire project. Moreover, the different project teams in the innovation process were not sharing information either; there was no platform to discuss issues that other projects were facing. All the information sharing was dependent on the project managers and their way of handling this responsibility.

There were positive examples mentioned about information flow and feedback in Kongsberg. Innovation projects without customer request were fostering an active information exchange between the involved members. Because of the missing customer requirements the members had to consult the knowledge owners of the different departments to define the product specifications. Another example given by the respondents was the highly efficient communication during product launches. In this phase, the product development department and production were working hand in hand to solve upcoming issues to keep the promised delivery date.

**Resources and time**

All interviewed employees gave an account that during the product development and production phases the time pressure was an issue. Particularly during the ramp-up phase of serial production the time pressure was extremely high. The cause of this pressure in the production ramp-up was usually related to delays in the projects.

Most of the respondents perceived the workload in Kongsberg at an acceptable level. Furthermore, resources available were enough to perform the task during the innovation process. One suggestion was that the allocation of resources should be improved. Only the members of the production department were stating a lack of production engineers to handle all projects.

Another resource related account given by the interviewee was that they had experienced a high employee turnover in the past years. In their opinion, this caused additional workload and time pressure as the new employees were not 100% operational.

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5 Lessons learned are a common industry term for meetings done at the end of a project where all problems and their solutions are discussed and documented.
Communication

The description given of the internal communication in Kongsberg was collegial but complicated. All interviewees agreed that the language spoken by the employees involved in the innovation process was Swedish and English was mostly used in communication with suppliers, customers and other manufacturing sites not located in Sweden. The employees involved in the projects were working at the same location in Mullsjö. The buildings were partly separated by distances up to 200m; there was no canteen available but various common rooms.

Four of the interviewees had been working for a long time in Kongsberg and others had just recently joined. This pattern was representative for the other employees working at the Mullsjö site; they were facing a high employee turnover during the last five years. The interviewees were mentioning the missing contact network of the new employees as a limitation in their daily work. They further pointed out that the department managers, project managers, knowledge owners and the global manufacturing group were important contacts.

Five of the respondents mentioned that the exchange of involved employees in the projects was caused by the high average duration of two years. This situation created a great demand on the project leaders to keep the project members updated. Depending on the project leader, this was done either with cross-functional meetings or functional meetings. Within this context the difficulties with informing the remotely located purchasing department were mentioned.

Most of the interviewees experienced an improvement in communication after the Tech-Centre\(^6\) opening, as the entire development department was working at the same open office area. Nevertheless, the communication was still not considered as perfect; there was an over usage of email and not enough face-to-face talking. Furthermore, the active contact with the 100m remote located production area and the production department was still limited.

\subsection*{4.3 Focus group}

The focus group was used to validate the findings of the semi-structured interviews. In Kongsberg, the duration was 1 hour and 6 employees participated. Three main subjects were discussed, and the participants were asked to express their opinions about what motivates them (\textit{driving forces}) and what restricts them (\textit{restricting forces}) to 1) \textit{Be creative}, 2) \textit{Be involved}, and 3) \textit{Exchange information}. The results of the focus groups were concluded in the simple force field\(^7\) analysis based on Lewin (1951) displayed in the following Table 8.

\footnote{6 The global development centre of Kongsberg is called Tech-Centre.}

\footnote{7 For further explanation about force fields see chapter 3.2.3}
Table 8: Focus group results in Kongsberg, (n = 6, Investigated force fields: “Be Creative”, “Be Involved”, “Information exchange” in the context of the innovation process.)

<table>
<thead>
<tr>
<th>Driving Forces</th>
<th>Restricting Forces</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Force field &quot;Be Creative.&quot;</strong></td>
<td></td>
</tr>
<tr>
<td>• Right amount of pressure</td>
<td>• Time pressure-Tight schedule</td>
</tr>
<tr>
<td>• Market competition</td>
<td>• Too process orientated</td>
</tr>
<tr>
<td>• New technology</td>
<td>• Not enough resources</td>
</tr>
<tr>
<td>• Cross-functional teams</td>
<td>• Culture (customer driven company)</td>
</tr>
<tr>
<td>• Knowledge and information sharing</td>
<td>• Lack of support</td>
</tr>
<tr>
<td>• Risk taking</td>
<td>• Problem-solving orientated (fire fighting)</td>
</tr>
<tr>
<td><strong>Force field &quot;Be Involved.&quot;</strong></td>
<td></td>
</tr>
<tr>
<td>• Resource dedication</td>
<td>• Exchange of resources during a project</td>
</tr>
<tr>
<td>• Working as a team</td>
<td>• No dedication of resources</td>
</tr>
<tr>
<td>• Communication</td>
<td>• Departmental thinking (island thinking)</td>
</tr>
<tr>
<td>• Taking responsibility</td>
<td>• Bad communication</td>
</tr>
<tr>
<td>• Efficient use of resources</td>
<td>• Physical distance</td>
</tr>
<tr>
<td><strong>Force field &quot;Information Exchange.&quot;</strong></td>
<td></td>
</tr>
<tr>
<td>• Resource dedication</td>
<td>• No dedication of resources</td>
</tr>
<tr>
<td>• Information sharing</td>
<td>• Exchange of resources during a project</td>
</tr>
<tr>
<td>• Following the process</td>
<td>• Knowledge not easy accessible</td>
</tr>
<tr>
<td>• Early involvement</td>
<td>• Not easy to use PLM system</td>
</tr>
<tr>
<td>• Proper documentation</td>
<td>• No possibility for lessons learned after projects</td>
</tr>
</tbody>
</table>
5 Findings Case Fagerhult

This chapter contains the findings of the case company Fagerhult. The way of presenting follows the chronological order of the used instruments. Furthermore, the interview findings are organised according to the categorisation described in chapter 2.3.3.

5.1 Questionnaires

Following this subsection contains the results from the questionnaires.

5.1.1 Creative climate questionnaire (CCQ)

The CCQ was used to assess the creative climate of the case company, to add further evidence to the interview findings and compare the two firms. The questionnaire contains fifty questions based on a ten-dimension model of creative climate; “Challenge, Freedom, Idea Support, Trust/Openness, Dynamism/Liveliness, Playfulness/Humour, Debate, Conflicts, Risk-taking and Idea time. (Ekvall, 1997, p. 86)

One five-question block represents one climate dimension. The respondent should answer each question choosing from a scale of 0 to 3, whereby 0 stands for “inte alls” (not at all) and 3 stands for “i hög grad” (highly). For further explanations about dimensions see Appendix 8.7 and continuative interpretations the paper published by Ekvall (1997).

Table 9 shows in the first row the according to the key interpreted answers of 29 participants from Fagerhult. The second row displays the average score of other Swedish companies. This average is based on research made by Ekvall (1997) in his studies about creative climate. A low score indicates less support for creativity in this particular dimension. Only in the dimension conflict, a lower score indicates a better result. If all dimensions are lower than the average the company can be considered as uncreative.

<table>
<thead>
<tr>
<th></th>
<th>Challenge</th>
<th>Freedom</th>
<th>Idea support</th>
<th>Trust/Openness</th>
<th>Dynamism/Liveliness</th>
<th>Playfulness/Humour</th>
<th>Debate</th>
<th>Conflict</th>
<th>Risk taking</th>
<th>Idea time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Res.</td>
<td>1.53</td>
<td>1.53</td>
<td>1.804</td>
<td>1.428</td>
<td>1.5</td>
<td>1.53</td>
<td>1.55</td>
<td>1.5</td>
<td>1.53</td>
<td>1.43</td>
</tr>
<tr>
<td>Ø</td>
<td>1.9</td>
<td>1.74</td>
<td>1.64</td>
<td>1.6</td>
<td>1.55</td>
<td>1.69</td>
<td>1.28</td>
<td>0.88</td>
<td>1.12</td>
<td>1.48</td>
</tr>
</tbody>
</table>

Table 9: Results from climate questionnaire Fagerhult
(Respondents= 29, Non respondents = 3)
5.1.2 Interface Assessment Tool (IAT)

The questionnaire contained 24 questions to discover challenges in “technological and market uncertainty, product and production complexity, and geo-graphical and organizational dispersion” in company’s innovation projects. Each of the statements describes a circumstance that may represent a challenge that could threaten the project’s success. Each person should rank each statement on a scale from 1 to 6, while 1 indicates “completely disagree” and 6 indicates “completely agree” with the statement as it applies to the project.

