The speed of change increases due to the pace of technological change and globalisation, and many industries that usually have acted in stable settings will in the future act in more dynamic marketplaces. To be able to manage dynamic conditions, the organisation needs to continue delivering effectively in existing business areas while developing new systems, products and processes to take advantage of new opportunities in the future. Thus the organisation must be able to use abilities for exploitation and exploration simultaneously or, in other words, strive for continuous innovation including ambidexterity.

In the traditional manufacturing industry, many companies use some sort of improvement programme for achieving operational excellence, and a trend among multinational manufacturing companies is to deploy and integrate corporate improvement programmes (XPS). These are based on lean production and inspired by the Toyota Production System. Generally, improvement programmes such as XPS largely support the development of exploitation capabilities but not exploration capabilities, which instead may have to stand back. Previous research stresses a need to develop knowledge and support regarding how manufacturing companies can modify their production systems to remain resource-efficient while simultaneously adapting to more radical changes.

Accordingly, this thesis contributes with a longitudinal case study at a manufacturing plant integrating an XPS under dynamic conditions. The research shows that there is a risk that the XPS concept is abandoned due to a lack of understanding of how it contributes to solve the turbulent situation that appears under dynamic conditions. At the same time, it is important to develop and support exploration skills in parallel, as these abilities are not particularly well developed in this context. Furthermore, the research shows that a strategy formulation process striving for deep involvement can be used as a means of creating ambidextrous capabilities.

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ADAPTING TO DYNAMIC CONDITIONS THROUGH CONTINUOUS INNOVATION IN MANUFACTURING

Lina Stålberg

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ADAPTING TO DYNAMIC CONDITIONS THROUGH CONTINUOUS INNOVATION IN MANUFACTURING

Lina Stålberg

Akademisk avhandling

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Akademin för innovation, design och teknik
Abstract
The speed of change increases due to the pace of technological change and globalisation, and many industries that usually have acted in more stable settings will in the future act in more dynamic marketplaces. In order to be able to manage dynamic conditions, the organisation needs to continue delivering effectively in existing business areas while developing new systems, products and processes to take advantage of new opportunities in the future. This means that the organisation must be able to use abilities for exploitation and exploration simultaneously or, in other words, strive for continuous innovation including ambidexterity.

In the traditional manufacturing industry, many companies use some sort of improvement programme for achieving operational excellence. Hence, a trend among multinational manufacturing companies is also to deploy and integrate corporate improvement programmes (XPS). These are based on lean production and inspired by the Toyota Production System. Generally, improvement programmes such as XPS largely support the development of exploitation capabilities but not exploration capabilities, which instead may have to stand back. Previous research states that these are problematic and complex issues that need to be further understood and developed. Therefore, more knowledge and support needs to be developed regarding how manufacturing companies can adapt their production systems to remain resource-efficient while simultaneously adapting to more radical changes.

The overall purpose of this research project is to contribute to an increased understanding of how XPS integrations can be developed towards continuous innovation to be able to manage more dynamic conditions. Accordingly, the research objective is to develop recommendations supporting continuous innovation in manufacturing. An overall longitudinal study has been carried out containing five case studies at a manufacturing company integrating an XPS during dynamic conditions, i.e., with large variations in volumes and mixes of products together with the introduction of new products and production concepts. The studies conducted and the results are presented in five appended papers.

The research shows there is a risk that the XPS concept is abandoned due to a lack of understanding of how the XPS contributes to solve the turbulent situation that appears under dynamic conditions. At the same time, it is important to develop and support exploration skills in parallel, as these abilities are not particularly well developed in this context. Furthermore, the research shows that a strategy formulation process striving for high involvement can be used as a means of creating ambidextrous capabilities.
Abstract
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Sammanfattning

Förändringshastigheten ökar i omvärlden på grund av snabba teknikförändringar och globalisering. och många industrier som tidigare befann sig i mer stabila miljöer kommer framöver att befinna sig på mer dynamiska marknader. För att kunna hantera dynamiska villkor behöver organisationen fortsätta leverera effektivt i befintliga affärsområden och samtidigt utveckla nya system, produkter och processer för att kunna dra nytta av nya möjligheter i framtiden. Det här innebär att organisationen måste klara av att använda förmågor till effektivt resursutnyttjande (exploitation) och utforskande (exploration) samtidigt, med andra ord att sträva efter kontinuerlig innovation inklusive ambidextrit.


Det övergripande syftet med forskningsprojektet är att bidra till en ökad förståelse för hur integreringar av XPS i produktionssystem kan utvecklas mot kontinuerlig innovation för att kunna hantera dynamiska förändringar. Vidare är målet att utveckla rekommendationer som stödjer kontinuerlig innovation i produktionssystem. En longitudinell studie av en integration av XPS har följaktligen utförts på en fabrik i ett tillverkande företag. Studien innehåller fem fallstudier som utfördes under dynamiska villkor, det vill säga med stor variation i volym och mix av produkter samt med introduktion av nya produkter och produktionskoncept. De utförda studierna och resultaten presenteras i fem bifogade artiklar.

Forskningsvisar att det finns en risk att konceptet XPS överges på grund av att man inte förstår hur det hjälper till att lösa den turbulenta situation som uppstår under dynamiska villkor. Samtidigt är det viktigt att parallellt utveckla och stödja förmågor till utforskning (exploration) eftersom dessa förmågor inte är särskilt välutvecklade i denna kontext. Vidare visar forskningen att en strategiformuleringsprocess där man strävar efter stor delaktighet kan användas som ett medel för att skapa ambidextrösa förmågor.
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_Lina Stålberg_

Eskilstuna, May 2018
Publications

Appended papers


Stålberg is the main and corresponding author and presenter of the paper.


Stålberg is the main and corresponding author of the paper.


Stålberg and Gåsvaer are the main and corresponding authors and Stålberg was the presenter of the paper.


Stålberg is the main and corresponding author of the paper.


Stålberg is the main and corresponding author and presenter of the paper.
Additional publications


Definitions

**Continuous improvement:** “the continuous process of improvement in the company done with the participation of all staff” (Sanchez and Blanco, 2014, p. 988).

**Continuous innovation:** “the on-going interaction between operations, incremental improvement, learning, radical innovation and strategy aimed at effectively combining operational effectiveness, innovation and strategic excellence, or exploitation and exploration” (Martini et al., 2013, p. 12).

**Dynamic conditions** are caused by a dynamic outside world, which constantly sets an organisation in front of new situations and events it needs to master (Azadegan et al., 2013). Dynamic conditions internally involve rapidly changing volumes and changed mixes of products together with new products and concepts that also need to be managed in the production system.

**Exploitation** relates to the knowledge associated with achieving a more efficient use of existing resources. Exploitation includes the knowledge and know-how resulting in more efficient routines and procedures (Jacobsen and Thorsvik, 2014).

**Exploration** is related to the learning of new things and identification of new possibilities. Exploration includes, for instance, new products or new production methods that substantially differ from previously accepted methods. Exploration is necessary for innovation and rethinking to take place (Jacobsen and Thorsvik, 2014).

**Lean production** operates to increase production efficiency by continuously eliminating waste in the production processes by applying the main principles just-in-time and jidoka and by striving for perfection through continuous improvement. The purpose of the principle just-in-time is to produce and deliver goods in the exact amount and at the exact time as they are needed. The principle jidoka concerns building quality into the product by ensuring that everything is done right from the start and stopping immediately if something does go wrong (Petersson et al., 2009).

**Organisational ambidexterity:** the capacity of an organisation to address mutually conflicting demands (Birkinshaw et al., 2016).

**Production system** can be viewed as a transformation system including activities and facilities needed to transform raw material into products or parts of products (Hubka and Eder, 1988, Bellgran and Säfsten, 2010).

**XPS:** a corporate improvement programme based on lean production and inspired by the Toyota Production System and tailored to the specific needs of the company (Netland and Aspelund, 2014).
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1. Introduction

This chapter introduces and describes the background to this research area and intends to give the reader an understanding of the research. The problem statement is described, leading to the objective of the thesis and the research questions. Further, the scope and delimitations are discussed and the chapter ends with a presentation of the outline of the thesis.

1.1 Background

The speed of change in the external environment increases due to the pace of technological change and globalisation, and organisations must respond to this fast changing environment in order to stay competitive (SQMA, 2012, Teece and Leih, 2016). Our context (organisational life world) has after the two world wars slowly accelerated, which may have been perceived by managers and employees as a stable and fairly static process in the 50s and 60s (Ahrenfelt, 1995). Today companies experience a significantly higher speed of change in the external environment that leads to new and strong demands on adaptation and internal organisational change. Thus organisations used to be characterised by stability and predictability, but contemporary organisations of today are on the contrary characterised by change (Jacobsen and Thorsvik, 2014), and many industries that usually have acted in more stable settings will from now on act in more dynamic markets (Boer and Gertsen, 2003, Steiber and Alänge, 2013, Eriksson et al., 2016, Teece and Leih, 2016). This involves a need for the organisation to be able to deliver effectively in the existing business and simultaneously continue further development of the company and business models that are needed in order to gain advantage of opportunities in the future caused by external changes (Steiber, 2014).

Research on adaptability in companies is not new; Steiber and Alänge (2016), e.g., introduce the so-called Silicon Valley model as a means to increase adaptability in organisations. The research shows interesting new perspectives based on observations from Tesla Motors, Google, Apigee, Facebook, LinkedIn and Twitter. Important principles in the model are dynamic capabilities, a continually changing organisation, a people-centric approach, an ambidextrous organisation, an open organisation that networks with its surroundings and a systems approach (Steiber and Alänge, 2016). However, more research is needed in old-fashioned companies with a history of being more conservative when it comes to the ability to adapt to new circumstances at a dynamic market (Eriksson et al., 2016, Fundin et al., 2017, Fundin et al., 2018). For instance, the construction equipment industry has for a long time acted in more stable settings but must now also adapt more rapidly. The challenge will be to realise continuous operational improvements while also exploring alternative transmission technologies and novel mobility concepts such as electromobility. This is required to meet changing political regulations and customer demands as well as to cope with large market fluctuations. Thus this industry, with production systems that have been developed over many years, still has more difficulties to adapt its production systems to dynamic conditions, where
a production system can be defined as a transformations system including activities and facilities needed to transform raw material into products or parts of products (Hubka and Eder, 1988, Bellgran and Säfsten, 2010). This need for adaptation involves being able to simultaneously incrementally and radically improve the production system, in order to either adapt production processes to fit in the existing production system or adapt the production system itself (Rother, 2010, Yamamoto, 2017).

In industry, the need for continuous improvement in products and processes is widely recognised, and many companies apply some kind of continuous improvement concept in which continuous improvement can be defined as “the continuous process of improvement in the company done with the participation of all staff” (Sanchez and Blanco, 2014, p. 988). The improvements are typically incremental in nature, even though it is argued that continuous improvement involves improvements ranging from incremental to those of a more radical nature (Elg et al., 2007), and the improvements are achieved through the structured application of tools and techniques targeted at the identification and removal of waste and variation in all processes (McLean et al., 2017). Even though continuous improvement has been applied in industry for many years, continuous improvement concepts are still challenging for companies, and most of these change efforts fail or do not meet targets (Oakland and Tanner, 2007, Bhasin, 2012b, McLean et al., 2017). The challenge lies not in the concepts itself, but in the integration (Bessant and Caffyn, 1997), and what complicates the understanding of continuous improvement further is that it is dualistic; it is both a concept and an integration (Bessant and Caffyn, 1997).

There are many continuous improvement concepts in the development towards operational excellence, of which lean production (LP) is one of the most generally accepted today (Marodin and Saurin, 2013, Sörqvist, 2013, McLean et al., 2017). A trend among multinational manufacturing companies is also to deploy corporate improvement programmes as company-specific production systems (XPS, where X is the company-specific name and PS is the production system). These are based on LP and inspired by the Toyota Production System but tailored to the specific needs of the company (Netland, 2013b). From a corporate perspective the main objective of a multi-plant improvement programme is to coordinate a dispersed production network into aligned world-class competitive plants. The XPSs are also viewed as a strategic way of operating for the company. The XPSs are usually developed at the headquarters and then deployed at the plants. When integrated at a plant, the XPS will be adapted to the specific circumstances at the plant, so that it will have a better fit with the specific plant in question (Netland, 2012, Netland and Aspelund, 2014).

According to Netland and Ferdows (2016), an XPS integration develops in an S-curve manner, and a typical lifecycle path of XPS integration in a plant consists of the four phases establishment, reengineering, continuous improvement and process innovation (Netland, 2012), where the plant in the phase of process innovation is
world class and improves by pushing the performance frontier. In order to do so, the plant must succeed with process innovation, because imitating others only brings a plant to the frontier and not beyond (Netland, 2012). Process innovation implies to have the ability to realise radical and incremental improvements at the same time (Yamamoto, 2013). In fact, integration of continuous improvement concepts follows an evolution towards a learning organisation that will later master process innovation (Bessant and Caffyn, 1997, Bessant et al., 2001). Thus, integrating an XPS is a long-term commitment; achieving those unique internal resources that give a competitive advantage takes many years, and there are many pitfalls on the way (Netland and Aspelund, 2013, McLean et al., 2017). However, generally XPS programmes only support incremental innovation, which is also emphasised by other researchers implying that quality management models or continuous improvement concepts do not support radical innovation/improvement (Eriksson et al., 2016) and suggesting that this support needs to be developed. What is also troublesome is that LP principles build on the assumption that the industry logic and the market are relatively stable (Steiber, 2014).

In relation to this and the increasing speed of change causing a need for more dynamic changes there is also an ongoing discussion in other disciplines regarding the fact that the research scene for continuous improvement has switched towards continuous innovation, since it has shifted from only shop floor improvements to also involve learning and innovation (Boer and Gertsen, 2003, Martini et al., 2013). Continuous innovation constitutes not only incremental improvement, but learning, innovation and radical improvement as well. Further, Martini et al. (2013, p. 12) describe continuous innovation as the “on-going interaction between operations, incremental improvement, learning, radical innovation and strategy aimed at effectively combining operational effectiveness, innovation and strategic excellence, or exploitation and exploration”.

Accordingly, the concepts of exploitation and exploration originate from organisational learning and were introduced by March (1991), where exploitation includes refinement, choice, production, efficiency, selection, integration and execution. Exploration, on the other hand, involves things captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discovery and innovation. Further, making exploitation and exploration capabilities co-exist in synergy is, however, also a dilemma that many organisations face, since the inherent logics of exploitation and exploration counteract each other (March, 1991, Jacobsen and Thorsvik, 2014). In the production system development context the dilemma of the concepts concerns how to make them co-exist since process management as a part in operational excellence programme tends to foster good exploitation capabilities at the expense of exploration capabilities that can be outcompeted (Benner and Tushman, 2003). This makes it difficult to realise larger, more innovative changes, as exploration capabilities then are needed. And as long as process management concepts like LP, Lean Six Sigma etc., tend to be viewed as overall panaceas for success, the dilemma will remain (Benner and Tushman, 2015). However, even though it is difficult, there are organisations succeeding in
managing both exploitation and exploration capabilities; they are called ambidextrous organisations (O'Reilly and Tushman, 2013).

1.2 Problem statement and research objective

Improving the production systems and increasing performance is crucial for the manufacturing industry in order to stay competitive globally, operational excellence concepts are often used for that purpose. Among these concepts, LP, on which XPS is based, is currently one of the most adopted ones in manufacturing companies. In recent years, due to the increased external speed of change, the market has become much more turbulent causing needs for managing more dynamic changes. This means that manufacturing companies must adapt more rapidly to realise continuous operational improvements while also exploring new technologies and concepts to meet changing political regulations and customer demands as well as to cope with large market fluctuations. In other words, the company needs to have good exploitation capabilities in order to be resource-efficient as well as good exploration capabilities in order to be able to adapt and capture future opportunities. Hence operational excellence concepts, like XPS, mainly contribute to the development of exploitation capabilities in the production systems and might outcompete exploration capabilities that also are needed in order to adapt to changes. Thus the XPS principles build on the assumption that the industry logics and the market are relatively stable and so the development mainly of exploitation capabilities through XPS integration makes it difficult to manage more dynamic conditions in the production systems. Still these challenges need to be managed.