The cumulative score for a given challenge indicates the risk that the challenge may disrupt the project. Lakemond et al., (2013) provides specific instructions for the interpretation of the result, which contains three scales. 1) If the cumulative score is equal or below 13, it indicates that no special attention is needed, 2) if it is between 14 and 19 active monitoring is necessary, and finally 3) if the score is above 20 preventive managerial actions should be taken. The results of this questionnaire and the interpretive instructions are presented below in Table 10 in total 27 employees answered the questionnaire.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market uncertainty</td>
<td>12</td>
</tr>
<tr>
<td>Technological uncertainty</td>
<td>13</td>
</tr>
<tr>
<td>Product complexity</td>
<td>16</td>
</tr>
<tr>
<td>Production complexity</td>
<td>13</td>
</tr>
<tr>
<td>Organisational separation/technology</td>
<td>10</td>
</tr>
<tr>
<td>Organisational separation/production</td>
<td>12</td>
</tr>
</tbody>
</table>

Interpretation of Table 10 results

4. Score ≤ 13 = No special attention is needed
5. Score 14 – 19 = Active monitoring is necessary
6. Score ≥ 20 = Take preventive managerial actions.

5.2 Interviews

The interview findings are organised according to the categories described in Table 1 in chapter 2.3.3. Firstly the findings about the creativity interaction points, product knowledge and creative climate are presented. Secondly the findings of the interface technology development/product development are presented according to the categories Technology scope, Transfer management and Strategic and operational factors. Thirdly the findings in the second interface product development/production are
presented according to the categories Involvement, Product manufacturability, Resources and time and Communication. All information is purely based on the answers given by the interviewees in the seven semi-structured interviews of the main study.

Note: Because of confidentiality agreements, no specific job roles or other personal information are mentioned, in order to avoid the identification of the specific respondent.

5.2.1 Creativity interaction points

Knowledge
Knowledge building was not a major topic within Fagerhult; all the interviewed employees did not consider knowledge as a limitation in their work. The innovation process was not foreseen the active knowledge building and documentation of it. General documents like drawings and other product related information were stored in the product lifecycle management (PLM) system. At the time of the interviews new attempts to secure specialized knowledge about lighting with a mentoring program were started. The idea of this program was that a very experienced person trained a newly entered employee. Furthermore, the development team initiated another program to document knowledge in a more efficient way. It is worth mentioning that Fagerhult was not aiming for completely new or radical ideas. They targeted an incremental approach that creates small improvements which leads to a whole new product or solution (Product generation strategy). A boost in knowledge creation was caused by the introduction of the new LED technology, with this technology change new specific field knowledge had to be created.

Creative Climate
The opinions about the climate within Fagerhult were congruent between the interviewees. Most of the respondents believed to have enough time to be creative or at least were allowed to spend time on new ideas. They felt a strong support and no restrictions from their managers and the organisation when they came up with new ideas. The general opinion was that Fagerhult was a very creative company compared to the competition were also similar to each other. The interviewees pointed out Fagerhult’s ability to foresee the customer’s needs, finding creative solutions to actual problems and having close customer contact. Furthermore, they considered the design department as the most creative in the company but also other departments in the company showed high ambitions to provide creative ideas in their opinion. A manager used the purchasing department as an example, which presented new supplier solutions to the designers for potential product applications. “In our company even the purchasers are creative…”

During the interviews negative points were mentioned about the climate in Fagerhult. A the priority of Fagerhult’s projects was to finish products in a half year pace, till the next market launch window, the interviewee’s perceived high time pressure. Also, the clear targets with high ambitions to product quality and design were noticed as limiting their creativity. The highest likelihood to be creative was mentioned by members of the development team; other departments in the innovation process were facing more direct customer pressure and less time for new
ideas. Moreover, it was stated that most of the new ideas were improvements instead of radical new ideas. The real new ideas came from particular individuals with exceptional performances. They were described to have a “free spirit” to be able to think out of the box, be more open minded as others and contribute with their ideas heavily to the success of the company. A manager was describing those employees, as “they are this type of people that are coming out and say, “Eh I have an idea”. Most of them were working an extended time in Fagerhult (or at least five years) and maintained a good network with their peers. Furthermore, there was a unity that the leader had the responsibility to identify those people and try to build the right environment for them.

The members of the production department also had a distinctive perspective, they saw themselves more problem-solving oriented or developing new ways to produce a product. Moreover, they stated that their motivation for creating new ideas was low due to their daily problem-solving oriented work.

5.2.2 Interface technology development / product development

Technology scope
The level of product knowledge within Fagerhult was considered by the interviewees to have a high level of specialisation with in-depth complexity. This was embedded in a long tradition how to design, produce and test lighting solutions. The respondents gave an account that the employees owned the specific product knowledge and built enormous experience in their fields. A high percentage of those employees had been working more than five years or more in the company. Therefore, it was considered as important to identify those people and save their experience in case of them leaving the company. There were actions in planning to document this highly specialised knowledge, but as a manager mentioned:

“It is hard to document real knowledge, it is very difficult to put something on paper and make sure that everyone reads and understands it.”

Other respondents confirmed the problematic situation in Fagerhult with documenting information and product knowledge. They added that product knowledge was barely stored and not easy to find. The process was foreseeing that all product and project data had to be saved in the PLM system. Six of the interviewees were not sure how to access those data, as they were restricted or not possible to find without experience about the particular project.

Another aspect was that product knowledge was typically accessible only via contacts and experience. This situation was difficult for new employees. They had to go through an introduction program, supported by the managers, as there was no formal documentation of key individuals in the company. All of the respondents were pointing out that the climate within Fagerhult was helping to build a network, as everyone was willing to support and answer questions. “It just can be a bit difficult to get hold of them” as a manager mentioned.
During the interviews, difficulties with transferring lessons learned information through all the departments were pointed out. At that time, this information was just shared during technical meetings and not with other departments involved in the innovation process. This caused issues since the complexity of the product knowledge increased with the introduction of the new LED technology.

Transfer management
Fagerhult’s innovation process was respected by the interviewees as a well-structured process and suitable for the company’s needs. It had a serial structure and forced communication between the involved departments. A few potential improvements were mentioned in communication and consequent finalization of the concept phase. One of the problems in the concept phase were the unfinished technological development projects, which were continued in the development phase of a product. Those parallel technology development projects caused time loss and additional cost. Furthermore, in the concept phase the teams were not cross-functional as they contained only design engineers or in some cases external resources. This situation caused technical problems during the product development phase, which often led to a redesign of a concept. The respondents mentioned that there were just a few examples of successful department comprehensive projects starting in the concept phase (including production engineering). After the development phase had been started, the team members were in charge to exchange project information into their departments. There was no communication between the single project groups.

Within projects and daily business, the most used communication channels were email, telephone and meetings. The project leaders had the unique responsibility to distribute the project information and decisions among the involved members. Furthermore, most of the interviewees were not sure who had the responsibility for organising the information stored in the PLM system. Another account given by the respondents was the product manager had the responsibility to transfer the information from sales or customers to the project groups. Most of the interviewees were criticising how documents and information were saved and spread in the organisation.

Strategic and operational factors
Fagerhult’s strategy was always investing in the future while enabling their employees to take responsibility and risks. Most of the respondents stated that it was officially accepted to make mistakes, as long as the mistakes were done not more than twice. Based on this cultural background, strategic decisions were always made considering the long-term goals to have outcomes to secure the future of the organisation. The interviewees stated that improvements were possible in clear communication of particular technology goals and reducing time pressure to be able to choose the best solution.

8 Lessons learned are a common industry term for meetings done at the end of a project were all problems and their solutions are discussed and documented.
5.2.3 Interface product development / production

**Involvement**
Most of the respondents had the opinion that the production department was involved according to the process description when a project was released from the concept phase. Every project team was cross-functional and contained at least one representative from each department involved in the innovation process. There were weekly update meetings, organised by the project manager in order to exchange and discuss the actual progress and issues within the project.