Hence, what happens when a plant integrates an XPS under more dynamic conditions? First, managing change like an XPS integration and developing continuous improvement and exploitation capabilities is challenging as such. Second, striving to combine or in some way adapt the XPS integration to also include or balance it with radical innovative improvements and develop exploration capabilities in the plant makes the challenges even more complex. Thus, these are challenges that many plants will face in order to manage dynamic conditions, which is needed for long-term competitiveness in the fast changing environment of today. However, as previous research states that these are problematic and complex issues that need to be further understood and developed, there is a need for new research concerning integration of continuous improvement concepts under more dynamic conditions and understanding how these concepts can be developed towards continuous innovation.

Accordingly, the overall purpose of this research project is to contribute to an increased understanding of how XPS integrations could be developed towards continuous innovation to be able to manage more dynamic conditions. In line with this, the research objective is to develop recommendations supporting continuous innovation in production systems. The logic behind the research objective is visualised in Figure 1.
1.3 Research questions

In order to fulfil the objective, three research questions (RQ) are addressed:

RQ1) How does an XPS integration evolve under dynamic conditions?

The first research question responds to the need to understand how an XPS evolves under dynamic conditions. Dynamic conditions (referring to internal dynamic conditions) are defined as rapidly changing volumes and mixes of products that need to be produced in the production system, together with also new incoming products and concepts that also need to be made in the production system.

RQ2) What are the challenges during the XPS integration under dynamic conditions?

The second research question addresses issues like challenges, obstacles, barriers, etc., affecting the XPS integration during dynamic conditions. Becoming aware of these challenges makes it possible to understand how to deal with the difficulties arising.

RQ3) How can an XPS integration be developed towards continuous innovation under dynamic conditions?

The third research question is formulated in order to be able to understand how the needed improvements, from incremental to both incremental and radical innovative improvements, could be supported in the production system under dynamic conditions.
1.4 Scope and delimitations
The scope of this research project is the process of developing continuous improvement towards continuous innovation under dynamic conditions in a production system. The overall unit of analysis is the process of developing continuous improvement towards continuous innovation over time viewed from different perspectives like transferring radical improvement to continuous improvement, a holistic perspective on production system improvement, exploration and exploitation in a production system and related challenges, XPS integration adaptable to dynamic conditions including challenges and the use of a strategy formulation process as a means to bridge the gap between exploration and exploitation.

The research project is related and delimited to an XPS integration in one plant in a global corporate manufacturing organisation. The case gives deep and rich understanding of challenges and opportunities present in this process of change striving to incorporate incremental XPS-based as well as radical and innovative improvement into a holistic approach embracing all types of improvements conducted in the plant’s production system.

1.5 Outline of the thesis
Chapter 2 outlines the theoretical frame of reference used in this thesis. Chapter 3 presents the research methodology employed in this research. Chapter 4 provides a summary of published papers. Chapter 5 contains the analysis, and in Chapter 6 the results from the analysis are discussed leading to a proposal of how to support continuous innovation in a production system. Finally, in Chapter 7, a general discussion and the conclusions of the research are presented and future research suggested.
2. Theoretical framework

This chapter presents the theoretical framework used in this thesis. It is founded on literature studies carried out during the research process. It is based on relevant scientific articles and books and is mainly related to continuous improvement, XPS and continuous innovation.

2.1 Continuous improvement

Continuous improvement has its roots in the quality movement; some of the most common continuous improvement concepts available to improve production systems are: total quality management (TQM) (Deming, 1986, Juran, 1988), lean production (LP) (Womack and Jones, 2003, Liker, 2004), Six Sigma (Aboelmaged, 2010), Lean Six Sigma (Wheat et al., 2003), just-in-time (Sugimori et al., 1977), operational development programme (a programme originally developed by ABB (Ramquist and Eriksson, 2000)) and Kaizen (Imai, 1991). It is not easy to distinguish them completely, since they tend to overlap and some of them do not even have clear definitions (Bergman and Klefsjö, 2010, Sörqvist, 2013). There are several but also similar definitions of continuous improvement (Sanchez and Blanco, 2014); here the definition by Sanchez and Blanco (2014, p. 988) is used: “continuous improvement is defined as the continuous process of improvement in the company done with the participation of all staff”. Improvements are typically incremental in nature, even though it is argued that continuous improvement ranges from incremental to more radical (Elg et al., 2007); improvement is achieved through the structured application of tools and techniques targeted at the identification and removal of waste and variation in all processes (McLean et al., 2017).

Even though continuous improvement has been applied in industry for many years, integration of continuous improvement concepts are still challenging to companies and most change efforts fail or do not meet targets (Oakland and Tanner, 2007, Bhasin, 2012b, McLean et al., 2017). However, the challenge lies not in the concept itself, but in the integration of it (Bessant and Caffyn, 1997, Liker, 2004). Thus what complicates the understanding of continuous improvement is that it is both a concept and an integration, where the integration can be viewed as a long-term learning process (Bessant and Caffyn, 1997).

2.1.1 Continuous improvement integration as a learning process

Learning can be considered as the process in which knowledge is developed through the transformation of experience. Learning can further be regarded as a looping process where the acquisition of knowledge is always ongoing (Granberg and Ohlsson, 2009), and where the learning process leads to a change in practice (Argyris and Schön, 1978, Argyris, 1999, Jacobsen and Thorsvik, 2014). Knowledge is thus the outcome of learning, and it can manifest itself in many ways (Argote, 2013). Organisational learning can be defined “as a change in the organisation’s knowledge that occurs as a function of experience” (Argote, 2013, p. 13). Thus, it is not the organisations that perform the actions that produce the
learning; “[i]t is individuals acting as agents of the organisation who produce the behaviour that leads to learning” (Argyris, 1999, p. 67). To adapt to changing environments and to adjust under uncertain conditions and also to increase efficiency can be argued to be the goal of organisational learning (Dodgson, 1993). Organisational learning can then be seen as a mechanism providing capability development in organisations (Savolainen and Haikonen, 2007).

Single-loop and double-loop learning are two types of organisational learning that are related to continuous improvement integrations (Bessant and Francis, 1999, Bessant et al., 2001, Hines et al., 2004). Single-loop learning is about learning to do the specified behaviours better, where goals and values guiding these behaviours are taken for granted (Jacobsen and Thorsvik, 2014). Single-loop learning is appropriate for repetitive routine issues, and it helps get the day-to-day job done (Argyris, 1999). Single-loop learning occurs when an organisation detects a mistake, corrects it and carries on with its present policies and objectives. Double-loop learning is “why-learning” and is characterised by eventually finding that the results obtained are not consistent with what is needed or intended and therefore wondering why it is counteracting the intention and whether it can be so that goals and values underlying the behaviours are not what is wanted (Jacobsen and Thorsvik, 2014). Double-loop learning is more relevant for complex, non-programmable issues, since it ensures that there will be another day in the future of the organisation (Argyris, 1999). Double-loop learning occurs when an organisation detects a mistake and changes its policies and objectives before it can take corrective actions.

In relation to this, managing both kinds of learning is important for the long-term development of continuous improvement capability and is one of the key transitions facing organisations in the continuous improvement integration process (Bessant and Francis, 1999). According to Bessant et al. (2001), this evolutionary learning process evolves through some maturity levels with a gradual assimilation and integration of some key behavioural routines over time (see Table 1). The maturity levels are: 1) trying out the ideas, 2) structured and systematic continuous improvement, 3) strategic continuous improvement, 4) autonomous innovation, 5) the learning organisation. This evolutionary learning process mainly involves single-loop learning at maturity levels 0–2, and it can take a long time since it is about engaging a large number of employees in systematic problem finding and solving. At maturity levels 3–5 the process also involves double-loop learning, because at specific times there will be a need to reconsider the problem, set new targets and link it with strategic goals, and this will require additional developed behaviours (Bessant and Francis, 1999).

The behavioural routines that are changed and absorbed over time (Bessant and Caffyn, 1997) are patterns of activities that are “the way we do things around here” (Ketokivi and Schroeder, 2004). These behavioural routines are related to abilities linked to continuous improvement (Bessant et al., 2001). These key routines and continuous improvement abilities are summarised in Table 1. They do not come in
a specific order; instead parts of them are developed over time. Further the key routines and continuous improvement abilities are general, but the enablers for how to attain them are contextually dependent (Bessant et al., 2001). The enablers take many forms, such as procedures, company policies and practices, resources and structures. Some examples of enablers are idea management systems, facilitators, measurement systems, recognition systems, problem-solving methodologies and the acceptance of spending time on improvement activity (Bessant et al., 2001).

Table 1. Key routines – abilities associated with continuous improvement.

Adopted from Bessant et al. (2001, p. 72).

<table>
<thead>
<tr>
<th>Key routines</th>
<th>Abilities associated with continuous improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Understanding continuous improvement</td>
<td>The ability to articulate the basic values of continuous improvement</td>
</tr>
<tr>
<td>b. Getting into the continuous improvement habit</td>
<td>The ability to generate sustained involvement in continuous improvement</td>
</tr>
<tr>
<td>c. Focusing on continuous improvement</td>
<td>The ability to link continuous improvement activities to the strategic goals of the company</td>
</tr>
<tr>
<td>d. Leading the way</td>
<td>The ability to lead, direct and support the creating and sustaining of continuous improvement behaviours</td>
</tr>
<tr>
<td>e. Aligning continuous improvement</td>
<td>The ability to create consistency between continuous improvement values and behaviour and the organisational context (structures, procedures, etc.)</td>
</tr>
<tr>
<td>f. Shared problem solving</td>
<td>The ability to move continuous improvement activity across organisational boundaries</td>
</tr>
<tr>
<td>g. Continuous improvement of continuous improvement</td>
<td>The ability to strategically manage the development of continuous improvement</td>
</tr>
<tr>
<td>h. The learning organisation</td>
<td>Generating the ability to enable learning to take place and be captured at all levels</td>
</tr>
</tbody>
</table>

2.2 XPS

In the manufacturing context, lean production (LP) is one of the most generally accepted concepts for continuous improvement (Sörqvist, 2013, McLean et al., 2017), and there has been a tremendous growth of literature related to LP in the last 25 years (Jasti and Kodali, 2015). LP formally appeared in the article “Triumph of the lean production system” by Krafcik (1988). The concept originates from Toyota Production System (Ohno, 1988) and was introduced and spread to the Western world through the book “The Machine that Changed the World” by Womack et al. (1990). LP operates to increase production efficiency by
continuously and tirelessly eliminating waste in the production processes by applying some main principles, which are just-in-time and jidoka, and by striving for perfection through continuous improvement processes (Liker, 2004, Petersson et al., 2009). Waste can be classified into seven categories: over-production, waiting, transportation, unnecessary inventory, inappropriate processing, defects and unnecessary motion (Monden, 2012). The purpose of the main principle of just-in-time is to produce and deliver goods in the exact amount and at the exact time as they are needed. Applying just-in-time assumes that one can work with very short setup and throughput times, that the scrap is negligible and that the availability of machines and plants is high. The main principle jidoka concerns building quality into the product by ensuring that everything is done right from the start and stopping immediately if something does go wrong. It is about creating predictability with respect to product quality (Petersson et al., 2009, Jasti and Kodali, 2015).

A trend across many manufacturing industries is, according to Netland (2013b), who has extensively investigated this phenomenon in several studies, to develop company-specific production systems (XPS, where X denotes the company-specific name and PS denotes the production system). These are corporate improvement programmes inspired by LP and the Toyota Production System. XPS development has become common because previous efforts have shown that for sustained success, improvement programmes need a higher degree of systematisation and adaption of the best practice to the unique characteristics and environment of each company (Netland, 2013b). Inspired by the success of Toyota and its Toyota Production System, many companies hope that having a similar but tailored concept in place will largely contribute to their own competitiveness, if their XPS principles take after the principles of the Toyota Production System and LP. Hence, an XPS represents the strategic choice of operating principles most important to a company, and thus an XPS represents “an own-best-way approach to the one-best-way paradigm” (Netland, 2013b, p. 1093). Also, according to Netland and Sanchez (2014), an XPS is an example of a holistic approach to improvement, where the best of just-in-time, Six Sigma, TQM, LP, etc., can be strategically selected by the organisation.

From a corporate perspective the main objective of multi-plant improvement programmes is to create competitive strength by coordinating dispersed production plants into aligned world-class competitive plants where best practice can be shared (Boscarini et al., 2016). The XPSs are developed at the headquarters and then deployed at the plants. When the XPS is integrated in a plant, it will be adapted to the specific circumstances in the plant, in order to achieve a better fit (Netland, 2012, Netland and Aspelund, 2014). However, the balance between adaptation and adoption of the XPS can be a dilemma in an integration since there are no clear guidelines concerning adaptation and adoption (Netland and Aspelund, 2014).
Adaptation of the concept is important since it improves institutionalisation at the plants. Adaptation can further be defined as “the process by which an adopter strives to create a better fit between an external practice and the adopter’s particular needs to increase its ‘zone of acceptance’ during implementation” (Ansari et al., 2010, p. 71). Adoption is full acceptance of the concept. However, even though adaptation is important, it can make it more difficult to share best practice between plants (Szulanski, 1996, Jensen and Szulanski, 2004). Therefore, it is important to try to find an appropriate balance between adaptation and adoption, which can be challenging and continues to be challenging during the whole integration of XPS since the concept is developed over time (Ansari et al., 2010). Further, Netland and Aspelund (2014) suggest an interesting solution to this dilemma, the Arrow core concept by Winter and Szulanski (2001). This concept can be used as a guideline when discussing and making necessary adaptations, where the Arrow core is what constitutes the very core of the concept, and as long as the Arrow core is transferred, a partial transfer process will give the expected and wanted results (Winter and Szulanski, 2001, Netland and Aspelund, 2014).

### 2.2.1 Integration of XPS

During the XPS integration the plants are supported by a central XPS organisation and by local change agents at the plant. Regular assessments of the XPS integration are made in order to follow up the progress and also to put pressure and thereby to help avoid regression in the programme as well as trigger a cultural change (Kotter and Choén, 2002). Netland (2012) points out four phases in the lifecycle of XPS integration: establishment, reengineering, continuous improvement and process innovation. In the establishment phase, the XPS programme takes the form of a project that has been preceded by a top-management decision to develop an XPS for the corporate company. During this phase the content, the structure and the integration process (which might vary between plants) of the XPS programme are designed. In order to reduce confusion in the organisation, the XPS is developed as far as possible before it is deployed. However, for the plants to be able to understand what the XPS means to them, if it might differ from the global XPS, each plant must also spend some time in the establishment phase.

The reengineering phase is required if the plant has a functional layout or operates with mass production logic. Therefore this phase involves a major change in the physical layout, which also works as “a threshold for change that to some extent hinders reengineered companies from falling back to the old factory standard” (Netland, 2012, p. 38). Further, productivity is exponentially affected during this phase by the change into a lean production system. During the next phase continuous improvement is developed. According to Netland (2012), this phase can be hard to sustain since it is dependent on a high level of employee participation, the culture as such must contribute to encouraging improvement suggestions, constant management commitment is needed and the XPS processes and structure must also be able to handle the improvement suggestions, where the XPS system as such must be flexible since it is shared between sites. The

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improvements achieved are incremental and take place in a continuous and linear way. The last phase of process innovation is both difficult to reach and sustain. When arriving at this phase the company is “world class and improves by pushing the performance frontier” (Netland, 2012, p. 39) by succeeding with process innovation. Here the improvements/innovations are realised in a step-by-step manner, based on a widespread capacity for learning.

Later on, Netland and Ferdows (2016) also investigated how performance develops in relation to the lean integration. They found that it evolves in an S-curve manner along with the maturity levels of beginner, in transition, advanced and cutting-edge. Accordingly, the beginner phase is more of an exploration phase understanding the concept, and during that phase the performance increases at a low rate. The next phases have more of a character of exploitation. The transition phase is characterised by a rapidly improving performance level based on the many so-called “low-hanging fruits” (quick fixes with quick results). The advanced stage is characterised by a steep rise but a decelerating performance level. All low-hanging fruits have been picked and momentum is kept by focusing on comprehensive improvement projects with long-term results. The cutting-edge stage is related to a high level of performance but a flat part of the S-curve, since it becomes harder to have a high rate of improvement because plants at this stage must push the frontier themselves; in other words, process innovations are needed (Netland and Ferdows, 2016).

2.2.2 Challenges during XPS integration
Even though LP is a well-known concept, and even though there is a well-developed XPS and support for the planned change (Al-Haddad and Kotnour, 2015), the integration of LP/XPS is challenging to companies (Bhasin, 2012a, Marodin and Saurin, 2014, Netland, 2016, McLean et al., 2017). It is explained as a large-scale change, involving changes of the technical systems, the management systems and the culture (Liker, 2004, Netland, 2012, Sörqvist, 2013). As described, LP is to a large extent based on continuous improvement (Womack and Jones, 2003, Shah and Ward, 2007), and therefore the integration process involves learning and will never end, since it is always possible to become leaner (Bessant et al., 2001, Hines et al., 2004, Liker, 2004, Sörqvist, 2013), something that organisations often fail to understand (Saurin et al., 2011). All lean journeys start under different circumstances and there are no general integration steps even though there are general elements (e.g., value stream mapping) where the integration process involves evolution and refinement of the principles and practices (Bhasin, 2012b, Marodin and Saurin, 2013) through the plan–do–check–act cycles of Deming (1986).

There are many studies that have investigated key factors for LP integration, most of them from the perspective of critical success factors (Marodin and Saurin, 2013, Näslund, 2013, Netland, 2016). Netland (2016, p. 2441) suggests “five bundles of actions” important for LP integration in any plant: commit, lead and be involved; train and educate; have a plan and follow it up; allocate resources and share gains;
and apply lean tools and methods. From the perspective of failure of LP integrations there are fewer studies and hence a need for more research (Bhasin, 2012a, Marodin and Saurin, 2014, McLean et al., 2017). In Table 2, themes related to failure of continuous improvement initiatives (lean, Six Sigma and Lean Six Sigma) are compiled based on a systematic literature review conducted by McLean et al. (2017).

Table 2. Themes related to failure of continuous improvement initiatives. Adapted from McLean et al. (2017)

<table>
<thead>
<tr>
<th>Themes related to failure according to McLean et al. (2017)</th>
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<tbody>
<tr>
<td>Motives and expectations</td>
</tr>
<tr>
<td>Organisational culture and environment</td>
</tr>
<tr>
<td>Management leadership</td>
</tr>
<tr>
<td>Integration approach</td>
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<tr>
<td>Training</td>
</tr>
<tr>
<td>Project management</td>
</tr>
<tr>
<td>Employee involvement levels</td>
</tr>
</tbody>
</table>
Feedback and results

Failure to review projects and the wider initiative as a whole may contribute to failure. Examples: Inaccuracies, poor review and poor communication can lead to this, the effectiveness of assessment will be impacted if there are poor or infrequent reviews.

In the light of environmental turbulence causing dynamic conditions, LP integration becomes complex and can lead to failure as can be seen in Table 2 (organisational culture and environment), since LP is argued to be better suited for more stable conditions (Azadegan et al., 2013, Birkie, 2016). This is mainly because “[t]he higher levels of unpredictability and instability in dynamic environments make it difficult for lean operations to synchronize production processes and reduce inventory, which undermines the effectiveness of lean operations” (Azadegan et al., 2013, p. 205), meaning that the just-in-time parts need to be rethought (Birkie, 2016). However, if companies have been integrating lean well and have built a well-integrated LP system based on experimentation and learning, this learning can be adapted to the needs of the specific context to improve the company’s ability to handle uncertainties better. However, more research is needed in order to more fully understand the complexity of LP integration under dynamic conditions (Azadegan et al., 2013, Marodin and Saurin, 2015, Birkie, 2016), and, as McLean et al. (2017) state, the organisation may not have control over the environment, but it is important that these factors are considered and planned for.

2.3 Continuous innovation

Continuous innovation was born in the field of product development in the process “aimed at innovating products within a family” (Boer and Gertsen, 2003, p. 806). With the product life cycles being shorter, the speed of product innovations increases (Cole, 2001). However, product innovations can only be successful if the production system is able to absorb them quickly and produce them efficiently and effectively (Boer and Gertsen, 2003), and therefore companies must go beyond continuous product innovation (Boer and Gertsen, 2003, Steiber and Alänge, 2016), and make innovation also of processes and organisation a regular part in daily business. Since there are innovations in the production system as well, like there are innovations in process technologies (such as 3D printing and production monitoring and control systems supported by IT) and management systems (such as lean and agile production) (Yamamoto, 2017), there is an increased need for combining the two areas effectively (Boer et al., 2006, Martini et al., 2013).

Accordingly, the field of continuous innovation studies the innovation process through the ongoing interaction between exploration and exploitation creating a synergistic combination of operational effectiveness and strategic flexibility (Boer and Gertsen, 2003, Magnusson and Martini, 2008, Martini et al., 2013). This implies searching for new arrangements in relation to product–market–technology–organisation. The range of newness in this search goes from continuous improvement to radical change, i.e., including both incremental
(focusing on exploitation) and radical innovation (exploration) (Boer et al., 2006, Gupta et al., 2006, Magnusson and Martini, 2008). Martini et al. (2013, p. 12) define continuous innovation as the “on-going interaction between operations, incremental improvement, learning, radical innovation and strategy aimed at effectively combining operational effectiveness, innovation and strategic excellence, or exploitation and exploration”. Further, continuous innovation capability is described as the effective enablement of the “ongoing interaction between operations, incremental improvement and learning (exploitation processes), and radical innovation and change (exploration processes)” (Boer et al., 2006, p. 2).

In a context different from traditional manufacturing, some examples of continually innovative organisations (entrepreneurial organisations) have been researched by, among others, Steiber and Alänge (2016). Their research shows interesting perspectives based on observations from Tesla Motors, Google, Apigee, Facebook, LinkedIn and Twitter. Based on their research they have created a management model for managing continuous innovation principles, which are dynamic capabilities, a continually changing organisation, a people-centric approach, an ambidextrous organisation and an open organisation that networks with its surroundings. Dynamic capabilities can be defined as “the firm’s ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments” (Teece et al., 1997, p. 516).

Steiber (2014) and Steiber and Alänge (2013) compared the principles of continuous innovation with the more narrow lean thinking based on the principles by Womack and Jones (2003) and with the broader TQM concept, which is similar to the lean philosophy (Bergman and Klefsjö, 2010). Steiber and Alänge (2013) found that the more narrow lean thinking is not compliant with continuous innovation principles and argue that there is a risk that a more narrow lean thinking with its principles, methods and tools hinders an organisational flexibility that is needed in a fast changing world. However, they also found that many of the soft parts of the TQM concept, like the importance of a strong culture, employee empowerment, the primary role of visible leaders and total approach, are similar to the characteristics of continuous innovation. The main difference seems to be the overall management focus on, e.g., continuous improvement versus continuous innovation and on things such as the design of organisational structure and management processes. Also there seems to be a difference in the way of thinking, where the broader TQM concept stands for a reactive market-pull mentality while continuous innovation, which emphasises radical innovation, represents a more proactive product-push mentality. Steiber and Alänge (2013) further suggest that if continuous innovation is to become as important as continuous improvement, the concept (TQM) needs to be updated specifically regarding how best to organise and manage people for both incremental and radical innovations.
Subsequently, Steiber and Alänge (2016) also discuss whether or not continuous innovation is suitable for large bureaucratic established companies, which they consider “finely tuned machines that use highly efficient processes to reach large markets” (Steiber and Alänge, 2016, p. 168) implying that it is very difficult to radically change these companies. However, they emphasise that the need for developing dynamic capabilities to sense and seize new opportunities is important and the challenges of ambidexterity require a strong function for exploration in addition to efficient exploitation.

Since it is expected that more mature industries in the future will move towards more dynamic conditions, this in turn will create a more general pressure for continuous innovation. However, research related to the interface of (product) innovation and production systems is limited, especially addressing the perspective of the production system; further, there is a general lack of the actionable knowledge that practitioners need to design, implement and develop effectively towards continuously innovative organisations (Boer and Gertsen, 2003, Martini et al., 2013, Eriksson et al., 2016, Steiber and Alänge, 2016, Fundin et al., 2017, Yamamoto, 2017, Fundin et al., 2018).

2.3.1 Exploration and exploitation
Research on exploration and exploitation mostly draws on James March’s notion of exploration and exploitation (Almahendra and Ambos, 2014). March (1991) introduced exploitation and exploration in his seminal article in the early 1990s as follows: exploitation includes refinement, choice, production, efficiency, selection, implementation and execution. Exploration, on the other hand, involves things captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discovery and innovation (March, 1991). These two concepts have different objectives and therefore require different strategies, processes, capabilities and structures and may also have different impacts on the organisation’s overall performance (March, 1996). While exploitation is linked to a short-term and more specific perspective seeking to increase efficiency and reliability and establish standardised processes, exploration aims at achieving flexibility and creating new knowledge and new ways of doing things, often related to deep research and activities with greater risks for the company (Levinthal and March, 1993, March, 1996).

March’s initial work on knowledge exploitation and exploration originates from organisational learning. However, in the last two decades, the concepts have been integrated in a wide range of management studies and literature, thus proven to be widely applicable management concepts (Almahendra and Ambos, 2014). The continuous combination of exploratory and exploitative activities has become an important part of creating sustainable competitive advantage and therefore an essential lens for interpreting various behaviours and outcomes within and across organisations (Eisenhardt et al., 2010, Lavie et al., 2010, Almahendra and Ambos, 2014). Exploitation is related to incremental innovation/improvement and
exploration, on the other hand, is related to radical innovation (Tushman and O'Reilly, 1996). Further, in the process management domain (LP, Six Sigma, TQM and more), the productivity dilemma of exploration and exploitation was first addressed by Benner and Tushman (2003), and it is still relevant since improvement concepts (of which process management is a part) still tend to be viewed as overall panaceas for success (Benner and Tushman, 2015).

The productivity dilemma concerns the inherent logics of the concepts and the tendency of counteraction. In the process management domain there is a focus on efficiency and exploitation of existing resources and knowledge, and this has shown to drive out variation and more radical or exploratory innovation, as sameness is more valued than creativity (Benner and Tushman, 2003, Benner and Tushman, 2015). Since the inherent logics of the concepts tend to counteract each other, exploration can be driven out in a context dominated by exploitation. Thus a continuous improvement concept like LP tends to foster good exploitation capabilities at the expense of exploration capabilities, even though the concept itself is not intended to do so (Fundin et al., 2017). However, as there is a need for larger, more innovative changes within the production system as well, exploration capabilities are also needed in this context in order to adapt, something that lacks support in continuous improvement practices today (Eriksson et al., 2016, Palm et al., 2016, Backström et al., 2017).

2.3.2 Ambidexterity
Ambidexterity can be defined as the capacity of an organisation to address mutually conflicting demands (Birkinshaw et al., 2016). Duncan (1976) was the first researcher to apply the concept of ambidexterity (derived from the anthropological literature) in the organisational domain. Among the first scholars to contribute to the discussion of ambidextrous organisations in relation to exploration and exploitation were Michael Tushman and Charles O’Reilly (Almahendra and Ambos, 2014). Tushman and O'Reilly (1996, p. 24) defined organisational ambidexterity as “the ability to simultaneously pursue both incremental and discontinuous innovation... from hosting multiple contradictory structures, processes, and cultures within the same firm”, and emphasised that organisational ambidexterity was required for long-term survival and that organisations need to explore and exploit simultaneously to be ambidextrous. In addition, according to Simsek et al. (2009), research on ambidexterity usually uses March (1991) notions of exploration and exploitation. Further on it has also been shown that ambidexterity is positively associated with firm performance, that it is more beneficial under conditions of uncertainty and when sufficient resources are available, which is often the case with larger companies (O'Reilly and Tushman, 2013).

There are different ways to achieve ambidexterity (O'Reilly and Tushman, 2013): sequentially by shifting structures over time, originally suggested by Duncan (1976), and perhaps more suitable for companies in more slowly moving...
environments; by exploring and exploiting simultaneously, where autonomous explore and exploit subunits are structurally separated (Tushman and O'Reilly, 1996); or by designing features of the organisation to allow individuals to divide their time between exploratory and exploitative activities, so called contextual ambidexterity (Gibson and Birkinshaw, 2004). The former two are also referred to as differentiation approaches to ambidexterity and the latter to integration approaches to ambidexterity (Raisch et al., 2009). The differentiation approaches to ambidexterity are historical approaches to cope with the diverging activities. These approaches achieve ambidexterity by emphasising the usage of structure and strategy to enable differentiation among organisational units. Separated efforts are targeted at either one of the two contrasting activities (Martini et al., 2013). The integration approaches to ambidexterity focus on behavioural mechanisms to integrate the diverging activities (Gibson and Birkinshaw, 2004, Raisch et al., 2009, Eisenhardt et al., 2010). For this thesis, structural and contextual approaches for ambidexterity are of more interest, since inspiration is gained from more fast-moving contexts, and therefore these two approaches will be further described.

According to Raisch et al. (2009), the tensions that structural ambidexterity creates are resolved at the next organisational level down. This implies that a business unit can become ambidextrous by creating two functions or subdivisions with different foci. A manufacturing plant may become ambidextrous by creating two different teams, one in charge of exploitation and another in charge of exploration, and a single team may become ambidextrous by allocating different roles to each individual. Accordingly, structural mechanisms are used to enable ambidexterity, whereas most individuals are seen as focused on either exploration or exploitation activities (Raisch et al., 2009). Further, structural ambidexterity entails to have “separate structural units for exploration and exploitation but also different competencies, systems, incentives, processes and cultures – each internally aligned” (O'Reilly and Tushman, 2008, p. 193). The separate units are held together by a common strategic intent with overall values and mechanisms contributing to wanted effects in relation to overarching objectives. Here, the ability of the organisation to sense and seize new opportunities through simultaneous exploration and exploitation is the key to ambidexterity and therefore becomes a leadership issue rather than a structural one (Andriopoulos and Lewis, 2009, Raisch et al., 2009, O'Reilly and Tushman, 2013). Accordingly, structural ambidexterity (or differentiation approaches to ambidexterity) generally consists of autonomous structural units for exploration and exploitation, mechanisms contributing to wanted effects in relation to overarching objectives, an overall vision that supports the need for both exploration and exploitation and a leadership able to manage the tensions related to several organisational alignments (O'Reilly and Tushman, 2013).

Contextual ambidexterity, or an integration approach to ambidexterity, also called behavioural ambidexterity (Birkinshaw et al., 2016), is defined by Gibson and Birkinshaw (2004, p. 209) as “the behavioural capacity to simultaneously
demonstrate alignment and adaptability across an entire business unit. Alignment refers to coherence among all the patterns of activities in the business unit; they are working together towards the same goals. Adaptability refers to the capacity to reconfigure activities in the business unit quickly to meet changing demands in the task environment”. To further achieve contextual ambidexterity, processes and systems are needed that support and enable individuals to decide how to divide their time between alignment and adaptability. Therefore, the ability to balance exploration and exploitation is related to an “organisational context characterised by an interaction of stretch, discipline and trust” (Gibson and Birkinshaw, 2004, p. 214). Contextual ambidexterity assumes that ambidexterity is rooted in an individual’s ability to explore and exploit. In a study by Adler et al. (1999), mechanisms for unifying efficiency (alignment) and flexibility (adaptability) that rely on individuals to make their own choices are described. The workers perform routine tasks like automobile assembly (exploitation) but are also expected to continuously change their jobs to become more efficient (exploration). Further, production workers switch between the two tasks supported by parallel organisational structures, such as quality circles (meta-routines, routines applied for changing other routines; they facilitate the performance of non-routine tasks). These structures, also including the larger management system and a supportive culture, enable people from the same unit to move back and forth between a bureaucratic structure for routine tasks and an organic structure for non-routine tasks (Adler et al., 1999).

There are also shortages that concern the ambidexterity approaches. For the structural approach they mean that it has to be recombined in order to create value, and there is a need for top management teams to ensure integration across differentiated units (O’Reilly and Tushman, 2008, Raisch et al., 2009, O’Reilly and Tushman, 2013). Accordingly, pure differentiation approaches create different forms of separation that probably result in sharp interfaces, ambiguous priorities and a lack of common orientation (O’Reilly and Tushman, 2013). Conversely, the integration approaches are limited by the individuals taking on exploitative and explorative tasks. Since they rely on the same basic experiences, values and capabilities to carry out both tasks, it can be difficult to explore fundamentally different knowledge areas. Other challenges are related to the individual dependency: those individuals who focus on creativity and exploration differ even in personality from those who emphasise implementation or exploitation activities (Amabile, 1996); it is also challenging for an individual to excel at both exploitation and exploration (Gupta et al., 2006). Also organisational factors affect individuals’ ability to act ambidextrously (Raisch et al., 2009).