Members of the production department mentioned that they felt not early or enough involved in the project. A common issue with production involvement was mentioned to be that they were just allowed to approve drawings and bring in smaller changes and not propose bigger changes. Suggestions to overcome this situation were more cross-functional meetings and lab sessions, job rotation models or even mix the people between the departments for a limited time horizon. The opinion about early involvement was partly shared by the development department employees, as they would appreciate an earlier involvement of the production. The opinions about the extent of involvement of the production department the parties were at issue.

All respondents agreed on the usefulness of knowledge about production processes for potential product creation. A firm limiter of engagement was the availability of production engineers. They tended to be involved in two or three development projects at the same time what consumed 30% up to 40% of their work time. Other activities were spread over the daily business, internal production and improvement projects. This lack of availability created waiting times for other departments. A potential solution was proposed by a manager to rent out a production engineer who helps to create an understanding of production issues and reduce the waiting times within the development department. “I would appreciate someone sitting from production in the development.”

**Product manufacturability**
Most of the interviewees were in agreement about problems with feedback and information exchange between the departments involved in the innovation process. First, an ordinary feedback culture was not present in Fagerhult. Second, there were the typical "lessons learned" meetings where all the challenges and problems during the project were discussed and documented. This information was neither stored nor used in future projects and this led to repetitive faults in the projects. A manager mentioned, “It happened in the past that we solved the same problem twice in different projects.” Third, the quality of the information transferred back into the departments was varying strongly and was depending on the involved individuals. Fourth, once a project was finished information rarely reached the development department. Especially feedback about production improvements and faced issues were not reported. Finally, there was little to no feedback from installers or customers as the quality department was handling all issues regarding faulty products and the taken corrective actions.
All respondents agreed that feedback about problems and challenges during product and production development, as well as from serial production would be essential for future products. Especially the understanding, why a change during production was necessary would have a high value for the design engineers to understand the big picture.

**Resources and time**

All interviewees had agreed that either in innovation process projects to reach product launch dates or tight improvement projects, time as their biggest problem. Fagerhult’s practice to launch every six months new products was creating strenuous demands on the project organisation and left less space for faults or extraordinary experiments.

At the time of the interviews, the amount of projects waiting in "pipeline" was described as large and the available resources to realise them as not sufficient. Resources were a controversial topic; four of the interviewees had the opinion there were too few resources available for all the work need to be done, others saw the problem in their allocation or no problems at all. The respondents suggested improving the resource dedication in the projects to provide more resources in the concept phase, as this would increase the output quality and reduce issues in later stages. The interviewees also mentioned the need to focus on a smaller amount of projects executed in parallel to reduce the duration of the projects. Another solution was mentioned to reduce disturbances during projects ("noise") to achieve a higher efficiency.

The interviewees gave account about the uneven workload during the year. There were periods of low staff count and extremely high workload. For example, during summer time all the prototyping and test production runs were made when most of the employees were on holidays. During this time Fagerhult used temporary workers that caused additional difficulties and pressure in the production, as those workers were not experienced. A proposed solution was an exchange of resources between the departments to level out the workload and reschedule the product launch dates.

**Communication**

The description given of the internal communication in Fagerhult was open, helpfully and collegial. A high percentage of the employees had worked for a long time in Fagerhult and were fostering a close relationship to each other. They usually spent their coffee breaks and lunch together. The respondents shared the opinion that the reason for this unique situation was the location in a tiny village where only Fagerhult AB was located.

All interviewees agreed that the language spoken by the employees involved in the innovation process was Swedish. English was mostly used in communication with suppliers, customers and other manufacturing sites not located in Sweden. The employees involved in the projects were working in the same building. The building complex was internally connected and built one big block, with a nice canteen and coffee break areas. It was common for the employees to solve issues during their breaks and discuss open working tasks.
Nevertheless, the communication was not described as perfect; there was a tendency to overuse email and do not speak directly with each other. Furthermore, it was mentioned that contact between the departments in the innovation process was not anymore as powerful as it was used to be. The “island thinking” had increased, the willingness to take responsibility lowered and the teamwork was reduced during the last years. Moreover, the presentation of goals and requirements in projects was described as not all the time transparent and some information remained in the departments. Another mentioned issue was that the customer requirements were often not transferred to the product development and production departments.

5.3 Focus group

The focus group was used to validate the findings of the semi-structured interviews. In Fagerhult, the duration was 1 hour and 12 employees participated. Three main subjects were discussed, and the participants were asked to express their opinions about what motivates them (driving forces) and what restricts them (restricting forces) to 1) Be creative, 2) Be involved, and 3) Exchange information. The results of the focus groups were concluded in the simple force field\(^9\) analysis based on Lewin (1951) displayed in the following Table 11.

Table 11: Focus group results in Fagerhult, (n = 12, Investigated force fields: “Be Creative”, “Be Involved”, “Information exchange” in the context of the innovation process.)

<table>
<thead>
<tr>
<th>Driving Forces</th>
<th>Restricting Forces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force field “Be Creative.”</td>
<td>Force field “Be Creative.”</td>
</tr>
<tr>
<td>• Development of technology</td>
<td>• Too specific requirements at the beginning of concept</td>
</tr>
<tr>
<td>• New solutions (LED)</td>
<td>• Too specific in the begging of project</td>
</tr>
<tr>
<td>• Increase of architects in the business</td>
<td>• Lack of understanding</td>
</tr>
<tr>
<td>• Sitting together</td>
<td>• Not enough freedom (room for choices)</td>
</tr>
<tr>
<td>• New ideas from suppliers</td>
<td>• Time pressure- tight schedule</td>
</tr>
<tr>
<td></td>
<td>• Communicating within their “box”, not with others</td>
</tr>
</tbody>
</table>

\(^9\) For further explanation about force fields see chapter 3.2.3
Table 11: continued

<table>
<thead>
<tr>
<th>Driving Forces</th>
<th>Restricting Forces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force field “Be Involved.”</td>
<td>Force field “Information Exchange.”</td>
</tr>
<tr>
<td>• Same building</td>
<td>• Project process</td>
</tr>
<tr>
<td>• Workload (need to be involved)</td>
<td>• Not following the process</td>
</tr>
<tr>
<td>• Standardized process (when followed)</td>
<td>• Restricted access to information</td>
</tr>
<tr>
<td>• Questions from R&amp;D</td>
<td>• The way of using the system</td>
</tr>
<tr>
<td>• Early involvement</td>
<td>• No exchange of information between customer and catalogue projects</td>
</tr>
<tr>
<td>• Information</td>
<td>• Concentration of information to few persons</td>
</tr>
<tr>
<td>• Better corporation of sub-processes</td>
<td>• Not using the lessons learned from other projects</td>
</tr>
<tr>
<td>• Idea exchange</td>
<td>• Working right</td>
</tr>
<tr>
<td>• Right level of involvement</td>
<td>• Not using the lesson learned from other projects</td>
</tr>
</tbody>
</table>

- Size of organisation (big)
- Workload
- Not enough resources
- Sub-processes ("noise", disturbances)
- Late involvement
- Time pressure
- Big number of projects
- Lack of knowledge
- Waiting for information
6  Analysis and discussion

In this chapter, the findings are discussed and analysed regarding the fulfilment of the research aim. The research questions are answered and discussed in relation to theory, proposed framework and previous studies. Also, the chosen methods and implementation are discussed and final conclusions, and recommendations for further research are presented.

6.1  Structure of the analysis and discussion

To summarise, the aim of this study was to explore the mechanisms involved between the innovation process interfaces and creativity in two manufacturing companies. In particular, a focus on the influence of the interface factors on knowledge and climate as prerequisites for creativity was investigated. Answering the following research questions specified the aim:

1. How does the innovation process affect the human creativity in a manufacturing company?
2. How do the innovation process interfaces affect information exchange between the involved departments?