Although there are different modes of ambidexterity that use separate ways to deal with the need for exploitation and exploration, in-depth studies have shown that over time companies may use combinations of these to balance exploitation and exploration (O’Reilly and Tushman, 2013). Accordingly, when exploratory efforts achieve strategy and customer legitimacy and are less vulnerable to being crowded
out by the focus of exploitation in the company, the firm shifts to contextual ambidexterity – where both exploration and exploitation are executed throughout the same company or business unit (Benner and Tushman, 2003).

There is a great deal of research on ambidexterity but still much is unclear, like, e.g., the role of senior team and leadership behaviours in engaging in the conflicting demands of exploration and exploitation, since leaders must be able to manage the allocation of resources between the routine and new business domains (O’Reilly and Tushman, 2013). Also, broader questions on how organisations effectively manage a strategic paradox still remain (Benner and Tushman, 2015). Further, since process management persists and new programmes promoted as universal panaceas for organisational challenges continuously emerge, it is important to continue to carefully understand how popular practices like LP influence organisations (Benner and Tushman, 2003, Benner and Tushman, 2015).

2.4 Literature synopsis

In Table 3, theories about XPS and continuous improvement integrations are linked, where Bessant et al.’s (2001) framework (maturity levels) will be used in the analysis to explain what happens in the XPS integration according to Netland’s (2012) integration phases.

Table 3. Linking XPS and continuous improvement integration theories

<table>
<thead>
<tr>
<th>XPS integration (phases) (Netland, 2012)</th>
<th>XPS integration (maturity levels) (Netland and Ferdows, 2016)</th>
<th>Continuous improvement integration (maturity levels) (Bessant et al., 2001)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishment</td>
<td>Beginner (exploration phase)</td>
<td>Trying out the ideas</td>
</tr>
<tr>
<td>Reengineering (if needed)</td>
<td>Beginner (exploration phase)</td>
<td>Trying out the ideas</td>
</tr>
<tr>
<td>Continuous improvement</td>
<td>In transition (exploitation phase)</td>
<td>Structured and systematic continuous improvement</td>
</tr>
<tr>
<td></td>
<td>Advanced (exploitation phase)</td>
<td>Strategic continuous improvement</td>
</tr>
<tr>
<td>Process innovation</td>
<td>Cutting-edge (exploitation phase)</td>
<td>Autonomous innovation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The learning organisation</td>
</tr>
</tbody>
</table>

Issues that will be further especially elaborated on in the analysis are summarised in the following bullet points:

- Continuous improvement integration is a learning process involving single- and double-loop learning, where the involvement also of double-loop learning makes it possible to make it a strategic capability; however, it is difficult to enable this key transition.
• XPSs are corporate improvement programmes used for transforming a dispersed production network into aligned world-class competitive plants where best practice can be shared. This raises adaptation issues, especially under dynamic conditions, that need to be further investigated.

• XPS integrations are difficult, especially the phase of continuous improvement since that is dependent on deep employee involvement, and it is difficult to sustain this phase and develop it further.

• There are many challenges related to XPS integration, where especially the challenge related to the environment makes the XPS integration complex, based on just-in-time more suitable for stable conditions, and more research is needed regarding dynamic conditions.

• Continuous innovation is important for companies acting in dynamic environments and concerns the ongoing interaction between operational excellence and strategic flexibility. However, the perspective from production system innovations is underestimated and more research is needed concerning the effects of continuous innovation on the production system as well as the need for actionable knowledge.

• Exploration and exploitation are related to continuous innovation capability. Since the production system is an important part of building continuous innovation capability, the concepts of exploration and exploitation need to be further understood in this context, especially since the productivity dilemma affects this context and since continuous improvement concepts lack support for exploration.

• Ambidexterity concerns ways to manage exploration and exploitation and is used to further understand how these can be applied in production systems and support dynamic conditions as well as to investigate the relation to XPS.
3. Research methodology

This chapter presents the research methodology for the research project in this thesis. First it outlines the research strategy. Then the research process is described including a presentation of the case company and the studies conducted. The chapter ends with a discussion concerning the quality of the research including ethics and the role of the researcher.

3.1 Research strategy

Research concerns the systematic search for new knowledge (Vetenskapsrådet, 2017), where the aim is the creation and development of knowledge and the output is contribution to knowledge (Karlsson, 2009). To be able to do a systematic search for new knowledge, the researcher has to adopt a suitable approach that is able to give insights into the phenomenon or the process that is of interest (Arbnor and Bjerke, 2009, Karlsson, 2009) and that makes it possible to answer the research questions (Yin, 2014). The phenomenon of interest in this research is the process of developing continuous improvement towards continuous innovation in a production system under dynamic conditions. This involves understanding a process of change in which people interpret issues and acts; the truth is then regarded as more subjective and the researcher needs to take on a more interpretive approach to create understanding (Arbnor and Bjerke, 2009, Karlsson, 2009). In line with this, qualitative research has mainly been applied (Gummesson, 2000, Karlsson, 2009, Merriam, 2009), where the research strategy more specifically has been to conduct a longitudinal case study in real time, which is suitable when studying a process of change that unfolds over time (Åhlström and Karlsson, 2009). With the opportunity to follow this long-term process of developing continuous improvement towards continuous innovation in a longitudinal study as an industrial Ph.D. candidate and with almost unlimited access to data and great transparency in the case company, a single case approach was also chosen in order to acquire in-depth knowledge of the phenomenon (Åhlström and Karlsson, 2009, Barratt et al., 2011, Yin, 2014). This longitudinal approach does not deal with specific time intervals but instead covers trends over an extended period of time, following a developmental course of interest (Yin, 2014). In other words, it gives a number of cross-sectional snapshots in time of the phenomenon (Åhlström and Karlsson, 2009).

3.2 Research process

Thus the empirical studies have been conducted within the overall longitudinal case study at a single case company. The overall research process can be seen as an iterative process between theoretical and empirical studies and contains three larger studies, Study A, Study B and Study C_{1,2,3}. In line with this, the problem statement has been based on identified industrial problems in the case study company during its integration process as well as gaps found in previous research. The literature includes books and articles found mainly by using the Mälardalen University library directory and the databases Emerald, Google Scholar, Scopus,
Mainly case studies have been conducted since they have a distinct advantage when a how or why question is asked about a contemporary set of events over which the researcher has little or no control; they are also preferable when investigating a specific phenomenon (Yin, 2014). Another important advantage of case study research is the possibility to also get a holistic view of a process and the research phenomenon (Gummesson, 2000). The case study approach was in one of the case studies also combined with an interactive research approach since that specific study aimed to address a practical concern, the creation of scientifically acceptable knowledge as well as enhanced competencies of the parties involved in the study through processes of dialogue and learning (Ellström, 2007).

In the case studies, empirical data were collected through interviews, observations, participating observations and documents. In the case study that was combined with an interactive research approach, the empirical data were also collected through co-researcher reflections and notes. The collected data were mainly qualitative data but some were also quantitative. The qualitative data have been analysed using mainly pattern matching logic according to Yin (2014) and category construction inspired by Merriam (2009), where pattern matching compares an empirically-based pattern with a predicted pattern that was established before the data collection started (Yin, 2014). A category is the same as a theme, a pattern, a finding or an answer to a research question. Category construction involves transcription of all interviews/field notes, open codification of the first interview/field note, grouping of open codification, creation of master list of themes, after-reading through the second interview/field note in the same way as the first, reading through the rest of the interviews/field notes and gradually evolving themes, refinement of the themes and description of results based on themes (Merriam, 2009). Table 4 presents an overview of the research conducted.
Table 4. Overview of the research conducted

<table>
<thead>
<tr>
<th>RQ</th>
<th>Study</th>
<th>Research approach</th>
<th>Unit(s) of analysis</th>
<th>Techniques for data collection (number)</th>
<th>Paper: number and title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2</td>
<td>A</td>
<td>Holistic multiple case study</td>
<td>Continuous improvement process</td>
<td>Interviews (18) Observations (9) KPI documents</td>
<td>I: Transitioning radical improvement to continuous improvement</td>
</tr>
<tr>
<td>1, 2</td>
<td>B</td>
<td>Embedded single case study</td>
<td>Holistic improvement approach, challenges</td>
<td>Interviews (10) Participating observation (1) Documents in the operational management system Questionnaire (1)</td>
<td>II: Exploring a holistic perspective on production system improvement</td>
</tr>
<tr>
<td>3</td>
<td>C₁</td>
<td>Literature review and embedded single case study</td>
<td>Exploration and exploitation in the production system, challenges</td>
<td>Literature review Interviews (4) Observations (8)</td>
<td>III: Exploration and exploitation within operations</td>
</tr>
<tr>
<td>1, 2</td>
<td>C₂</td>
<td>Holistic single case study</td>
<td>Challenges that have an impact on organisational adaptability and the XPS integration</td>
<td>Observations (15) Participative observations (9) Interview (1) Assessment data documents</td>
<td>IV: Lean production integration adaptable to dynamic contexts</td>
</tr>
<tr>
<td>(2), 3</td>
<td>C₃</td>
<td>Embedded single case study with an interactive research approach</td>
<td>Exploration and exploitation challenges, strategy formulation process</td>
<td>Observations (11) Participative observations (30) Strategy documents Co-researcher reflections (10) Notes (50)</td>
<td>V: Strategy formulation – bridging the gap between exploration and exploitation</td>
</tr>
</tbody>
</table>
3.2.1 Case company

The case study company is a manufacturing plant that had 800 employees when the research project started; by the end of 2015 the number of employees had decreased to 550. The plant is integrated into a global corporate manufacturing organisation in the construction equipment industry. Based on the XPS, the plant experienced an LP transformation that started in 2007. Since this specific plant was a bottleneck for parts of the corporation, there was a need to quickly increase its capacity, and therefore the business strategy to integrate XPS was to perform a radical change that is like a reengineering phase, a so-called transformation of the plant, over two years (2007–2009) in order to create a good base for continuous improvement. During these two years, the plant was rebuilt from a more functional layout into a flow-based layout, with two larger flows based on product families, including both machining cells and assembly lines. The company-specific production system XPS was integrated (a lean way of working) into all assembly lines and machining cells by a cross-functional project-based organisation between 2007 and 2010. In 2009 the plant experienced a deep recession as did many other manufacturing companies. However, it was still believed that the higher volumes and the mix of products for which the plant was dimensioned and designed during the XPS transformation would return. In 2010 the ownership of the XPS integration was transferred from the project-based organisation to the line organisation in the plant. The line organisation continued to develop the production system towards XPS, aiming to establish an infrastructure for continuous improvement and further integration of the XPS, now with a “continuous improvement approach”. During this period of four years, 2010–2013, the organisation established a continuous improvement approach and achieved a deeper understanding of XPS. Several methods and tools were integrated and further improved. The continuous improvement approach also changed during this period from a more controlled approach to more of a go-to-gemba approach. During that period, there were discussions regarding what improvement programmes, methods and tools to use and how to integrate them. These discussions were sometimes perceived as obstacles since they moved the focus away from the XPS integration. The problems that emerged concerned how to combine and merge all concepts, such as new improvement programmes, methods and tools, but also how to relate those concepts to current working processes. However, at the beginning of 2014 the plant decided to carry out a reorganisation in order to start adapting, since the need for managing those challenges caused by dynamic conditions with lower volumes and a different mix of products together with new coming products and changes had increased significantly. The challenges identified under dynamic conditions are compiled in Table 5. During 2015 the situation was still troublesome. Previously, the XPS programme had been viewed as a strategy for the plant to reach its desired position. However, during the last years XPS had begun to be questioned and the relation between XPS and the new desired strategy was unclear.
Table 5. Compilation of the challenges identified under dynamic conditions

<table>
<thead>
<tr>
<th>Challenges identified under dynamic conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producibility of new products</td>
</tr>
<tr>
<td>New products/architecture in the assembly</td>
</tr>
<tr>
<td>Optimisation and improvement of working methods and methods in assembly</td>
</tr>
<tr>
<td>Increasing staffing flexibility</td>
</tr>
<tr>
<td>Getting control of the competitiveness in relation to competitors</td>
</tr>
<tr>
<td>Proactively developing new and existing methods in production in cooperation with the product development function</td>
</tr>
<tr>
<td>Purchasing or manufacturing and balancing assortment (for smoother production in the machining area)</td>
</tr>
<tr>
<td>Differentiating the production plans to increase flexibility (investments, degree of automation, degree of specialised equipment)</td>
</tr>
<tr>
<td>Better handling of variation in volume, mix and capacity (conscious balance between managing volume/mix variation and used inventory)</td>
</tr>
<tr>
<td>Need for a training and development centre</td>
</tr>
<tr>
<td>Need for more proactive quality work to build a stronger quality culture</td>
</tr>
<tr>
<td>Leadership development</td>
</tr>
</tbody>
</table>

In Figure 3 the XPS integration level over time is visualised, giving an overview of the process, as the XPS integration level is a measure of how far the plant has come in its XPS integration. The assessments were made by trained company assessors, usually on a yearly basis. In Figure 4 the variation of volumes over time is visualised, contributing to the dynamic conditions. The number of components produced is on a yearly basis, but there is also variation during each year. However, the conditions are even more turbulent than can be seen in this graph since the mix of products also has changed. In Figure 5 the change in the mix of products can be seen. Table 5 and Figures 4 and 5 together give an overview of the challenging situation the plant had had for several years causing dynamic conditions internally.
Figure 3. Visualisation of the XPS integration levels from 2007 to 2015 based on XPS assessment data. The x-axis shows the years. The y-axis shows assessment levels. In 2011 a new version of the assessment template was released with higher demands on each level, explaining the low increase in assessment points between 2010 and 2011.

Figure 4. Visualisation of the variation of volumes over time. The y-axis shows number of components produced per year. The x-axis shows the years.
Figure 5. Visualisation of the mix of products. The plant was designed based on an expected mix of the final products A and B during the reengineering phase. However, until 2014 the mix of the final products had changed significantly causing an unbalanced plant.

3.2.2 Study A – Paper I

The starting position for Study A was the transition of the radical integration phase (reengineering phase) of XPS into the next phase of continuous improvement at the case company. The study aimed to explore key factors for continuous improvement processes and how these factors would enable development of continuous improvement as well as further development of the organisation after the radical integration phase. The study also aimed to pinpoint industrial problems that could form the basis for future research.

Study A was an exploratory holistic multiple case study (including both qualitative and quantitative data), consisting of six pilot teams from the case company, four machining cells teams and two assembly teams. All teams had gone through the radical phase and had started to focus on continuous improvement. As the term exploratory study suggests, such a study is often conducted because a problem has not been clearly defined, or its real scope is unclear, and it will help identify a research focus when the understanding is still insufficient or lacking. It may also help researchers discover important categories of meaning and generate hypotheses for further research (Marshall and Rossman, 2006, Blessing and Chakrabarti, 2009, Yin, 2014).

The study started with a literature review concerning key factors for continuous improvement processes. The empirical data were collected through interviews, observations and documents. The interview guide used for the study was based on eight key factors for improvement processes that were derived from a literature review. Eighteen interviews were conducted with six production supervisors, six team leaders and six operators, one of each from each team. The interviews were
recorded and lasted between 60 minutes and 1.5 hours each. Nine team improvement meetings were observed. The documents collected consisted of business ratios: scrap, 5S audit and transformation audit.

The qualitative data were analysed using pattern matching (Yin, 2014), where the key factors found in the literature review were used as the patterns to be compared with. The unit of analysis was the continuous improvement process. The business ratios were mainly used in order to distinguish two teams to compare in terms of success factors, a successful and a less successful team. The qualitative questions in the interview guide were quantified for a better and more visual comparison of the teams. The results were presented to all informants and to other managers in the plant organisation in order to make sure the conclusions made sense and to validate the results as well as to give feedback to the case company.

3.2.3 Study B - Paper II

The purpose of Study B was to examine how holistic improvement work can be organised and what challenges can be observed in the process of adopting a holistic perspective on production system improvement.

Study B was mainly a qualitative study, including a descriptive and exploratory embedded single case study and a questionnaire. The study was carried out in 2012, three years after the completion of the radical integration phase of XPS, and the organisation had continued to work with continuous improvement. It was descriptive since it investigated how holistic improvement work can be organised and it was exploratory since the purpose of Study B also was to identify challenges present in the process of reaching a holistic perspective on production system improvement.