In order to answer the research questions human creativity was defined as the individual’s process of producing new and useful ideas. Additionally, knowledge and the creative climate were identified as interaction points of human creativity towards the production system. Whereby the creative climate represents the summary of peoples’ impressions about the organisation including the underlying assumptions and values of the organisational culture. Knowledge is a human faculty resulting from interpreted information, facts and skills acquired through experience or education, which is related to how to produce or develop a product (Turnbull, 2012).

The innovation process was identified as the process that embraces all activities that foster the adoption of a new product into a market. The innovation process is commonly divided into three and in some cases overlapping sub-processes: technology development, product development, and production, generate two interfaces in between the sub-processes. Those two interfaces “technology development - product development” and “product development - production” are representing the challenges involved in the cooperation and integration of those sub-processes. The various challenges or factors were categorised relating to the two interfaces and their similarities.

To combine the two theoretical concepts of the innovation process and creativity, a conceptual framework was developed which proposes a causal link between the innovation process and creativity. It assumes that the innovation process interfaces influences either product knowledge or the creative climate as interaction points of creativity. In order to study the influence of the interfaces, the categorised factors were used as a guide for the fieldwork and structure the findings, and the analysis.
In a cross case analysis, all findings were combined and analysed for occurring patterns with the results presented in Appendix 8.4 through 8.6. The following subsections, contain the third step of the cross case analysis and is executed to answer the research questions. The identified patterns in the categories product knowledge and creative climate were evaluated for connections towards the innovation process and discussed in relation to creativity theory. Every pattern identified in the following interfaces “technology development - product development” and “product development - production” was checked and discussed for their influence on creative climate or product knowledge, and their theoretical support.

6.2 Research question 1

The identified patterns of the second step of the analysis will be analysed and discussed according to the theory, and the proposed conceptual framework in chapter 2.3. The summary of the identified influences allows answering research question 1:

How does the innovation process affect the human creativity in a manufacturing company?

6.2.1 Creativity interaction points

Product knowledge

Both cases evidence provided shows that product knowledge\(^{10}\) was essential for creating new ideas and for efficient innovation processes in the organisations. This finding was supported by the theory that saw knowledge as a prerequisite for creativity to appear (Ekvall, 1997) and as a resource for the implementation of new ideas (Fagerberg, 2004). Moreover, both companies were not aiming for revolutionary ideas; they were using an incremental approach that creates small improvements, which led to a whole new solution (Product generation strategy). This fact implies that both companies’ innovation processes were not made to handle complete new ideas. However, one exception was Kongsberg’s innovation process, as in their process active knowledge building was foreseen. Also, within the two case companies’ innovation processes, there were no existing routines or rules regarding how to document product knowledge in an appropriate way. This resulted in a situation where the employees were the source of knowledge, which puts the companies in a state of a permanent risk of losing important product knowledge. Kongsberg introduced a special role of “knowledge owners” to document specific product knowledge and made it accessible. Furthermore, Kongsberg introduced a dedicated group to transfer actively knowledge from production into the other innovation process departments.

All findings within the category product knowledge indicate that product knowledge is influenced by the characteristics of the innovation process and plays a significant role in new idea generation, within both case companies. The findings also imply

\(^{10}\) Product knowledge contains all knowledge necessary to create and produce a specific type of product. In the following paragraphs the term product knowledge is used substitutional.
that the individuals working in the innovation process departments own product knowledge. This situation makes the documentation of this product knowledge in an appropriate and understandable way highly important for both companies to secure this knowledge.

**Creative Climate**

The results of the creative climate questionnaire (CCQ) indicated that both companies had different levels of creativity. Fagerhult’s results were above Kongsberg’s but the differences were not as big as expected by the companies. Especially since Fagerhult’s internal opinion sees them as much more “creative”.

Respondents in both companies were of the opinion that individuals represented the creativity in the organisations, not the teams as stated in theory (Drazin et al., 1999). Those “creative” individuals cultivated their contact with their peers actively, and these contacts were used to exchange product knowledge with other members of the innovation process departments. The “creative” individuals were described to have individualistic preferences to solve problems, and had a strong influence on their team members. These findings show the importance of a good creative climate in an organisation, because as it fosters the knowledge exchange between the departments involved in the innovation process. Furthermore, there was a coincidence between theory and the companies, that managers had the responsibility to create a protective environment for the creative individuals (Amabile, 1988).

A few limiters of creativity were mentioned in both companies, these were too high time pressure and workload, no risk-taking in the organisation, and no communication between the departments of the innovation process. Risk-taking was seen as crucial issue; the organisations should offer space for manageable risks, as exploring new technologies or invest money in promising ideas. Likewise, the sharp focus on customer projects did not allow enough room for creative activities. This finding was further extended by Kongsberg and Fagerhult regarding that the innovation process limited creative activities and was designed for the development department. The combination of these accounts gave a clear indication of the dependence between the structure of the innovation process and creativity.

Another finding in both case companies was that they perceived the product development department as the creative part of the innovation process. The production department was noticed the be strong in problem-solving and not involved in any creative activities. Also, they distinguished not explicitly between problem-solving and creativity as proposed in theory (Torrance, 1979).

Concluding the findings in the creative climate category, there is evidence present that the innovation process structure influences the way of working of the involved individuals. This fact implies that the innovation process also influences how much of a possibility those individuals have to be creative since it directly affects the workload, time pressure, and communication in the involved departments. The traditional separation of the sub-processes, technology development, product development and production (Figure 7) conveys indirectly, the information to the
employees, which of the involved department is supposed to be creative or not. This hidden assumption and perception of the employees that the technology development department is supposed to be creative could lead to reduced creative activities in other departments if the company is not actively fostering creativity. Furthermore, the structure of the innovation process should allow the managers to create a protective environment for creative individuals to reduce high time pressure and workload. Finally, the process should foster communication between the departments as creative individuals are benefiting from the additional knowledge.

**6.2.2 Interface: Technology development / product development**

*Technology scope*

The knowledge related to products and production processes used in the innovation process at Kongsberg had an average complexity compared to Fagerhult’s. Both companies were facing difficulties in accessing their product knowledge as it was owned by the employees or stored in their product life cycle (PLM) system. The only way to access the product knowledge was through direct contacts and the experience of which person had the information, which was needed. This situation required the willingness of those individuals to share their particular knowledge about products and processes.

There was broad agreement on and support by the theory that the managers need to ensure that new employees get enough help to be integrated into the organisation, and be provided with the right contacts (Daim et al., 2009). Kongsberg used the special role of “knowledge owners” as a single point of contact to improve the accessibility to the right persons in the organisation, who owned the specific product knowledge. Within Fagerhult and Kongsberg, the access to product knowledge in the PLM system was restricted through authorisation rules; there were no clear data structures or rules on how to document product knowledge. This accessibility was additionally hampered by the necessity of experience of previous projects where in the PLM data structure to find particular information about former product solutions.

The results in the first category, *technology scope* in the interface “technology development/product development” according to Figure 7, are related to product knowledge access. In both cases, the access to product knowledge was hampered through organisational circumstances e.g. the lack of information on which person owns which product knowledge, or how managers introduce/support new employees. Other restrictions were created with how the PLM system was structured and used by the employees. If those results are applied to the context of the first interface, it can be assumed that the integration between the technology development and product development departments influences how product knowledge is accessible.
Analysis and discussion

Transfer management
In both case companies, the innovation process was perceived as well structured and able to fulfil the requirements for efficient communication; whereby email, telephone, and meetings were used as communication channels. However, the findings pointed out that the communication between the innovation process departments still need improvement.

In Fagerhult and Kongsberg, the project leaders had the unique responsibility to distribute the information among the development project team members, and decide how they were stored in the PLM system. This situation made the quality of the information distribution between the innovation process departments, depended on the individual project managers. This dependency on individual projects managers was further extended due to the absence of guidelines for structure product and project-related data in the PLM system. To overcome this problem, both case companies were using cross-functional teams to increase the information exchange. One difference between the companies was in which state, during an innovation process project, the cross-functional teams were used. Kongsberg used them in the concept phase, but not in the development phase. Fagerhult had the opposite practice; they had cross-functional teams just in the development phase. These polar findings can be explained based on the requirements of the different markets they were operating in. Kongsberg’s innovation process faced high time pressure during the concept phase, due to a limitation of eight weeks to hand in their offers to their customers. Fagerhult was facing this time pressure in the development phase due to fixed product launch windows.