Data were collected through interviews, documents (in the operational management system) and a participating observation in terms of a workshop with the informants. The interview guide was based on questions related to a previously developed concept model. There were 10 interviewees from different parts of the plant organisation. The interviewees were managers on different levels in the plant and XPS change agents; all interviewees had been involved in the XPS integration in different roles between the years 2007 and 2012. The interviews were recorded and some notes were made simultaneously when good ideas popped up. The interviews lasted 30–45 minutes each; all were transcribed. A questionnaire was also distributed to 13 informants from five other manufacturing companies with the aim to increase the generalisability of the results and further validate the conclusions (following the advice from the journal in which Paper II later was published). These five manufacturing companies were integrating LP and the informants were managers and change agents with experience from LP integrations, both in their companies and, in some cases, also in previous work.

To analyse the data from the interviews, pattern matching (Yin, 2014) with a basis in the concept model and category construction inspired by Merriam (2009) was
used. The units of analysis were a holistic improvement approach and challenges. In the workshop with the informants, the results from the case study were presented in order to be sure the conclusions made sense and to validate the results. Based on the feedback some more clarifications could be made. The workshop was also used to give feedback to the case company concerning how to develop the improvement process further.

3.2.4 Study C1 – Paper III

The purpose of study C1 was to get an increased understanding of exploration and exploitation characteristics, to specify what they translate to in the context of improvement and development structures and processes in the production system and to identify practical challenges.

Study C1 was an exploratory study including a literature review and a qualitative embedded single case study. It was exploratory since it aimed to investigate the concepts of exploration and exploitation, what they translate to in a production system and identifying challenges. The study was conducted in 2015, six years after the completion of the radical improvement phase (reengineering phase), and the company had worked with continuous improvement for nearly six years.

A wider literature review was conducted searching for high-quality, well-cited journal articles related to the keywords exploration and exploitation. Databases used were Google Scholar and Scopus. The articles were reviewed with the aim to find definitions, interpretations and descriptions of the terms exploration and exploitation, which were then compiled in a table. Based on the table, key characteristics of exploitation and exploration were identified and presented in a literature summary including a developed understanding of the concepts.

The empirical data were collected mainly through semi-structured interviews and observations. The interview guide was based on questions related to the case company’s improvement and development processes. The interviewees were chosen based on their insights into the improvement and development processes in the production system. The interviewees were the production development manager, two production developers and an XPS change agent. The interviews were recorded and lasted 30-45 min each; all were transcribed. The observations took place at a management level through three project meetings and five strategy meetings.

The empirical data were analysed by the two researchers (the first two authors of Paper III), using category construction according to Merriam (2009), where the units of analysis were exploration and exploitation in the production system and challenges. The key characteristics and the interpretation of the concepts of exploration and exploitation presented in the literature summary were used as the basis for the analysis. The results were shared with the informants in order to validate that the conclusions made sense.
3.2.5 Study C$_2$ – Paper IV

Study C$_2$ aimed to investigate how an XPS integration is affected by dynamic conditions and how such an integration can be adaptable to dynamic conditions.

Study C$_2$ was an explanatory holistic single case study. It included both qualitative and quantitative data. It was explanatory since it explained what happened with the XPS integration and it also suggested how an XPS integration can be adaptable to dynamic conditions. The study was carried out between 2014 and 2015, five or six years after the completion of the reengineering phase, and the plant had continued the XPS integration since then. However, during this time the plant had started to realise that the low volumes with a varying mix of products seemed to be the new normal together with new products and production concepts, and they needed to adapt to those circumstances.

The empirical data were collected through observations, participative observations, documents and through an in-depth semi-structured interview. The observations (during XPS meetings, start-up meetings, management team meetings, strategy meetings and daily conversations) were made with the researcher present at the case company during periods of time from 2014 to the middle of 2015; the observations were documented as field notes in a log book and were continuously reflected on. The participative observations took place at a management level through strategy meetings once a week during approximately eight months; the participative observations were also documented as field notes in the log book and were continuously reflected on. Data collected through documents concerned XPS assessment data, volume data, product mix data and archival data (for example, number of improvements) related to the XPS integration. The extensive interview was made in order to validate and clarify some observations. The interviewee was chosen based on his insights into the improvement and development processes at the plant as a project manager for parts of the XPS integration between 2007 and 2015. The interview lasted 60 minutes; it was recorded and then transcribed.

The empirical data, field notes, documents and the transcribed interview were analysed using category construction (Merriam, 2009), where the unit of analysis is the challenges that have an impact on the ongoing XPS integration. The categories were gradually reflected upon, discussed and revised in the supervisor team.

3.2.6 Study C$_3$ – Paper V

Study C$_3$ aimed to explore challenges related to exploitation and exploration on an overall level and to analyse whether and how a strategy formulation process can be used as a means to bridge the gap and facilitate the development of exploration and exploitation capabilities in a production system. The purpose also included analysing the consequences of a strategy formulation process for an XPS.

It is an exploratory qualitative embedded single case study with an interactive research approach. It is exploratory since it investigates what challenges are related to exploitation and exploration and how they can be solved. The study was
conducted in 2015, six years after the completion of the reengineering phase; the organisation had continued the XPS integration since then. By this time the organisation had started to realise that the low volumes with a varying mix of different components seemed to be the new normal together with new products and production concepts, and they needed to adapt to those circumstances. However, since this was a complex situation for the plant, the plant manager initiated this research project in order to understand and get help to improve the situation. The mission was to conduct a strategy formulation process and create a new strategy for the plant that could be implemented later in order to help to adapt to the prevailing circumstances. As this project also was of interest to this research project and in line with the focus of the research, it was seen as a good study to conduct. The case study approach was combined with an interactive research approach as the study also aimed to address a practical concern in real time, as well as to increase the competencies of the team involved in the study, which can be done through processes of dialogue and learning (Ellström, 2007).

The setup for the project included a project manager who also was the co-researcher, three employees from the production development function (the manager and two production development engineers) and a researcher (the author of this thesis) following the process. Over time the strategy team also included employees from the support functions, such as two logistics developers, a quality developer and an XPS coach. The pre-studies included members from the strategy team and employees with specific roles and knowledge from different functions in the plant. In Figures 6 and 7 the processes for the strategy formulation and for the pre-studies are visualised.

![Strategy process diagram](image)

**Figure 6.** The high-involvement strategy formulation process (visualised in the dotted box) as a part of the whole strategy process. Study C3 investigated the strategy formulation process.
Figure 7. Visualisation of the process used for the pre-studies.

In the pre-studies, the perspective, opportunity/imaging and solutions phases were inspired by Carleton et al.’s (2013) *Playbook for Strategic Foresight and Innovation*. The perspective phase involves a frame of reference, “holding up a mirror to the past so that you may better anticipate the future”, the opportunity phase involves “an ability to see growth opportunities that exist today and extend into the future”, and the solutions phase involves “define solutions, prototyping ideas”. The pre-studies were also conducted in an iterative way. To be able to create understanding and take on a more explorative approach, the strategy team was also educated about innovation teams, like how to start up innovation teams, as well as enablers for innovation during a workshop (Johnsson, 2017b, Johnsson, 2017a).

The roles of the researchers in this project were twofold: to drive and help the project forward and to study issues related to exploration and exploitation and the strategy formulation process. The co-researcher acted as the project manager, who planned, drove and executed the project, while the researcher took a less active role in the project and was more of an observer. The researcher and the co-researcher continuously reflected on the process and made adjustments based on new knowledge created throughout the process. The reflections were often shared with the project team, in order to discuss the findings and share knowledge. With this approach the case company continuously achieved new knowledge and the ability to develop a better strategy formulation process. The researchers got empirical data to be utilised in analyses, theory development and publications.

Accordingly, the empirical data were collected through 11 observations, 30 participative observations, several documents, 10 co-researcher reflections and 50 notes. The observations took place at a management level through management
meetings, strategy meetings and a workshop; the observations were documented as field notes in the log book and were continuously reflected on. The participative observations also took place at a management level through workshops, strategy meetings, pre-study meetings and other meetings; the participative observations were also documented as field notes in the log book and were continuously reflected on. The documents were mainly strategy documents that were developed in the project. The co-researcher’s reflections were also noted in the log book, often leading to new strategy documents that were presented to the team. The notes concerned own reflections that popped up and were written down in the log book.

The analysis was made using category construction, inspired by Merriam (2009), where the units of analysis are exploration and exploitation challenges, and a strategy formulation process. It was an iterative process, starting in the field notes of all sources as suggested by Yin (2014), by identifying challenges related to the concepts of exploitation and exploration in relation to improvement and development work on an overall level. During the analysis the categories were discussed in the research team and gradually improved. The strategy formulation process itself was analysed as to whether it could be used as a means to bridge the gap and facilitate the development of exploration and exploitation capabilities. The results (Paper V) were shared with one of the informants in order to validate that the conclusions made sense. The informant made some comments that were considered and resulted in changes in some of the formulations in Paper V.

3.3 Research quality

Important aspects for evaluating the quality of any research are validity, reliability and ethics (Karlsson, 2009, Merriam, 2009). In qualitative research, internal validity concerns the extent to which research findings are probable, reliability concerns the extent to which there is consistency in the findings, and external validity concerns to what extent the findings of a qualitative study can be generalised or transferred to other situations (Merriam, 2009). The research presented in this thesis is qualitative and is interested in a phenomenon occurring over time. A suitable research strategy has then been to apply a longitudinal case study investigating this phenomenon over time.

The internal validity in this research is strengthened by the approach itself, since longitudinal case studies are used for researching change processes, making real-time observations (Åhlström and Karlsson, 2009). Further, internal validity has been increased by using triangulation in collecting the data (participative observations, observations, interviews, documents, co-researcher reflections, notes), and the coding/categorisation process has taken place over time, which makes it easier to understand whether the conclusions are correct, by letting the informants review the results and also letting colleagues and supervisors read and comment on the results (Merriam, 2009, Åhlström and Karlsson, 2009).

Reliability has been increased by striving for a systematic research process in which the observations are explicitly described (Åhlström and Karlsson, 2009).
The field notes of the observations contain information about when the observation was made, in what forum and which informants were present. The field notes also distinguish between pure facts of the observation and the researcher’s own reflections during the observation. The researcher has also in the thesis tried to thoroughly describe how the studies were conducted and how the findings were derived from the data, which increases the reliability in a way that a reader can follow how the researcher came to her conclusions (Merriam, 2009, Åhlström and Karlsson, 2009).

When it comes to external validity or generalisation, it relates to theory, especially for single cases and longitudinal case studies (Åhlström and Karlsson, 2009, Yin, 2014). In this thesis analytical generalisation has been applied, trying to compare or use the theoretical framework in the analysis of data in Chapter 5, contributing to developing frameworks like those by Netland (2012) or Bessant et al. (2001). Providing a thick description of the case and the studies also facilitates transferability, which leaves the generalisability to the reader to decide (Merriam, 2009, Åhlström and Karlsson, 2009).

Ethics is related to the credibility of the researcher (Merriam, 2009) and can be said to be “conscious, reflected and motivated morality” (Vetenskapsrådet, 2017, p. 12) in relation to conducting research. Accordingly, the researcher has always notified the informants about the objective of the research, handled the collected data confidentially and applied anonymisation of informants in reports and papers (Merriam, 2009, Åhlström and Karlsson, 2009, Vetenskapsrådet, 2017).

Regarding the specific case studies in the longitudinal case study, quality has also been considered in relation to the quality measures for case studies as suggested by Yin (2014), construct validity, internal validity, external validity and reliability; see Table 6.
Table 6. Summary of validity and reliability in the case studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Construct validity</th>
<th>Internal validity</th>
<th>External validity</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Comparing business ratios – implying CI</td>
<td>Pattern matching logic based on key factors from theory</td>
<td>Multiple case study: replication logic</td>
<td>Case study protocol, case study database</td>
</tr>
<tr>
<td></td>
<td>Data triangulation Informants reviewed the results</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Data triangulation Informants reviewed the results</td>
<td>Pattern matching logic based on concept model (Category construction)</td>
<td>Generalisable to theoretical propositions (expand and generalise theories)</td>
<td>Case study protocol, case study database</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>Data triangulation Informants reviewed the results</td>
<td>(Category construction)</td>
<td>Generalisable to theoretical propositions (expand and generalise theories)</td>
<td>Case study database</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>Data triangulation Results discussed in the supervisor team</td>
<td>(Category construction)</td>
<td>Generalisable to theoretical propositions (expand and generalise theories)</td>
<td>Case study database</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>Data triangulation Informant reviewed the results</td>
<td>(Category construction)</td>
<td>Generalisable to theoretical propositions (expand and generalise theories)</td>
<td>Case study database</td>
</tr>
</tbody>
</table>

3.3.1 Role of the researcher
The role of the researcher has changed over time. The research project started out with the researcher’s interest in understanding continuous improvement and the case company’s need to develop a continuous improvement capability. Thus when this research project began, the research was conducted half-time and the other half of the time was spent working practically as a change agent with the XPS integration at the case company. This division of conducting research and doing practical work continued till 2012. During this time the researcher worked in close collaboration with the XPS manager and other employees at the case company. In 2012 the researcher became a Ph.D. candidate at the Innofacture Research School,
However, still employed by the company but now belonging to a research department in another part of the corporate organisation. Later the conditions at the case company changed; e.g., the XPS manager quit and a reorganisation was made. These changes increased the distance between the case company and the researcher. However, the researcher continued to follow the case company in the longitudinal study investigating the process of developing continuous improvement towards continuous innovation. In 2015 the plant manager wanted help in developing the strategy for the plant, which led to a closer collaboration again.

When it comes to bias, the researcher has had preconceptions, both conscious and certainly unconscious, from having worked in the company for several years, as well as previous experiences both good and bad, and also a deep preunderstanding of how things worked and work in the case company. However, the researcher has tried to conduct good-quality research by paying attention to validity, reliability and ethics as described above, where especially letting the informants review the results, treating the informants with respect, doing data triangulation, doing analysis together with research colleagues in some cases, discussing studies and results with fellow researchers and supervisors and having peer reviews has helped to deal with and minimise the bias of the researcher.
4. Paper summaries

This chapter summarises the papers written as parts in the scope of this research project.

4.1 Paper I: Transitioning radical improvement to continuous improvement

The purpose was to map general success factors important for continuous improvement in order to achieve a deeper understanding of the transition from a radical integration phase of XPS to a more continuous improvement phase in order to facilitate and develop continuous improvement in the plant. It concerned factors that enable continuous improvement after the radical integration phase and factors that are important for further development of continuous improvement in the plant.

The paper is based on a literature review and a holistic multiple case study. The case study was conducted in 2009 at the case company, just after the radical phase of the XPS integration had been completed.

From the literature review eight comprehensive success factors were derived: vision and goals, control and follow-up, training and learning, leadership, way of working, participation, organisation and support and values. The case study shows that success factors important for enabling continuous improvement after a radical integration phase of XPS are participation, control and follow-up, leadership and values. In order for the organisation to enable further development of continuous improvement, it is important that the success factors vision and goals, training and learning, way of working and organisation and support continue to develop. Figure 8 visualises the findings.

Figure 8. Visualisation of the findings.
4.2 Paper II: Exploring a holistic perspective on production system improvement

The purpose of Paper II was to understand how holistic improvement work can be organised and what challenges can be observed in the process of reaching a holistic perspective on production system improvement, in order to better support industry in XPS integration and the development of a holistic perspective on production system improvement. The aim was to answer the research questions: How can holistic improvement work be organised? and What challenges can be observed in the process of reaching a holistic perspective on production system improvement?

The paper is based on an embedded single case study carried out at the case company in 2012. The design of the case study was guided by a previously developed concept model (Stålberg et al., 2012).

The findings were in short the organisation of the improvement work in three approaches: 1) continuous improvement in the XPS programme, 2) the operational development programme and 3) the process for managing objectives and key performance indicators (a performance plan approach). However, the operational development programme and the performance plan approach are incorporated in the continuous improvement process in XPS as approaches to manage the improvement work in alignment with the production strategy.