It needs to be mentioned that Fagerhult and Kongsberg were not actively performing technology development as shown in Figure 7 and proposed in theory (Daim et al., 2009). Both of the companies considered their concept phase as a replacement for technology development, since they were using already existing technologies for their products.

The results in the second category, transfer management in the interface “technology development/product development” according to Figure 7, are related to how information is distributed among the involved departments. In both cases, the implementation of the innovation process was perceived as sufficient to ensure information exchange but still needed improvement. The particular problems of project managers acting as information distributors and the missing guidelines on how to store information in the PLM system, can be considered as integration problems. This integration between the sub-processes technology development and product development is therefore influencing how information is exchanged between them. If further, information is considered as an essential element of knowledge it can be assumed that the interface influences the product knowledge distribution in the same way.
Strategic and operational factors
The two case companies provided opposite results because Kongsberg went through a strategic new orientation and Fagerhult was in a stable and growing phase. In case of Kongsberg, the company was at the beginning to become a solution provider instead of a customer follower. As this strategy change was at his very beginning, the employees perceived the taken actions to achieve this change as not sufficient. Poor management support and low investment in future orientated projects were considered as limiting the motivation and the willingness to be creative. The situation was more negatively rated due to the comparatively strict rules and structure in Kongsberg was hindering creative activities. In case of Fagerhult, the situation was different due to the relative stable and future orientated strategy. Fagerhult was comparatively investing more actively into the future by adopting new technologies, taking risks with new product ranges, and allowing their employees to spend time on new ideas. Additionally, the management was perceived as providing the long- and short-term goals in a transparent and open way.

The results in the third category, Strategic and operational factors in the interface “technology development/product development” according to Figure 7, are related to how operational strategy influences the creative climate. In both situations, the strategy followed by the case companies was perceived as supporting creative activities or not. This implies that the strategy is next to limiting the possibilities to be creative, as well as influencing the motivation and willingness of the employees to spend time on new ideas. Considering the theory of creative climate, the employees perceive the effects of the strategy in their environment and act accordingly as described in Lewin’s (1951) behavioural function (Orpen, 1990). This finding leads to the assumption that the first interface affects the creative climate in the technology development and product development departments.

6.2.3 Interface: Product development / production

Involvement
Adler (1995) suggested beneficial involvement of the production department in the previous innovation sub-processes technology development and product development (Figure 7), was in both case companies foreseen but in reality not implemented. In Fagerhult and Kongsberg the findings show that the production department was involved too late, and had no major influence on the previous processes of the innovation process. The employees mentioned a potential reason for the late involvement; it is unclear clear when precisely this involvement needed to take place. This situation created in both companies a random and unstructured way of involving the production department. Contradictory to this situation, Fagerhult as well as in Kongsberg; the development department would highly appreciated an earlier involvement of the production department, to improve their development work with knowledge about production processes. The findings imply that the employees were aware of the benefits of an early production involvement but were restricted by the implementation of the innovation process in the organisation.
Other findings indicate that in both case companies the cooperation between the production and product development departments was affected by the limited availability of production engineers. The heavy involvement of the production engineers in the daily business and production improvement projects caused delays in the other innovation process departments, because they had to wait for the information they needed. The present island thinking between the production and product development departments extends this problematic situation.

The results in the first category, involvement in the interface “product development/production” according to Figure 7, are related to the cooperation among the involved departments. Both cases provided evidence that late involvement of the production department in previous innovation sub-processes was caused by the implementation of the innovation process. Non-existing guidelines made it impossible for the employees to know when the involvements needed to take place, creating a frustrating situation, because they were aware of the benefits of early involvement. Also this implies that the active involvement of the production department has a positive impact on the creative climate, and not only on the product knowledge exchange. Particularly interesting is the finding that one role (e.g. production engineer) is able to disturb the cooperation between the production and product development departments, and therefore, limits the information exchange. If those results are applied to the context of the second interface, it can be assumed that the interface affects the creative climate and the product knowledge exchange depending on how the involvement of the production department is organised.

Product manufacturability

Neither Fagerhult nor Kongsberg had a distinctively established the feedback between the product development and production department. As already mentioned in the category transfer management of the first interface 5.2.2, the project managers distributed most of the information among the involved departments and not their members. The only exception in Fagerhult was during a product launch were an intensive feedback was necessary to coordinate all actions needed to produce the product. A similar situation was present in Kongsberg during the concept phase, where they had to provide their customers a product concept in a very short time frame, and production related information was necessary. Employees in both companies described these phases as the most efficient ones. The lack of feedback between the product development and production department causes the problem that important information (e.g. product design changes or improvements during production) does not reach the development department in a timely fashion.

Another issue in both cases was the lack of using information created during the “lessons learned” meetings, at the end of every project. The worst case of this is when the given information in not stored at all reports in the PLM system. Additionally if the reports were stored the quality was a low level because they did not covered the whole project or just focused on one specific problem.
The results in the second category, *product manufacturability* in the interface “product development/production” according to Figure 7, are related to feedback between the involved departments. Both cases provided evidence that an exaggerated feedback is beneficial for the information exchange and increases the efficiency of the innovation process. The feedback allows discussing the occurred challenges and problems of the finished projects or issues during production of the product. Moreover, a high quality of the stored information will ensure their usefulness for further innovation projects. Summarising those results, it can be expected that the interface between product development and production is defining how feedback is organised and the quality of that information is ensured. If further information is considered as an essential element of knowledge it can be assumed that the interface influences product knowledge in the same way.

**Resources and time**

For Fagerhult as well as Kongsberg employees, time was the main issue that influenced the corporation between the product development and production department (Figure 7). Urgent customer orders or tight improvement projects limited the available time and increased the workload for the employees. The limited time was causing further delays in the daily work between the two departments, because they had to wait for information coming from the other department to continue their work. The time pressure issue increased even more in Fagerhult’s case because of uneven workloads, and in Kongsberg’s case due to holiday absences or high employee turnover. Most of the employees were of the opinion that a better allocation of resources or more resources in the development and production department would decrease the time pressure and increase the possibility to work on new ideas. Furthermore, there was a coincidence that the employees felt distracted by sometimes-useless tasks in their daily work and were of the opinion a reduction of this “noise” would help to increase the available time.

The results in the third category, *resources and time* in the interface “product development/production” according to Figure 7, are related to time, workload and resources. There is evidence presented that the cooperation between the two departments is influenced by time pressure and high workload. This situation implies the stress levels for the employees is increased and has a negative effect on the creative climate within the departments (Amabile, 1997). Resources are classified as a potential solution to reduce time pressure and create time for new idea. To summarising the results, it can be assumed that the interface between product development and production affects the creative climate as it controls the workload and time pressure for the employees.

**Communication**

As claimed by Vandevelde & Dierdonck (2003) the communication between the product development and production departments is essential for the integration between the two sub-processes (Figure 7), and acts as transport medium for the information or product knowledge exchange. In both organisations, the employees described the communication as appropriate, open, collegial and not limiting. The short physical distances between the product development and production departments were perceived as beneficial for the communication and the contact
network among the employees. In Kongsberg, the product development and production department were located in separated buildings in the same factory location. Fagerhult's product development and production departments were even located in the same building complex. There were no hindering language barriers present (Vandevelde & Dierdonck, 2003), since the main spoken language was Swedish followed by English, the official company language.

However, the communications were not perfect in the case companies and were hampered by the island thinking of the two departments, which reduced teamwork, and caused the tendency to overuse email instead of direct communication. The usage of emails in the daily business was considered limiting the communication as it was time-consuming and delaying the workflow. Another limitation of communication in case of Kongsberg was their high employee turnover, because they had to continuously introduce new employees, which weakened the communication between the employees and their bonds.