However, it was also found that even if an organisation is able to organise for holistic production system improvement processes, there are several challenges to face. Challenges identified in this study are the following: no evident description of the overall improvement work process (where it is described how the approaches are merged and fit and what methods/tools to use, for example, “fast problem solving”, “quick Kaizen”, Kaizen events); lack of a holistic perspective on improvement opportunities since the main improvement opportunities are not evident (management needs to stay focused on XPS integration and methods and tools such as value stream mapping and loss analysis); a production strategy has only been formulated once after the radical integration phase, in which the XPS integration is seen as the strategy, however the interviewees expressed a need to discuss and update the strategy on a regular basis to keep it relevant; there is no updating of the operational management system on the XPS processes in the production system, and a conflict has therefore emerged between the XPS and the operational management system concerning the need of an operational management system and how it relates to the XPS; the XPS is sometimes interpreted as the production system and it is difficult to understand what the XPS really is and this creates confusion in the process of gaining a holistic perspective on the improvement work (some view XPS as a management system/business system and some view it as a more limited improvement programme); there is no specific performance measure regarding improvement work in the performance measurement system and it is unclear how the improvement activities affect the key performance indicators (no aggregated measure in the measurement system).
A number of measures are evident (number of closed actions in team plans, team vitality measurements, i.e. the living process, cost per component and estimated savings), but the holistic picture of improvement work is not fully grasped; there is no systematic process to address specific perspectives on improvements (like creativity and innovation, inspired by Hoerl and Gardner (2010)).

4.3 Paper III: Exploration and exploitation within operations

The purpose of Paper III was to increase the understanding about exploration and exploitation characteristics, to concretise what they translate to in the context of improvement and development work in a production system context and to identify practical challenges in order to better understand how to develop exploration and exploitation capabilities in a production system.

The paper is based on a literature review related to the keywords exploration and exploitation and is an embedded single case study. The case study was conducted at the case company in 2015.

The main findings were in short key characteristics for exploration and exploitation. Key characteristics for exploration are experimentation/discovery, novelty (greater novelty of the ideas generated), play, variation (concerted variation), risk-taking/uncertainty, distant search/path-creating search, pursuit of new knowledge, regeneration, adaptability, free association, ample choices and diversification. Key characteristics for exploitation are refinement (experimental refinement), use and extension of existing knowledge, local search, execution/implementation, control/stability/reliability, repetition/intensification/extension, selection/choice, predictability/approximation, minimal deviation, convergence/alignment and productivity.

Based on the key characteristics the following interpretation of exploration and exploitation in a production system context emerged:

“Exploration is about experimentation and the pursuit of new knowledge. It is characterized by diversification, high novelty of the ideas generated, free association and ample choice, thus also about uncertainty and taking risks. Consequently, exploration is set out to do, yet not limited to, something new (locally or globally).”

“Exploitation is about refinement and improvement of existing practice through the use and extension of existing knowledge. It is characterized by control, stability and predictability, achieved through convergence and alignment. Consequently, exploitation is about doing the same, but better.”

It was also found that exploitative activities mainly correspond to the activities of the XPS programme and that explorative activities are rarely applied, but that that kind of thinking clearly lies in the role of the production development function.
Two main industrial challenges were identified: 1) the awareness of the concepts of exploration and exploitation is weak and there are difficulties in understanding how to apply both concepts and 2) exploration activities are not prioritised due to daily issues.

4.4 Paper IV: Lean production integration adaptable to dynamic conditions

The objective of Paper IV was to understand how a continuous improvement approach such as an LP/XPS integration is affected by dynamic conditions and how an LP/XPS integration can be adaptable to dynamic conditions.

The paper is based on a holistic single case study carried out at the case company during 2014–2015. This was a period of time when the case company struggled to continue with XPS integration and simultaneously tried to adapt to decreased customer demands and a different mix of products that largely affected its just-in-time setup together with new incoming products and concepts.

The main problem is that the XPS needs to be adapted to actual circumstances (like adapting to or compromising with just-in-time) for which continuous improvement concepts according to the quality movement are designed: “doing the right things” instead of only “doing things right” (Fundin et al., 2017). However, the plant has no experience of such a process yet, since during the first maturity phases they have mainly applied single-loop learning (Bessant and Caffyn, 1997), meaning that they are learning to “do things right” according to the XPS. However, adapting just-in-time seems to require double-loop learning, where the XPS as such is reconsidered and new solutions are found, agreed on and implemented. Therefore the plant experiences challenges such as no. 5: some changes are necessary, such as adapting to varying volumes and mixes of products, which might involve solutions not perceived to be in line with the XPS principles, no. 6: the degree of freedom regarding changes of XPS principles is perceived as unclear in the plant – should they be viewed as guidelines or more as rules?, no. 7: the plant does not really know how to address problems involving larger, more “innovative” changes, and no. 8: when trying to deal with outside-the-box solutions, the plant is unsure of how to use the XPS principles.

These challenges become even more complicated since the plant is part of a corporate organisation in which the corporation views its XPS as its strategic way to operate, and challenge no. 9 occurs: since XPS is viewed as the strategic way of operating, there is low acceptance in the corporation for a bottom-up production strategy where the XPS is sometimes questioned by the plant, and the plant does not get support in finding other solutions.

The most important findings are that the adaptability is related to the maturity level of the XPS integration since a more mature organisation in terms of continuous improvement integration is better equipped to deal with the challenges occurring, due to its learning and experimentation capabilities. The main problem is that XPS
needs to be adapted to actual circumstances, such as compromising with just-in-time, which seems to require double-loop learning. This creates challenges to more immature organisations in which there seems to be a big risk of not being able to adapt the XPS concept since the skills are lacking, and then there is a risk that the XPS concept is perceived as not to be working, and the integration might fail. However, in order to avoid failure and benefit from the learning capabilities developed so far, it is suggested that the plant management team needs to be united and also keep the focus on the continued XPS integration to carry on building constant improvement capability and that there is a need to adapt changes to the XPS or adapt the XPS concept itself, which includes assessing whether or not the suggested changes and the XPS consistently support and reinforce each other. This involves creating guidelines regarding adaptation of XPS and facilitating a transition towards double-loop learning by thorough reflections in order to make the necessary adaptations.

4.5 Paper V: Strategy formulation – bridging the gap between exploration and exploitation

The purpose of Paper V was to further explore challenges related to exploitation and exploration on an overall level and to analyse whether and how a strategy formulation process can be used as a means to bridge the gap and facilitate the development of exploration and exploitation capabilities in a production system. The purpose also included analysing the consequences of a strategy formulation process for an XPS.

The paper is based on an embedded single case study taking an interactive research approach, conducted at the case company in 2015.

Five challenges appeared that are related to problems in making exploitation and exploration co-exist. These challenges were all approached in the strategy formulation process. The first challenge concerning *a need for new system solutions, but there is a lack of methodologies* was approached in the strategy formulation process by creating an iterative and explorative approach for the pre-studies and educating the strategy team in the concepts of exploration and exploitation as well as learning about innovation teams. This worked as an eye-opener, as the informants expressed it, and gave them the confidence to start working with a more explorative approach and thereby be able to approach new or unexpected solutions. The second challenge, concerning *balance of long-term strategies with short-term tactics*, was met by taking a long-term perspective in the pre-studies in order not to be limited by short-term issues. The third challenge, *creativity is encouraged, but performance is rewarded*, was not really dealt with in the strategy formulation process. Instead an awareness of the importance of creativity was achieved. The fourth challenge, the *need for new system solutions brings resistance from the XPS organisation due to perceptions of XPS as a strategy*, was managed by turning the strategic projects into development projects in the XPS framework. Thereby there will be a link between the XPS and the development work that supports mutual involvement and also contributes towards
managing the trade-offs between global conformity and local contingencies. The fifth and last challenge, *new solutions are discussed but without considering XPS*, was also met by turning the strategic projects into development projects in the XPS framework. In that way the strategic projects need to consider XPS principles and logics.

Based on these findings, a strategy formulation process can be used to solve most of those challenges of exploration and exploitation on an overall level and increase the awareness of the need for both concepts in a production system, since a strategy formulation process involves many elements and aims to create a plan with the most important actions to take. However, there is still a need to practise more to be able to develop good lasting explorative capabilities. By using a strategy formulation process for this purpose, the organisation and its management achieve awareness and can take the first steps in creating and using exploration capabilities and combine them with exploitation.
5. Analysis

In this chapter the empirical findings are analysed. The three research questions provide the basis for the analysis, and the findings are compared and elaborated on in relation to the theoretical framework.

5.1 Evolution of XPS under dynamic conditions

The assessment data visualised in Figure 3 in Chapter 3 show the XPS integration level over time. A large recession occurred in 2009 and the time after that was characterised by dynamic conditions, as can be seen in the variation in volumes and mix of products, see Figures 4 and 5 in Chapter 3 together with the challenges identified under dynamic conditions in Table 5. In Figure 3, it can be seen that the XPS integration continues to grow, since the XPS levels increase for some years (2010–2013) after the recession. In 2013 the XPS integration level flattens out and in 2014 it starts to decrease. Table 7 gives an overview of the analysis related to RQ1, How does an XPS integration evolve under dynamic conditions?

Table 7. Overview of the XPS integration with internal and external influences and their total effect on the continuous improvement maturity levels

<table>
<thead>
<tr>
<th>Phase of integration (Netland, 2012)</th>
<th>Years, XPS levels</th>
<th>Internal influences</th>
<th>External influences</th>
<th>Maturity levels (Bessant et al., 2001)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishment</td>
<td>2006–2007</td>
<td></td>
<td>High volumes; the plant is not able to produce all orders</td>
<td>Trying out the ideas</td>
</tr>
<tr>
<td>Reengineering 2007–2010, XPS level 1.4 2010</td>
<td>Restructuring flows; project-based ownership for the reengineering phase; XPS basics integrated in machining cells and assembly lines</td>
<td>Downturn; large volume drop in 2009</td>
<td>Trying out the ideas; approaching structured and systematic continuous improvement</td>
<td></td>
</tr>
<tr>
<td>Continuous improvement</td>
<td>2010–2013, XPS level 2.1 2013</td>
<td>Ownership of XPS integration transferred to the line organisation; striving to take a “go-to-gemba” approach; incorporation of the operational development programme; establishment of an infrastructure for continuous improvement</td>
<td>Volumes all-time high in 2011</td>
<td>Structured and systematic continuous improvement; approaching strategic continuous improvement</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>-----------------------------</td>
<td>----------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>2013–2015, XPS level 1.6 2015</td>
<td>Reorganisation; no XPS manager; strategy formulation; challenges identified in Table 5</td>
<td>Volumes decrease again in 2013, 2014; the mix of products has largely changed; challenges identified in Table 5</td>
<td>Declines below the maturity level structured and systematic continuous improvement</td>
</tr>
</tbody>
</table>

Accordingly, the XPS integration continues to develop in the first years (2010–2013) after the recession in 2009 and is approaching the maturity level of strategic continuous improvement. It is likely that the organisation, both the plant and the corporation, believes it is a temporary downturn, continues with the integration and strives for development of continuous improvement. On a corporate/global level, progress in XPS integration is expected and plants are compared in terms of XPS levels. In Paper I the findings are related to normal key factors for development of continuous improvement like vision and goals, training and learning, way of working, organisation and support and, especially during this time, also participation, control and follow-up, leadership and values. Further on, there are no findings that depart from these key factors and stress other important aspects. In Paper II challenges related to gaining a more holistic perspective on production system improvement are investigated, where the main challenges are still related to normal development of continuous improvement. However, the expressed need for updating the production strategy (where the strategy for competitiveness has been the XPS integration) could be an indication of a need for change. At the same time, when the informants were asked about different
perspectives on improvements, there was no awareness related to doing differently or, for example, a need for innovations. In relation to Table 7 (the plant approaching maturity-level strategic continuous improvement), and to the findings described above, it seems that this first phase of dynamic conditions has not affected the ongoing XPS integration. This is likely because the company believes the dynamic conditions are temporary and therefore continues as before and tries to proceed with the development of continuous improvement in line with what is expected in XPS. The XPS is still viewed as the strategy for competitiveness in the organisation.

In 2013, the XPS integration level curve flattened out and in 2014 it started to decline. The volumes decreased again, the mix had largely changed, and in addition discussions were ongoing related to the challenges identified in Table 5, creating a turbulent situation in the plant. The XPS concept was further questioned and the relation between XPS and the new wanted strategy was unclear. In Paper IV it can be seen that especially the just-in-time part needs to be reconsidered since that is more suitable for stable conditions (Birkie, 2016). Now the just-in-time parts undermine the effectiveness of XPS and reduce the trust in the XPS concept itself. However, there is also a relation to the maturity level of the plant concerning continuous improvement capability that also affects the integration and related adaptability. It has been described that the plant has been approaching Level 3, strategic continuous improvement, according to Bessant et al.’s (2001) scale. Approaching Level 3 entails shifting from mainly applying single-loop learning to also making use of more double-loop learning, which involves reframing the problem and analysing values and objectives before taking corrective actions (Argyris, 1999) and is a key transition facing organisations in this integration process (Bessant and Francis, 1999). Up to Level 3 the plant has mainly applied single-loop learning, implying that they have learnt to do things right in line with the XPS. However, it seems that they are not able to apply double-loop learning and thoroughly reflect on the problems occurring and subsequently adapt the XPS. Consequently, when the XPS concept does not seem to be working, resistance is created; the integration deteriorates and the developed continuous improvement abilities are negatively affected.

However, if it had been a more mature organisation in terms of continuous improvement capability, it would probably have had a well-integrated XPS system built on experimentation and learning (Birkie, 2016). This learning (both single-loop and double-loop learning) could then have been used to adapt to the dynamic conditions. The plant would probably have been able to adapt the XPS system.

Hence, there seems to be a breaking point where the dynamic conditions affect the company too much. This is a critical period of time when the organisation becomes aware of the need to adapt to dynamic conditions that can negatively affect the XPS integration.
5.2 Challenges during the continuous improvement evolvement

In line with RQ2, What are the challenges during the XPS integration under dynamic conditions?, when the plant in 2010–2013 still believed there were temporary dynamic conditions, the challenges were related to development of continuous improvement capability, first, to take the first steps in developing continuous improvement and, second, to find ways to merge different concepts into one common continuous improvement approach (Johnson et al., 2007, Netland and Ferdows, 2016) and to reach a holistic perspective on production system improvement. These challenges are related to developing continuous improvement routines (Bessant and Caffyn, 1997) with an evolution of the continuous improvement performance and practice approaching Level 3 on Bessant et al.’s (2001) maturity scale. This estimation is based on the assessment levels achieved at the time for the plant together with the description of the practice at each maturity level by Bessant et al. (2001) in comparison with the plant’s practice and challenges.

In Paper I, the challenges are related to transitioning from the reengineering phase into the continuous improvement phase. The transition mainly involves challenges addressed to the plant organisation itself (and not solely to the production teams in the machining and assembly areas), in order to sustain results achieved in the reengineering phase and to continue the development (Netland, 2012). These challenges are related to creating a vision including objectives in order to further align XPS and achieve further commitment, continuing training and learning in order to increase the knowledge of XPS, designing the overall improvement process so that there is a common way to work with improvements and create an infrastructure supporting the improvement processes (roles, responsibilities, skills).

At the time for Study B, presented in Paper II, the company struggles with integration of several improvement initiatives simultaneously. Even on a higher level in the corporation there is confusion concerning merging of initiatives. The merging of initiatives mainly concerns the operational development programme (Ramquist and Eriksson, 2000), the XPS programme and internally at the plant also a performance plan approach initiated by the plant manager. These merging issues complicate the XPS integration and create confusion (Johnson et al., 2007) and sometimes deflect the focus on developing continuous improvement capability. The challenges mainly relate to how to reach a holistic perspective on production system improvement. Examples of challenges are to gain a holistic perspective on improvement opportunities by management staying focused on the XPS integration and by systematic use of, for example, value stream mapping and loss analysis, to develop performance measures for the improvement work and to understand how to merge different improvement concepts into one approach.

During 2013–2015, when the XPS integration declined, the challenges changed from those related to development of continuous improvement capability to the need to also adapt to dynamic conditions. In Study C2, described in Paper IV, challenges related to the ongoing XPS integration and organisational adaptability...
were investigated. The challenges occurring were analysed in relation to their impact on developing continuous improvement abilities according to Bessant et al.’s (2001) framework. The challenges occurring are compiled in Table 8.