The results in the last category, communication in the interface “product development/production” according to Figure 7, are related to how the communication is established between the two departments. In both case companies have collegial environments and short physical distances positively affected the communication between the two departments, which is mirrored in the research of Lakemond et al. (2007) and Vandevelde & Dierdonck (2003). Moreover, there was no language barrier for communication, because they all spoke the same language. It is the nature of communication to include information exchange, but communication also affects the creative climate due to how it is executed. Summarising, it can be assumed that the interface between product development and production affects the creative climate and the product knowledge as it organises the communication between the departments.

6.2.4 Answering research question 1

In the previous paragraphs, the identified patterns in the categories product knowledge and creative climate were evaluated for connections towards the innovation process and discussed in relation to theory. The analysis/discussion of the findings in those two categories showed that product knowledge, owned by the employees working in the three sub-processes (Figure 7), is influenced by characteristics of the innovation process. Those characteristics (i.e. process design, process implementation in the organisation) define how product knowledge is valued, documented, and used to generate new ideas. Moreover, those characteristics also affect the way of working of the involved individuals and how many possibilities those individuals have to be creative. The traditional structure of the innovation process in three sub-processes “technology development/product development” and “production” conveys indirectly the information to the employees which of the involved departments is supposed to be creative, and influences their creative activities. Similar indications were found during analysing/discussing the

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11 See Appendix 8.4 till 8.6 for a detailed allocation of the identified patterns.
patterns identified in the interfaces for their influence on creative climate or product knowledge and their theoretical support.

The analysis/discussion of the patterns in the categories technology scope, transfer management, and strategic and operational factors in the first interface (Figure 7), show that the interface influences how product knowledge is distributed and is accessible between the technology development and product development departments. Organisational circumstances in those two departments i.e. the lack of information which person owns which product knowledge, or how product knowledge is stored and accessible in the PLM systems, were identified as the most influential. A particular finding was that the company’s strategy influences the creative climate within the two departments. The employees perceive that the strategy limits the possibilities to be creative and values indirectly these creative activities; this also influences their motivation and willingness to spend time on new ideas.

Within the categories involvement, resources and time, product manufacturability, and communication in the second interface (Figure 7) the analysis/discussion of the patterns shows that the interface influences the creative climate in the product development and product departments, and how product knowledge is exchanged. The active involvement of the production department in the innovation projects was identified to positively influence the creative climate and the product knowledge exchange, due to less frustration and better contacts among the involved employees. This influence could be further improved by intensifying the feedback between the two departments and ensure the quality of the exchanged information. Meanwhile, some identified negative feedback for the creative climate was; time pressure, and a high workload in the departments, which reduces the available time for creating new ideas. Special attention in the second interface needs communication between the two departments because of the strong influence the exchange of product knowledge has on the creative climate. The communication needs to happen in a collegial environment, in the same language, and in combination of personal contact (low physical distance) to be most beneficial for the creative climate and the exchange of product knowledge.

Combining the results of the two interfaces shows that the integration among the three departments mediates how the involved employees collaborate, communicate, and exchange information. This result is supported by the results in the categories: product knowledge, and creative climate and extended with innovation process characteristics as process design, process implementation in the organisation. Therefore, it can be assumed that both interfaces influence the creative climate and the product knowledge in the three departments: technology development/product development, and production. Applying the results to the context of the innovation process and replace the creative climate and product knowledge with human creativity leads to the answer of the first research question:

“How does the innovation process affect the human act of creativity in a manufacturing company?”

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12 See chapter 2.3.3
Based on the evidence found during this study it can be assumed that:

*The innovation process affects human creativity indirectly through its structural, strategic and physical implementation due to its influence on product knowledge and creative climate, as creativity prerequisites in the organisation.*

**6.3 Research question 2**

The elaborated findings for answering the first research question were reused and interpreted once more in order to answer the second research question:

*How do the innovation process interfaces affect information exchange between the involved departments?*

**6.3.1 Answering research question 2**

The results found in the two interfaces indicate that the interfaces of the innovation process actively foster or block the information exchange between the involved departments (Figure 7). In the interface technology development/product development, evidence was found that the information exchange is depended on how information or product knowledge is stored and distributed between the two sub processes of the innovation process. This was supported by the fact that the case companies introduced special roles to ensure the information exchange and usable product life cycle systems to make the data more accessible. There are indications that the used communication channels influence if the information exchange takes place or not, which is why direct contact was preferred instead of emails. Importance was given to the way of organising the handover between the involved departments in which cross-functional teams were clearly preferred because the exchange of information happens directly in the teams. A further finding was that managers stimulate information exchange through the way they communicate goals and targets to their employees.

The product development/production interface shows tendencies that an early involvement of the production department in technology development and product development increases the information flow, this is because the members are actively involved. This finding is supported by research made by Lakemond et al. (2007) and Vandevelde & Dierdonck (2003).

Also, the findings indicates that feedback between the innovation process departments is dependent on the quality of the documented information and how this information is stored for further use. The interfaces in the innovation process (Figure 7) influence the information exchange through their physical implementation. This includes physical distances, between the involved departments, and language barriers.

Combining the findings, leads to the answer of the second research question:
“How do the innovation process interfaces affect information exchange between the involved departments?”

Based on the evidence found during this study it can be assumed that:

The innovation process interfaces are the mediators for information exchange among the departments involved in the innovation process according to figure 7 due to the structural and managerial applications of the interfaces, and the used communication channels.

6.4 Comparison with previous studies

The possibility for comparing the results of this study with previous research is limited due to the absence of similar studies. One study made by Ekvall (1993) illustrates the dilemma during project work when creativity, strict planning, and control are desired. If the management insists on time and cost frames, the chance for creative solutions is reduced as justified standard and proven solutions will fill the efficiency requirements. Because of the limited freedom there is no scope for creativity (ibid). The innovation processes as displayed in Figure 7 can be considered as a similar construct for a project, leading to similar effects. In this study the findings indicate that the implementation of the innovation process has a direct impact on creativity since it influences product knowledge and creative climate. This structural implementation of the innovation process creates boundaries or limitations for creative activities such as time pressure, high workload, or reduced communication. If the findings of both studies are compared they show the same tendencies on how creativity is influenced by structures used in projects or processes.

6.5 Discussion of methods

The chosen research method of two single case studies was considered the most appropriate to explore the unknown field of the mechanisms between the innovation process and creativity. This study was not aiming for a generalized outcome but rather to develop a theory. Furthermore, the case study design gave us the opportunity to investigate the phenomenon in real life context, in two Swedish manufacturing companies, and helped us to understand the how and why the innovation process affects creativity.

Considering the immaturity of the theoretical field, an abductive approach was adopted for the development of the conceptual framework. This approach allowed us to develop and adjust our conceptual framework along the data collection and analysis in the orientation study. The abductive approach proved to be extremely useful and practical, because it focused the literature review and confirmed the presumed literature gap. With the development of a conceptual framework (Figure 7) the guideline for the fieldwork and analysis was created. The biggest risk in the abductive approach is the manipulation of the theory according to reality. Constantly evaluating and criticizing the obtained results avoided this risk.
Analysis and discussion

The study was conducted in two phases; the orientation study and the main study. Within the orientation study, unstructured interviews and the literature research were conducted. This gave us the opportunity to become familiar with the companies’ environment and start to grasp their culture. The unstructured interview approach allowed us to collect as much information as possible and identify the key persons in the organisations necessary for the further study. Moreover, the orientation study allowed the people to become more familiar with our subject and us as persons, which led to more friendly and open discussions. In our opinion this growth of trust in combination with the assurance of anonymity increased the chance to get more honest and open responses. To avoid losing our objectivity, we kept a professional behaviour level and we limited our visits to the companies in order to not create strong bonds with the employees.

During the main study, we collected the largest amount of data and examined the phenomenon in depth. We chose three types of data collection methods; questionnaires, semi-structured interviews and focus groups. The two questionnaires gave us the opportunity to gather in both companies a greater number of respondents’ opinions about the creative climate and interface challenges. Those findings were used to triangulate the findings from the other data collection methods and also provided us with a measure to compare the two case companies. Considering this method, we believe that the effort to release and analyse the questionnaires can be characterised as non-efficient, because the results could have be used to triangulate a small amount of other findings. Nevertheless, the results of the questionnaires proved to be valuable for the case companies and provided them with insights about their creative climate and innovation project’s challenges.

The semi-structured interviews were the main used method to collect in-depth and detailed data. The amount of conducted interviews is considered as representative, since they covered all the involved departments in the innovation process. To improve the trustworthiness of this research all interviews were recorded, transcribed, and fully summarized. The execution of the interviews was conducted in a consistent way to ensure that all respondents had the same understanding of the questions (e.g. give examples of how the question needed to be understood).

The focus groups were the last part of our main study and proved to be very useful for the triangulation of our findings. Additionally, the choice of documenting the results in force fields showed to be very effective for the later analysis. The overall participation is considered satisfactory, although we would have appreciated a bigger number of participants, especially in one of the case companies.

Although this study was not aiming for producing a generalized outcome, the findings can show “tendencies”, something that can be proved valuable for companies with the same context. External validity was achieved by comparing the findings and the developed model with related theories and research. The internal validity was achieved by the triangulation of our findings and the consistent and professional way of conducting this study. Furthermore, the presentation of data
and description of the case was done in a systematic and detailed manner, to increase the reliability of this study and allow a similar research.

### 6.6 Conclusions

The aim of this study was to explore the mechanisms involved between the innovation process interfaces and creativity in two manufacturing companies. Particularly how the interfaces between the sub-processes can give an indication on, if the process itself actively influences individual creativity. Based on the findings gained in the involved two case companies, the study concluded that the innovation process affects creativity through its own structural, strategic and physical implementation in the organisation. With the traditional separation of the innovation process in technology development, product development and production are two interfaces created which influences the cooperation between the sub-processes. The influence is visible in the way employees involved in the innovation process collaborate, communicate, and exchange information. This implies that the interfaces are affecting human creativity indirectly through affecting the product knowledge and the creative climate within the organisation, since they are prerequisites for creativity.

Finally, the study provided valuable insights on real life issues of inter-department work for further studies in this field and contributed with findings to extend the understanding of the involved mechanisms between the innovation process and human creativity. The study results could be used as a base for further investigations especially in combination with system theories as the interdependencies between the innovation process and creativity involves complex human interactions with the organisation.
7 References


# 8 Appendices

## 8.1 Appendix I: Company comparison

<table>
<thead>
<tr>
<th>Kongsberg Automotive Driveline</th>
<th>Fagerhults Belysning AB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td></td>
</tr>
<tr>
<td>Sweden Jönköping area (Mullsjö)</td>
<td>Sweden Jönköping area (Habo)</td>
</tr>
<tr>
<td><strong>History</strong></td>
<td></td>
</tr>
<tr>
<td>1957 production of brakes for Volvo trucks. Same location.</td>
<td>Has been in the lighting industry since 1945 at the same location.</td>
</tr>
<tr>
<td><strong>Market and core business</strong></td>
<td></td>
</tr>
<tr>
<td>KA Mullsjö produces gear shifters for passenger cars and heavy vehicles, head restraints, crash brackets, expansion tanks and on-board chargers. Global market orientation.</td>
<td>Functional lighting in a Scandinavian design. With a long-term focus on energy efficiency, via intelligent lighting controls and advanced LED technology. Global market orientation with focus Europa.</td>
</tr>
<tr>
<td><strong>Organisational structure</strong></td>
<td></td>
</tr>
<tr>
<td>Production plant with injection moulding and assembly lines and a Tech Centre for global design activities. A part of the wider Kongsberg Automotive group.</td>
<td>Headquarter with production facility, development centre and laboratories. Leads the main product developments for the brand Fagerhult and produces for Europa. Fagerhult owns other lightning brands globally.</td>
</tr>
<tr>
<td><strong>Innovation orientation</strong></td>
<td></td>
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<tr>
<td>Mostly works with product improvement and new product developments according to customer request. New strategy has taken place with more proactive innovation orientation. The newly build Tech Centre has already created a multi customer useable base product in the gear shifter segment. Shift towards driving the market instead of following it.</td>
<td>Mostly works with new product developments according to market needs. Strong in innovative design and high quality. Customer specific solutions available and special applications for medical environments. Is facing a technology change with implementation of the LED technology. Active in complete new lightning concepts and technologies.</td>
</tr>
<tr>
<td><strong>Innovation process</strong></td>
<td></td>
</tr>
<tr>
<td>Knowledge Building Development (KBD) process. It consists the whole innovation process and how new knowledge/concepts can be created and stored.</td>
<td>Innovation process with traditional gates between concept, development and production interfaces. No knowledge management.</td>
</tr>
</tbody>
</table>
8.2 Appendix 2: The logic behind the interview questions

*Question group 1* is for the clarification were creativity actually is present and in which from.

This base leads to the *Question group 2* or *3* depending on the answers of the person if he mentions knowledge and experience as essential part of creativity.

If the person doesn’t mention knowledge we check the perceived creative climate within the company to back up the questionnaire we made. *Question group 2*

Usually people tend here to talk about organisational barriers that lay the ground for either focus to *group 3* or *7* about collaboration.

*Question group 3* is about were knowledge is present in the company. This is essential, as we need to know from where we can transfer knowledge. Usually is connected with organisational barriers and structure answers.

*Group 5* is an understanding and check question about how they understand innovation and creativity and what they see as beneficial, problem solving or creativity.

*Group 6* is assessing the information flow (knowledge flow between the departments, projects and functions) this is relevant as our framework propose that knowledge just can be transferred within the given channels of the organisation.

*Group 7* is about the collaboration between the departments and how they work together especially when it comes to information sharing.

*Question 8 and 4* are open questions and are letting the interviewed person answer without any guidance.

*Question 9* is the clarification of our theoretical model and gives insights of the practical understanding of innovation.
8.3 Appendix 3: Interview questions

Interview questions

Where do you think that your company is most creative?

- Do you think that the groups are mostly creative or more the single persons, which are the brilliant heads?
- Based on your experience when a new product came to the table was it a person or team who brought it up?
- The people who are bringing up the ideas do they have a good network in the company?
- These people have been long in the company?
- Is networking a key factor? Or resources or time?
- Do you agree with the perspective that creativity creates a new idea and innovation is the process that brings the idea to reality?

How do you perceive the working environment in your company?

- Is there enough room to be creative?
- Is there a motivation from the company?
- Does the management support people to be creative?
- Do the people have the time to seat together and discuss?
- How do you introduce new team members? (Let him swim?)

How is the knowledge accessible within the company? (Knowledge regarding technology, solutions etc.)

- Are persons knowledge owners or is the knowledge stored in a system?
- Do you have a system that supports the knowledge transfer?
- How do you prefer to get knowledge?
- How should the knowledge accessible by persons (functions) or in a system?
- Do people know how to get information when it’s needed or do they need to find their own way?
- Would be beneficial to have someone to guide the knowledge?
- How do you train new team members?
How can a better information flow increase your creativity?

• Exchange of resources?

How do you understand the innovation process? (Clarification Question)

• Is creativity and innovation problem solving for you or something completely new?
• Is incremental creativity more achievable as real creativity?
• When you start a new project is this a customer request or something completely new?

How do you assess the information flow in your company in the innovation process?

• Is there an information flow in the whole process?
• Is there a feedback from other departments?
• Do you get feedback from production after you hand over the project? Would be beneficial?
• Are people from production involved early in the innovation process?
• How do you assess the involvement of production actually? (Enough / Too less?)
• Is there any feedback from the development department after a project is finished?
• Did you experience that people from production came up with new products or solutions?
• When it comes to starting a new project do you feel that you have all the needed information? (Costumer needs, requirements? Etc.)
• Do you use the “free” time (Lunch time, Fika brakes) to exchange info?

How do you characterize the collaboration between the departments involved in the innovation process?

• Is there a trade-off between speed and collaboration?
• Are meetings holds to exchange knowledge between the departments? How you assess such meetings?
• Do you have a follow up meetings after a project is finished and the production is running for a while? Do you discuss problems that maybe arose during the mass production?
• Do you store the information from the final meetings?
• Between projects is knowledge exchanged?
• Do you have some kind of job rotation? (Resources exchange) between departments? How you assess such a tool?