Table 8. Empirically found challenges when the XPS integration levels decline

<table>
<thead>
<tr>
<th>Empirically found challenges when the XPS integration levels decline</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A reorganisation causing reduced or no ownership for the continued XPS integration</td>
</tr>
<tr>
<td>2. Disagreements within the management team regarding to what extent and how to use the XPS principles</td>
</tr>
<tr>
<td>3. Large and ill-considered changes in relation to XPS (e.g., not using takt time in some assembly lines and making a continuous improvement process important for policy deployment optional)</td>
</tr>
<tr>
<td>4. Conflicts between plant and global support organisation concerning changes made</td>
</tr>
<tr>
<td>5. Necessary changes not in line with XPS principles (compromising with just-in-time)</td>
</tr>
<tr>
<td>6. Uncertainty regarding the freedom of making changes to XPS principles (are they rules or guidelines?)</td>
</tr>
<tr>
<td>7. Problems in addressing and managing larger more innovative changes (some of the challenges in Table 5) (difficulties in thinking outside the box)</td>
</tr>
<tr>
<td>8. When trying to deal with outside-the-box solutions (some of the challenges in Table 5), the plant is unsure how to use the XPS principles (it seems easier to just avoid XPS)</td>
</tr>
<tr>
<td>9. Low acceptance in the corporation for a bottom-up production strategy where the XPS is sometimes questioned</td>
</tr>
</tbody>
</table>

What could be seen is that these challenges have seriously harmed the development of continuous improvement abilities (routines), such as getting into the continuous improvement habit, focusing on continuous improvement, leading the way, aligning continuous improvement and continuous improvement of continuous improvement, in relation to Bessant et al.’s (2001) framework.

In line with McLean et al. (2017), it seems that the environment influences the integration and can contribute to the failure of an integration. This external effect can explicitly be seen in challenges 5 and 6, which address the principle of just-in-time, and also in challenges 7 and 8, which are related to the challenges identified in Table 5. However, while the plant may not have as much control over the external influences, it is important that they are considered and planned for (McLean et al., 2017). Thus, the main problem in relation to the XPS integration is that the plant is still quite immature in its continuous improvement abilities. The plant has no experience of reframing a process like just-in-time, nor other parts of the XPS, in relation to the challenges identified in Table 5, since during the first
maturity phases they have mainly applied single-loop learning, meaning they are learning to do things right according to XPS. Adapting just-in-time and considering other larger changes important for the future seems to require double-loop learning (Argyris, 1999), in which the XPS concept is reconsidered and new solutions are found, agreed on and implemented. If the plant had been more mature in terms of continuous improvement abilities, it would probably have been better equipped to deal with the challenges occurring in line with Azadegan et al. (2013) and Birkie (2016), since greater adaptability capabilities would have been developed.

Accordingly, the main challenges are to continue to support the XPS integration in order to continue building continuous improvement abilities and to simultaneously reconsider and adapt XPS. The subsequent challenges involve assessing whether or not suggested changes and the XPS consistently support and reinforce each other, creating guidelines regarding the adaptations of the XPS and facilitating double-loop learning by, e.g., thorough reflections to make necessary adaptations. In addition to these challenges comes another main challenge concerning how to manage other large and complex changes that are needed in relation to challenges identified in Table 5, i.e., striving to develop continuous innovation capability.

5.3 Adapting for continuous innovation

There is a great risk that the XPS integration does not reach high maturity levels like process innovation or learning organisation before it is negatively affected by dynamic conditions. At the same time it is argued that an XPS is not designed to drive radical innovation and hence the development of exploration capabilities (Netland, 2013a). Accordingly, it is important to find parallel ways to work with exploitation and exploration as well as to aim for development of exploration capability. Continuous innovation capability involves the effective enablement of the “ongoing interaction between operations, incremental improvement and learning (exploitation processes), and radical innovation and change (exploration processes)” (Boer et al., 2006, p. 2).

In line with RQ3, How can an XPS integration be developed towards continuous innovation?, Paper III investigates the concepts of exploration and exploitation in relation to improvement and development activities. It was found that exploitative activities mainly correspond to the activities of XPS in line with Tønnesen (2014) and Netland (2013a). Explorative activities were rarely applied, but that kind of thinking clearly lies in the role of the production development function, responsible for the long-term development of the plant also supported by Gåsvaer et al. (2016). Further, exploration activities are not even prioritised due to daily issues that tend to dominate in this context and therefore exploration capabilities have not yet been well developed. Another aspect of this problem is the productivity dilemma stating that process management that is part of XPS integration tends to drive out exploration and therefore exploitation capabilities will dominate in this context (Benner and Tushman, 2003, Benner and Tushman, 2015).
Further it can be argued that parts of the continuous innovation capability in the production system can be built by enabling the effective, ongoing interaction between the XPS integration (exploitation processes) and production development projects (exploration processes), where the production development function is an important link to strategic flexibility (Gåsvaer et al., 2016, Yamamoto, 2017). As mentioned, ambidexterity is defined as the capacity of an organisation to address mutually conflicting demands (Birkinshaw et al., 2016), like managing exploitation and exploration, and will therefore be an important part in continuous innovation capability. Accordingly, since it is important for each functional area to have a strategy that outlines how it will help to achieve the overall business unit strategy (Milttenburg, 1995), it is important that the functional production strategy contains activities that support processes for fostering both exploration and exploitation capabilities. For this purpose (and also due to the plant’s needs based on the challenges identified in Table 5), a strategy formulation process was used (Paper V, and visualised in Figure 6). Study C3 was also used partly to further understand what challenges are related to exploitation and exploration in this context and partly to understand how these can be overcome in relation to ambidexterity.

Since inspiration in this thesis is gained from organisations in more fast-moving contexts, relevant types of ambidexterity to consider are then structural and contextual approaches (O’Reilly and Tushman, 2013). As described, structural approaches use structure and strategy to enable differentiation among organisational units and the tensions created are resolved at the next organisational level down (Raisch et al., 2009). In this case this can be related to the XPS function (fostering exploitation processes) and the production development function (exploration activities). Contextual ambidexterity focuses on behavioural mechanisms to integrate the diverging activities (Gibson and Birkinshaw, 2004, Raisch et al., 2009). To further achieve contextual ambidexterity, processes and systems are needed that support and enable individuals to decide how to divide their time between exploitation and exploration (Raisch et al., 2009). Contextual ambidexterity can also be related to this case since the production development function is also involved in exploitation activities and hence is not solely an exploration function. Also, other exploitation functions like, e.g., XPS, quality and logistics are also expected to take part in exploration activities, which can be seen in the scope of the challenges identified in Table 5. Since there is no pure exploration unit, it might seem preferable to strive for contextual ambidexterity. In Table 9 the empirical challenges and their solutions from Paper V are presented and further elaborated on in relation to ambidexterity theory.
Table 9. Challenges related to exploitation and exploration and their solutions from Paper V, in relation to structural and contextual ambidexterity

<table>
<thead>
<tr>
<th>Challenges related to exploration and exploitation</th>
<th>Solution</th>
<th>Structural ambidexterity</th>
<th>Contextual ambidexterity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A need for new system solutions, but there is a lack of methodologies.</td>
<td>An iterative and explorative approach for the pre-studies was created (Figure 7), including some methods and tools. The strategy team was educated in the concepts of exploration and exploitation. They were also educated in innovation teams (see Study C3).</td>
<td>First steps in creating an autonomous unit for exploration (the production development function) promoting the creation of a vision that meets the need for both exploration and exploitation.</td>
<td>Pre-study process: a meta routine (a routine applied to change other routines). Creating a supportive environment.</td>
</tr>
<tr>
<td>Balance of long-term strategies and short-term tactics.</td>
<td>A long-term perspective was taken in the pre-studies not to be limited by short-term issues.</td>
<td>Supporting individuals to take on exploratory tasks.</td>
<td>Supporting individuals to take on exploratory tasks.</td>
</tr>
<tr>
<td>Creativity is encouraged, but performance is rewarded.</td>
<td>The challenge remained unsolved. However, an awareness of the importance of creativity was achieved.</td>
<td>A management issue to support differentiated units, especially explore units in this context.</td>
<td>A management issue to create a supportive environment, which facilitates for individuals to focus on exploration.</td>
</tr>
<tr>
<td>Need for new system solutions causes resistance from the XPS function due to perceptions of XPS as a strategy.</td>
<td>The strategic projects were made into development projects in the XPS framework. In that way also XPS was given legitimacy again and was perceived as being an important part in developing the production system (towards a lean production system).</td>
<td>A linking mechanism contributing to wanted effects in relation to overarching objectives. They need to be recombined to create value.</td>
<td>A mechanism supporting individuals to switch between exploration and exploitation and to act for both.</td>
</tr>
</tbody>
</table>
New solutions are discussed but without considering XPS. The strategic projects were made into development projects in the XPS framework. Then the projects need to consider XPS logics. Same as above, but it might negatively affect exploration, since the projects might be limited by XPS. Same as above, but it might negatively affect exploration, since the individuals might be limited by XPS.

From Table 9, it can be seen that these solutions can be examples of means to approach both structural and contextual ambidexterity. Accordingly, this mix also seems to be in line with previous research, which has shown that companies use combinations of these to balance exploitation and exploration; later on, when exploratory efforts achieve strategic legitimacy and are less vulnerable to being crowded out by the focus on exploitation in the company, then companies shift to contextual ambidexterity (O’Reilly and Tushman, 2013). Hence in this context it is suggested as preferable to strive for both structural and contextual ambidexterity when it comes to enabling an effective interaction between the XPS integration and the production development projects in order to adapt to continuous innovation.

In relation to this and to the differences in principles between XPS (i.e., the broader TQM concept is similar to the lean philosophy, on which also XPS is based; XPS assessments coaches plants towards holistic lean systems) and continuous innovation, Steiber and Alänge (2013), also supported by, among others, Eriksson et al. (2016), especially emphasise a need to update the TQM/lean/XPS concept of how to best organise and manage people for both incremental and radical innovations in order to make continuous innovation as important as continuous improvement. Accordingly, this has been further elaborated on in this chapter in relation to Paper III and Paper V, ending up in suggesting how to aim for ambidexterity by facilitating the interaction between the XPS integration and the production development projects. By suggesting how to organise and manage people for both incremental and radical change and by striving for a more proactive product-push mentality by increasing the understanding for exploration, continuous innovation can be facilitated.
6. Adapting to dynamic conditions through continuous innovation in production systems

This chapter discusses the results from the analysis, in line with the research objective. It ends by proposing recommendations supporting continuous innovation in production systems.

It is said that XPSs are mainly developed to contribute to exploitation, since they are corporate improvement programmes developed for that purpose and are hence not always viewed as a comprehensive lean philosophy for the company (Netland, 2013a). However, they have the potential to develop learning and experimentation skills by the evolvement through the higher maturity levels, which can be used to adapt more flexibly during uncertainty. As emphasised by Bessant and Caffyn (1997, p. 13), “[s]ince the turbulent nature of most organizational environments is such that increasing levels of change are becoming the norm,” therefore “involvement of employees in CI programmes may provide a powerful aid to effective management of change” (where CI is continuous improvement).

However, the dynamic conditions also affect and complicate the XPS integration as such and make it more difficult to reach its potential, i.e., the breaking point of the dynamic conditions identified, like this case shows a regression back to lower maturity levels in terms of continuous improvement abilities. When conditions become more dynamic, the XPS approach needs to be combined with the ability to make larger changes in order to faster adapt to the situation. However, the development of continuous improvement is still essential since it is important that more radical change is followed by incremental improvements to sustain the results (Imai, 1991). It is described that XPS integrations create abilities where process innovation is managed (Bessant et al., 2001, Netland and Ferdows, 2016); that implies being able to conduct improvements/innovations ranging from incremental to radical simultaneously. In that case, to manage dynamic conditions, plants would need to have reached higher maturity levels in their XPS integrations, where learning and experimentation skills are better developed. These are levels that few plants reach due to the high failure rate of change (Oakland and Tanner, 2007, Bhasin, 2012b, McLean et al., 2017). It takes a long time to reach these levels where continuous improvement becomes an important resource base to the company (Netland and Aspelund, 2013, Jacobsen and Thorsvik, 2014), even though an XPS integration as such is not time-dependent (Netland and Ferdows, 2016); instead it is dependent on enablers for continuous improvement such as management commitment to succeed (Bessant et al., 2001, Netland, 2016, McLean et al., 2017). Accordingly, it is important to find parallel ways to work with exploitation and exploration to support development of continuous innovation in production systems.

As mentioned earlier, integrating an XPS is a learning process, both to learn about the concept itself and to develop specific abilities, explained as developing continuous improvement behavioural routines that are related to an evolution of
the continuous improvement performance and practice (Bessant and Caffyn, 1997, Bessant et al., 2001). Therefore, before reaching the higher continuous improvement levels there is a risk that the XPS itself is viewed as the answer to all problems, since it is difficult and complex to grasp how the XPS affects and improves the production system due to the fact that it is also a learning process. In this case, the plant was still in the phase dominated by single-loop learning on Bessant et al.’s (2001) scale. Since the XPS is also viewed by the corporation as the strategic way of operating (Netland, 2013b), the corporation itself pushes the plants to integrate the XPS correctly. From an XPS perspective it is important to design products and processes that fit in a lean production system. However, there is also a tendency to view XPS as a non-changeable standard, which seems to hinder the development of the production system and creates resistance in the plant to the XPS as such during the search for new solutions. This adds to the risk that the plant will abandon or only superficially integrate the XPS concept under dynamic conditions since it seems that the XPS integration itself will not solve the problems occurring. Or, as described by Netland and Aspelund (2013), it will create inertia in the organisation at times when instead a high speed of change is needed. However, it can be discussed what would have happened if the case company had reached higher levels to the phase where more double-loop learning takes place; would it have been easier for them to adapt then? This is a relevant question to consider since double-loop learning is a similar type of learning as exploration (Jacobsen and Thorsvik, 2014), which is an important capability for radical change.

In this case a strategy formulation process in line with Platts et al. (1996) and Slack and Lewis (2008) was implemented to take the first steps towards continuous innovation including organisational ambidexterity, where a strategy can be understood as a description of what the organisation is planning to do in order to achieve the business objectives (Jacobsen and Thorsvik, 2014). The strategy can then support and guide the plant in how to combine and make larger changes and adapt the XPS concept if needed and yet continue with the XPS integration, i.e., guide the plant towards continuous innovation. The strategy was further formulated through a deep involvement strategy formulation process (Figure 6) to be able to achieve good understanding for the changes needed. Accordingly, the strategy and the strategy formulation process can be viewed as examples of means to facilitate the realisation of structural ambidexterity; in that way they are used as an overall vision supporting the need for both exploration and exploitation and as a linking mechanism contributing to wanted effects in relation to overarching objectives, as suggested by O'Reilly and Tushman (2013). Also this can be viewed as a means to support contextual ambidexterity since it requires a supportive context (Gibson and Birkinshaw, 2004), where a deep involvement strategy formulation process increases the understanding in the plant of the need for ambidexterity under dynamic conditions.

As described, most potential exploration capabilities are missing since this is in a production system context occupied with daily issues. Therefore it is suggested
that there is a need to start developing these in order to later on attain continuous innovation capability in the production system, since building exploration capabilities is about iterating exploration cycles (Yamamoto, 2017). Developing exploration capabilities concerns, in relation to the proposed interpretation of exploration in Paper III, how to create an explorative mindset and supporting methods for exploration tasks/activities. Having an explorative mindset will help to think outside the box when addressing greater problems (like the challenges identified in Table 5) and solutions and it will also give the managers and employees the necessary courage to take part in exploration tasks understanding that it is OK not to know where we are going and that it is fine to stay in that state for a while, as can be seen in Paper V. To better support exploration tasks, an iterative and explorative approach for the pre-studies in the strategy formulation process can be applied (Figure 7), which can be seen as a meta-routine (Adler et al., 1999) that can be used when dealing with non-routine tasks. This will help to support an explorative mindset and the process of finding solutions to problems and not being limited to old or familiar solutions. This meta-routine can also help to support contextual ambidexterity since it can help the individuals involved to shift between the modes of exploration and exploitation. This is especially essential in this context, since the individuals involved, like the production development function and other functions as well, are expected to take on and switch between exploration and exploitation tasks in their regular work.

Since the XPS is responsible for improving the production system in line with certain principles like, e.g., just-in-time, there is also a risk that production development activities are perceived not to be in line with the principles. Also, it could be seen in Studies C2 and C3 that there is a risk not to consider the XPS concept when searching for new solutions. Further it was stressed in Paper V that it is necessary to find ways to link the activities and that this can be done by viewing the strategic projects as development projects in the XPS framework, at least if striving for a lean production system. This also creates a need for the XPS function to be involved in the strategic projects and vice versa as this case shows. However, here one needs to be aware that this might be a problem, since exploration might be hindered or limited by the XPS concept as such, also emphasised by e.g. Benner and Tushman (2015).