If you had the possibility to do any improvement in the innovation process in your company (regardless time or resources) what would you do?

Showing the innovation model if they see the innovation process and creativity as in the theory described…

• Ask again about creative problem solving and real creativity.
### 8.4 Appendix 4: Creativity interaction points analysis

<table>
<thead>
<tr>
<th>Creativity interaction points</th>
<th>Results</th>
<th>Supported by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Creative Climate Question</td>
</tr>
<tr>
<td>Knowledge</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Knowledge essential for new ideas</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>No aim for revolutionary new ideas</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Incremental development of knowledge</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Difficulties with documentation of knowledge</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Risk for losing knowledge as it is own by individuals</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Special roles and groups for knowledge building</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Process is fostering knowledge</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Process is not fostering knowledge</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Climate</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Individuals not teams represent creativity</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>No clear differentiation between creativity and problem solving</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Creativity is located in development phase</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Problem solving in production</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Innovation process is limiting creativity</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Creative people have close contact to peers and exchange knowledge.</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Too strong focus on costumer project limits time for creative activities</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Allowance to take risks and invest in new ideas</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>No risk taking without costumer request</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Limiters of creativity: time pressure, high workload, no risk taking, and no communication.</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Managers need to create protective environment for the creative persons</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>
### 8.5 Appendix 5: Technology development / Product development interface factors analysis

<table>
<thead>
<tr>
<th>Interface factors</th>
<th>Results</th>
<th>Supported by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Creative Climate Quest.</td>
</tr>
<tr>
<td>Technology scope</td>
<td>Knowledge is owned by employees</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Good network required for accessing knowledge</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Knowledge is stored in PLM System</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Special role of knowledge owners</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Support of managers to newcomers</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Difficulties on accessing knowledge</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Climate helps to access knowledge</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Authorization restriction in PLM system</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>No guide lines for storing data</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Average level of complexity</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>High level of complexity</td>
<td>x</td>
</tr>
<tr>
<td>Transfer management</td>
<td>Well-structured process</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Very short concept phase</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Communication needs improvement</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Concept are finalized in development phase</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Emails, phone, meetings as communication channels</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>No cross-functional teams in concept phase</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>No cross-functional teams in development phase</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Project leaders responsible for the distributing of information</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Project leaders responsible for how the information is stored in PLM</td>
<td>x</td>
</tr>
<tr>
<td>Strategic and operational factors</td>
<td>No consistent decision taking</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Clear decision making</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>No transparent communication of targets</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Low risk taking and no managerial support.</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>High risk taking and support for employees</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Future orientated strategy</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Strict rules and structure are not motivating</td>
<td>x</td>
</tr>
</tbody>
</table>

K = Knowledge, C = climate, K+C = both
## 8.6 Appendix 6: Product development / Production in-terface factors analysis

<table>
<thead>
<tr>
<th>Interface factors</th>
<th>Results</th>
<th>Supported by:</th>
<th>Effects on</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Involvement</strong></td>
<td></td>
<td>Creative Climate Quests</td>
<td>Challenges Question</td>
</tr>
<tr>
<td>Too late involvement of production</td>
<td>x x x x x</td>
<td>K</td>
<td></td>
</tr>
<tr>
<td>No clear rules how and when other departments need to be involved</td>
<td>x</td>
<td>x</td>
<td>C</td>
</tr>
<tr>
<td>Production engineers are not available due to high workload- creating waiting times.</td>
<td>x x x x</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Early involvement is appreciated by product development and production</td>
<td>x x x</td>
<td>K</td>
<td></td>
</tr>
<tr>
<td>No active involvement of production in the development phase</td>
<td>x x x x x</td>
<td>K</td>
<td></td>
</tr>
<tr>
<td>Knowledge from production is highly welcomed by product development</td>
<td>x x x x</td>
<td>K</td>
<td></td>
</tr>
<tr>
<td>Island thinking</td>
<td>x x x x</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>No cross-functional teams in concept phase</td>
<td>x</td>
<td>x</td>
<td>K</td>
</tr>
<tr>
<td>Concept phase is not specific enough for production involvement.</td>
<td>x</td>
<td>x</td>
<td>K</td>
</tr>
<tr>
<td><strong>Product manufacturability</strong></td>
<td></td>
<td>Creative Climate Quests</td>
<td>Challenges Question</td>
</tr>
<tr>
<td>Lessons learned not used in other projects</td>
<td>x x x x x</td>
<td>K</td>
<td></td>
</tr>
<tr>
<td>No information exchange between the departments</td>
<td>x x x x x</td>
<td>K</td>
<td></td>
</tr>
<tr>
<td>No feedback culture</td>
<td>x</td>
<td>x x x x x</td>
<td>K</td>
</tr>
<tr>
<td>No feedback after innovation process is finished</td>
<td>x</td>
<td>x x x</td>
<td>K</td>
</tr>
<tr>
<td>High exchange of information during product launch and concept phase</td>
<td>x</td>
<td>x</td>
<td>K</td>
</tr>
<tr>
<td>Bad quality of transferred information</td>
<td>x x x x x</td>
<td>K</td>
<td></td>
</tr>
<tr>
<td>Information sharing depending on the project managers</td>
<td>x x x x</td>
<td>K</td>
<td></td>
</tr>
<tr>
<td><strong>Resources and time</strong></td>
<td></td>
<td>Creative Climate Quests</td>
<td>Challenges Question</td>
</tr>
<tr>
<td>Not enough resources in every phase of the innovation process</td>
<td>x x x x x</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Better allocation of resources needed.</td>
<td>x x x x x</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Too many projects at the same time</td>
<td>x x</td>
<td>x</td>
<td>C</td>
</tr>
<tr>
<td>Time pressure biggest issue</td>
<td>x x x x</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Luck of available production engineers</td>
<td>x x x x</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Too much “noise” to do the job</td>
<td>x</td>
<td>x</td>
<td>C</td>
</tr>
<tr>
<td>Uneven workload during the year caused my launch windows</td>
<td>x</td>
<td>x</td>
<td>C</td>
</tr>
<tr>
<td>High employee turn over-causes high workload</td>
<td>x</td>
<td>x</td>
<td>C</td>
</tr>
</tbody>
</table>

K=knowledge, C=climate, K+C= both
## Communication

<table>
<thead>
<tr>
<th></th>
<th>K</th>
<th>C</th>
<th>K+C</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overuse of emails-no direct talk causes delay in work</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication open, collegial</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Island thinking</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low teamwork and responsibility taking</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information sharing depending on the project managers</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facilities in the same wider area</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>In the same building and with the own canteen</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No language barriers-spoken languages English and Swedish</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low turnover of employees =&gt; strong bonds</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>High turnover of employee =&gt; limits communication</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical distance between production and product development department =&gt; limits interaction</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

K=knowledge, C=climate, K+C= both
Appendices

8.7 Appendix 7: Creativity dimensions

Göran Ekvall’s creative climate questionnaire is based on ten dimensions and covers each one aspect of the internal creative climate. (Isaksen & Ekvall, 2010)

Challenge and Involvement: To what extend the employees are involved in the operations and challenges. A high score represents better levels of engagement, commitment and motivation.

Freedom: The level of independency of the organisational members and their perceived level of autonomy.

Trust / Openness: Represents how trustworthy/ open the relationships are in the organisation. High levels are supporting the willingness to share ideas/information.

Idea time: Considers the amount of time that peoples are allowed to spend on new idea development.

Playfulness/Humour: This dimension represents the atmosphere, the spontaneity and level of stress in the workplace.

Conflict: The only negative dimension (contrast to debate), it shows presence of personal and emotional tensions that often leads to gossiping, plotting or warfare between the members.

Idea-Support: How ideas are supported within the organisation, how people taking ideas and suggestions, if they listen to each other’s. Summarized how professional handles the organisation new ideas.

Debate: How are debates held regarding ideas, experiences and knowledge, the way the different voices and viewpoints are considered and exchanged.

Risk-Taking: The handling of risks or the tolerance of uncertainty and ambiguity within the organisation. People are allowed to take decisions even with a high risk potential and are able to push new ideas.