When it comes to adapting or reconsidering the XPS concept itself or continuous improvement of continuous improvement as expressed by Bessant et al. (2001), there are no guidelines or recommendations that support how to think when it concerns adaptations (Netland and Aspelund, 2014). Viewed from a corporate perspective, the purpose of an XPS is to create competitive strength by coordinating a dispersed production network into aligned world-class competitive plants where best practice can be shared (Netland and Aspelund, 2014). According to Netland and Aspelund (2014), on the one hand, adaptation is important for increasing the institutionalisation of XPS at the plants, and on the other hand, adaptation makes it more difficult to share best practice between plants and make them aligned. However, considering the perspective of a specific plant, if the XPS
integration is not adapted or reconsidered, this will instead cause problems at the plant, and inertia and resistance might be created. Therefore it is suggested that the corporate organisation should not resist necessary adaptations for the plants but instead support and contribute by guiding towards appropriate solutions and create guidelines in order to show what to do and think about adaptations. There is ongoing development of the production system on a global level in the corporation in terms of smarter ways to adapt to dynamic conditions, however these solutions will be integrated in the plants in a longer term. However, the problems described occur now or in the near future and the plants need to deal with them on a daily basis.

However, only carefully considered changes where their effects on the XPS are evaluated should be made since they might make the XPS less efficient. Still, if the plant is aware of changes made and their effects, there will probably be understanding for the XPS approach not giving the expected results, and resistance towards the XPS itself might decrease. Therefore it is recommended to only integrate well-considered changes and communicate why the changes have been made in order to avoid misunderstandings in the plant that can undermine the acceptance for the XPS concept or risk that the XPS will be viewed as just another management fad (Røvik, 2000).

However, to transition from continuous improvement to continuous innovation including organisational ambidexterity in a production system under dynamic conditions requires much from the management team and will ultimately be an issue for the management team to address (Raisch et al., 2009, O'Reilly and Tushman, 2013). On an overall level it is important to become aware of the breaking point of the dynamic conditions in order to avoid failure of the XPS integration, because still efficiency and incremental improvements as well as a culture for continuous improvement are needed and exploitation is a part of continuous innovation capability (Boer and Gertsen, 2003, Martini et al., 2013). Therefore, it is suggested to start building exploration capability in parallel in order to build continuous innovation capability. Accordingly the following actions are considered important: continuously support the XPS integration; facilitate double-loop learning by thorough reflections; be open-minded for the need to adapt the XPS integration to new circumstances, yet carefully evaluate changes before integrating them; develop exploration capabilities and continuously encourage them and give space to functions responsible for the long-term success of the plant to engage in exploratory tasks; be aware of the contradiction in building exploration and exploitation capabilities by striving to combine structural and contextual ambidexterity; find means for balancing, supporting and linking exploration and exploitation processes, where the strategy formulation process and the created strategy itself are examples of such means. In figure 9, the recommendations for adapting to dynamic conditions through continuous innovation in production systems are visualised.
Adapting to dynamic conditions through continuous innovation in production systems

- Create means for balancing exploration and exploitation
  - Strategy-formulation process can be used
- Create links between exploratory and exploitative units
- Strive to combine structural and contextual ambidexterity
- Develop exploration capabilities
  - Protect exploration
- Carefully adapt the XPS
- Facilitate double-loop learning
- Continuously support the XPS integration

Figure 9. Visualisation of what it implies to adapt to dynamic conditions through continuous innovation in production systems. The breaking point of dynamic conditions indicates a critical period of time when the organisation becomes aware of the need to adapt to dynamic conditions. At this critical period of time it is suggested that the actions to the left are considered in an ascending order to start build continuous innovation capability in an iterative mode illustrated by the growing spiral. Hence, also a decline in XPS integration, illustrated by the red line and the red arrows could be avoided.
7. Discussion and conclusions

This chapter starts with a general discussion of the research presented in this thesis, followed by a methodological discussion. Then conclusions are drawn by answering the research questions and discussing the research objective. The scientific and industrial contributions are specified, and the chapter ends by suggesting areas for future research.

7.1 General discussion

The overall purpose of this thesis has been to contribute to an increased understanding of how XPS integrations could be developed towards continuous innovation to be able to manage more dynamic conditions. In line with this, the research objective has been to develop recommendations supporting continuous innovation in production systems. A theoretical framework was presented in Chapter 2 in order to provide a theoretical foundation for the research project. A longitudinal case study including five substudies was conducted at a case company integrating an XPS under dynamic conditions. The conditions are argued to be dynamic for this specific context, due to the wide variations in volumes and the changing mix of products together with new coming products and changes. The challenges identified under dynamic conditions are compiled in Table 5. Usually this company has acted in much more stable environments and therefore these conditions represent dynamic conditions for the company. Yet they might not do so for companies that normally act in highly volatile environments. The overall empirical findings from the longitudinal case study are presented in the case description in Chapter 3, and the findings from the substudies are presented in Chapter 4.

The theoretical framework consists of theories from the research fields of continuous improvement, XPS (lean production) and continuous innovation, which tend to overlap in some aspects. XPS can be viewed as an approach to continuous improvement, and continuous improvement is also a part of an XPS. However, both involve, among other things, learning, and in the field of continuous innovation it is argued that the research scene for continuous improvement has transitioned to continuous innovation since it nowadays involves learning and innovation. Continuous innovation implies a synergistic approach to exploration and exploitation, but usually exploration and exploitation are not used to explain issues in continuous improvement and XPS. Actually, XPS is argued to mainly support exploitation. However, in this thesis the areas of continuous improvement and XPS are used to explain the integration of XPS and related maturity levels and development of continuous improvement abilities, and also to describe related challenges. The area of continuous innovation, which includes exploration, exploitation and ambidexterity, is used to understand important aspects under dynamic conditions and how to transition to continuous innovation. The theoretical framework ends with a literature synopsis in Chapter 2.4, where it can be seen how these areas are constituted and how they will be used in the analysis.
The empirical findings from the overall longitudinal study presented in Chapter 3 concern the challenges identified under dynamic conditions in Table 5, the variation in volumes over time and the variation in the mix of products. This altogether shows and represents the dynamic conditions in this context. Another finding presented in Chapter 3 is the level of the XPS integration over time and the visualisation of the strategy formulation process (Figure 6) and the process for the pre-studies (Figure 7). The findings from the substudies in Chapter 4 include key factors and challenges when developing continuous improvement (Paper I), integration and merging of continuous improvement concepts (Paper II), understanding of the concepts of exploitation and exploration in a production system related to improvement and development work (Paper III), challenges related to integration and adaptation issues of an XPS under dynamic conditions (Paper IV), and a strategy formulation process as a means to bridge the gap between exploration and exploitation and facilitate ambidexterity (Paper V).

In Chapter 5, Analysis, the empirical findings were analysed in relation to the theoretical framework. The three research questions provided the basis for the analysis. Empirical data from all studies were used in some way in the analysis. The empirical data gathered from the later studies C2–C3 (Paper III, Paper IV, Paper V) and the empirical data presented in the method chapter made the greatest contribution to XPS integration under dynamic conditions and the development of continuous innovation. Further on, in Chapter 6, the results from the analysis were discussed, further developed and then compiled in relation to the research objective, leading to recommendations for how to adapt to dynamic conditions through continuous innovation in production systems. These recommendations are presented in Figure 9, Chapter 6.

Accordingly, this research contributes by having followed an XPS integration over time under dynamic conditions. It has identified that if the plant is not observant of the breaking point of the dynamic conditions, where the dynamic conditions affect the plant too much, there is a great risk that the XPS integration will regress or even fail. Instead, to be able to increase the adaptability, it is suggested that the plant should complement its continuous improvement abilities, which are developed through the XPS integration, with exploration capabilities to strive for continuous innovation in order to remain competitive. What has been seen further is that a deep involvement strategy formulation process can be used as a means and enhance the ambidexterity. A final contribution is the understanding of what ambidexterity in a production system might be.

7.2 Methodological discussion
A longitudinal single case study seemed to be a suitable research strategy when offered the opportunity to study this interesting long-term process of change as an industrial Ph.D. candidate striving for in-depth knowledge of the phenomenon over time (Åhlström and Karlsson, 2009, Yin, 2014). Adding to this choice was also the stated lack of longitudinal studies in this research area (Åhlström and Karlsson, 2009). Still, in the last study, Study C3, the case study approach was combined
with an interactive research approach (Ellström, 2007), aiming to also support the case company in its change process. However, from time to time during the research project there were discussions concerning whether or not an interactive research strategy could have been suitable to apply for the whole research project as well, since all conditions in terms of access, trust, objective, etc., were fulfilled and aligned from the company perspective and most likely also interesting findings would have been made. Still, as an industrial Ph.D. candidate who also previously had worked with the XPS integration at the case company, the researcher felt a need to distance herself from the study object and not be too involved in the change process. This was especially urgent during the first studies in order to be able to learn the research process and achieve a wider perspective and not be too limited by the industrial problems and consequently also try to limit the bias.

By considering internal validity, reliability, generalisability and ethics in the ways described in Chapter 3.3, good quality research has been striven for throughout the research process. Accordingly, the longitudinal approach itself strengthens the internal validity, where the coding process has taken place over time, data triangulation has further been used and the informants as well as colleagues and supervisors have reviewed the results. By striving for a systematic research process where the observations have been explicitly described; the field notes carefully and systematically have been made, reliability has increased. Also throughout the thesis the researcher has tried to thoroughly describe how the studies were conducted and how the findings were derived from the data so that the reader can follow how the researcher came to the conclusions. Generalisability has not been striven for in the first place, since mainly qualitative research has been applied and the research as such has aimed at deep understanding of the topic under study by using a single case and exploring different aspects of the topic during the XPS integration process towards continuous innovation. Nonetheless, analytical generalisability has continuously been applied implying that this research can be valid also for other manufacturing companies acting in similar settings. By also providing a thick description of the case and the studies conducted, the researcher has tried to facilitate transferability, and so the reader can decide the level of generalisability. Finally, regarding ethics, the researcher has reflected on her research morality in relation to ethic guidelines (Merriam, 2009, Åhlström and Karlsson, 2009, Vetenskapsrådet, 2017). Regarding this, the researcher has always notified the informants about the objective of the research, handled the collected data confidentiality and applied anonymisation of informants in reports and papers.

### 7.3 Conclusions

In this section the research questions are revisited and answered and the fulfilment of the research objective is discussed.

RQ1. How does an XPS integration evolve under dynamic conditions?, was formulated in order to understand what happens with an XPS integration under dynamic conditions. The question was then elaborated on in the analysis in Chapter 5.1 in relation to the theoretical framework and longitudinal empirical data.
from the case description in Table 5 and in Figures 3, 4 and 5 as well as empirical data from Study A (Paper I), Study B (Paper II) and Study C₂ (Paper IV). In Chapter 5.1 it is described that the XPS integration continues to develop during the first years with dynamic conditions, when the plant perceives it is temporary. However, when the plant realises the dynamic conditions are continuing and since the just-in-time part undermines the effectiveness of XPS, they begin to lose their trust in the XPS concept. This negatively affects the XPS integration, which does not get good support, and the XPS integration declines to a lower level. This has been called the breaking point of the dynamic conditions and is a critical period of time, when the plant becomes aware of the need to adapt to dynamic conditions, which can negatively affect the XPS integration. However, there is also a relation to the maturity level concerning the continuous improvement capability, which also seems to affect the evolvement of the XPS integration under dynamic conditions. The plant has approached maturity level 3, strategic continuous improvement. However, to reach this level and above requires shifting from having applied mainly single-loop learning to also applying double-loop learning, implying better experimentation and learning skills that increase the adaptability. Consequently, when the plant is not able to achieve this development, resistance is created, the XPS integration regresses and the developed continuous improvement abilities are negatively affected.

RQ2, What are the challenges during the XPS integration under dynamic conditions?, was addressed in order to explicitly understand what the difficulties and the needs are during the XPS integration under dynamic conditions. The question was addressed in the analysis in Chapter 5.2 in relation to the theoretical framework and longitudinal empirical data from the case description in Table 5 and in Figures 3, 4 and 5 as well as empirical data from Study A (Paper I), Study B (Paper II) and Study C₂ (Paper IV). Accordingly, the main challenges are to keep supporting the XPS integration to carry on building continuous improvement abilities and simultaneously reconsider and adapt XPS (where e.g. just-in-time is an issue). The subsequent challenges involve assessing whether or not suggested changes and the XPS consistently support and reinforce each other, creating guidelines regarding the adaptations of the XPS, and facilitate double-loop learning by, e.g., thorough reflections to make necessary adaptations. In addition to these challenges comes another main challenge concerning how to manage other large and complex changes that are needed in relation to challenges identified in Table 5, i.e., aiming to develop continuous innovation capability.

RQ3, How can an XPS integration be developed towards continuous innovation under dynamic conditions?, was asked in order to be able to understand how the needed improvements, from incremental to both incremental and radical innovative improvements, could be supported in the production system under dynamic conditions. The question was addressed in the analysis in Chapter 5.3 in relation to the theoretical framework and empirical data from Study C₁ (Paper III) and Study C₃ (Paper V). Since it was found that an XPS integration mainly contributes to the development of exploitation capabilities, it needs to be combined
with exploratory capabilities/processes to be able to move towards continuous innovation. Further it is declared that continuous innovation capability can be built by enabling the effective ongoing interaction between the XPS integration (exploitation processes) and production development projects (exploration processes). To be able to do this, the plant needs to provide means to approach both structural and contextual ambidexterity. By organising and managing people for both incremental and radical improvements/innovations and by striving for a more proactive product-push mentality through increasing the understanding of exploration, continuous innovation can be facilitated.

By answering the research questions and subsequently discussing the results in Chapter 6 based on the research objective, i.e., to develop recommendations supporting continuous innovation in production systems, the recommendations could be visualised in Figure 9. Accordingly, to transition from continuous improvement to continuous innovation including organisational ambidexterity in a production system under dynamic conditions requires a great deal from the management team and is an issue for the management team to tackle. On an overall level it is important to become aware of the breaking point of the dynamic conditions in order to avoid failure of the XPS integration, because still efficiency and incremental improvements as well as a culture for continuous improvement are needed and exploitation is a part of continuous innovation capability. Therefore it is suggested to start building exploration capability in parallel to build continuous innovation capability. Hence the following actions are considered important: continuous support of the XPS integration, facilitating double-loop learning by thorough reflections, being open-minded to the need to adapt the XPS integration to new circumstances, yet carefully evaluating changes before integrating them, developing and continuously encouraging exploration capabilities and giving space to functions responsible for the long-term success of the plant to engage in exploratory tasks, being aware of the contradiction in building exploration and exploitation capabilities by striving to combine structural and contextual ambidexterity, and finding means for balancing, supporting and linking exploration and exploitation processes, of which a deep involvement strategy formulation process is an example. In line with this the research objective can be considered fulfilled.

7.4 Scientific and industrial contributions

This research project aimed at achieving deep insight into the process of developing continuous improvement towards continuous innovation under dynamic conditions and to synthesise these insights into recommendations that can be used as a support for change.

Accordingly the project has generated both a scientific contribution to the research community and managerial implications for decision makers in the manufacturing industry. The scientific contribution is mainly related to the ongoing improvement discussion in the area of quality management and operations management, e.g., how an XPS integration evolves under dynamic conditions, how an XPS can be
combined with exploration, how continuous innovation can be understood and facilitated in a production system context as well as how ambidexterity can be understood and developed in a production system context. The practical contributions through the recommendations are mainly addressed to managers on different levels in the production system, like plant managers, production development managers, production supervisors and change agents involved in these types of change projects as well as senior managers responsible for strategic issues.

7.5 Future research

This research has its foundation in an XPS integration ongoing in a plant and from this perspective investigated how to approach continuous innovation in order to increase the adaptability under dynamic conditions, which are expected to continue in the manufacturing industry. Having this perspective is argued to be important since XPSs or other continuous improvement concepts are important for the efficiency of the production system, as well as it contributes in the long term to the development of experimentation and learning skills that are needed in this context. However, under dynamic conditions there is a risk that these programmes are abandoned.

Therefore, future research is suggested to continue to explore the intersection with product innovation from a production system perspective and how innovations in production systems are managed (like product innovations that require changes in the production system and new manufacturing technologies affecting the production system) in relation to XPS integrations (or other new management systems), i.e., to study the next iterations in the continuous innovation spiral from a production system perspective.

This could include investigating the adaptation process of XPS further in relation to production improvements/innovations, how to facilitate double-loop learning in relation to XPS further and perhaps also deuteron learning – learning how to learn (Granberg and Ohlsson, 2009), how to further develop and sustain ambidexterity in production systems and especially how to make exploration capabilities become a long-term skill in the production system context.
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