# Large-scale agile transformation in a manufacturing company

## a knowledge-based view

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## A knowledge-based view

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LUND UNIVERSITY

LICENTIATE THESIS

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**Title and subtitle:** Large-scale agile transformation in a manufacturing company – A knowledge-based view

**Abstract:** Agile has been touted as a concept to deal with and succeed in the fast-paced environment in which companies operate today. Based on this concept, practitioners have created frameworks and practices that have proven to bring benefits in software development. Looking to extend these benefits beyond software development, companies are launching large-scale agile transformation initiatives, however, these initiatives are associated with several challenges.

Some of the most prominent challenges in large-scale agile transformation initiatives are related to the understanding of agile within an organization. Studies point towards misunderstanding, lack of understanding and different understandings of agile. These challenges lead to resistance, frustration, inappropriate workloads, and increased cost of resource relocation, hindering successful transformation initiatives.

Challenges related to the understanding of agile within an organization are especially important among key roles (managers, change leaders, consultants, etc.) as they have the power to remove barriers, allocate resources, provide support, act as facilitators, and as mentors to motivate employees in large-scale agile transformation initiatives. Moreover, these challenges are critical in the initial phase of implementation of a transformation initiative, as is in this phase when key roles cooperate to develop a shared commitment and vision of the initiative. Challenges related to the understanding of agile within an organization are expected to be exacerbated in manufacturing companies.

Despite the relevance of these challenges, existing studies have not explored key roles' understanding of agile in depth. Therefore, the purpose of this thesis is to explore the key roles' understanding of agile in the initial phase of a large-scale agile transformation initiative in a manufacturing company.

Applying a knowledge-based view, this study shows that the key roles' understanding of agile is grounded in the knowledge frame (system of meaning based on ways of working, educational backgrounds, mental maps, etc.) of their organizational units. This results in knowledge boundaries that limit the key roles' shared and comprehensive understanding of agile among different organizational units. This study shows that these knowledge boundaries call for flexibility and dynamism in large-scale agile transformation initiatives in manufacturing companies. This thesis presents a conceptual model that illustrates an iterative ad hoc implementation of large-scale agile transformation initiatives in manufacturing companies.

**Key words:** Large-scale agile; organisational transformation; knowledge specialisation; knowledge boundaries; knowledge integration; manufacturing company.

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*Silvia Orejuela*

*Lund, November 2023*

# Abstract

Agile has been touted as a concept to deal with and succeed in the fast-paced environment in which companies operate today. Based on this concept, practitioners have created frameworks and practices that have proven to bring benefits in software development. Looking to extend these benefits beyond software development, companies are launching large-scale agile transformation initiatives, however, these initiatives are associated with several challenges.

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Applying a knowledge-based view, this study shows that the key roles' understanding of agile is grounded in the knowledge frame (system of meaning based on ways of working, educational backgrounds, mental maps, etc.) of their organizational units. This results in knowledge boundaries that limit the key roles' shared and comprehensive understanding of agile among different organizational units. This study shows that these knowledge boundaries call for flexibility and dynamism in large-scale agile transformation initiatives in manufacturing companies. This thesis presents a conceptual model that illustrates an iterative ad hoc implementation of large-scale agile transformation initiatives in manufacturing companies.

# List of appended papers

The licentiate thesis includes the following appended papers.

*Paper I*

Orejuela, S., Johansson, G., & Motte, D. (2022). *Establishing Factors to Consider While Adopting the Agile Approach in Manufacturing Companies.* Paper presented at the 10th Swedish Production Symposium (SPS2022), Skövde, Sweden.

Paper II

Orejuela, S., Motte, D., & Johansson, G. (2023). *Managers' understanding of agile in hardware development.* Paper presented at the International Conference on Engineering Design (ICED23), Bordeaux, France.

*Paper III*

Orejuela, S., Johansson, G., & Motte, D. (2023). *Large-scale agile transformation in a manufacturing company: A knowledge integration perspective*. (Submitted to *International Journal of Innovation and Technology Management*).

# Author's contribution to the appended papers

*Paper I*

Silvia Orejuela was responsible for the research design, data collection, and analysis of the study. She wrote the initial draft of the paper (including visualizations), edited it, and revised it according to feedback from the co-authors, study participants, and conference reviewers.

*Paper II*

Silvia Orejuela was responsible for the research design, data collection, and analysis of the study. She wrote the initial draft of the paper (including visualizations), edited it, and revised it according to feedback from the co-authors and comments from the conference reviewers.

*Paper III*

Silvia Orejuela was responsible for the research design, data collection, and analysis of the study. She participated in the study and compiled the theoretical framework used in this paper. Moreover, she wrote the initial draft of the paper (including visualizations), edited it, and revised it based on feedback from the co-authors.

# 1 Introduction

This chapter presents the background that motivates the study, introduces the research purpose, and provides an outline of the thesis.

## 1.1 Background

Manufacturing companies operate in a fast-paced business environment characterised by trends such as increasing customer demands for innovative and customized products, the use of new technologies in industrial practices (e.g., artificial intelligence, immersive reality, Big Data, additive manufacturing, etc.), and integration between the products' mechanical, electrical, and software parts (Baines, Lightfoot, Williams, & Greenough, 2006; Isaksson & Eckert, 2020). All these trends demand that manufacturing companies work according to new logics on their business processes to stay competitive (Isaksson & Eckert, 2020).

*Agile* has been raised as a concept to deal with and succeed in a rapidly changing environment. Based on this concept, the Manifesto for Agile Software Development (Beck et al., 2001) established a set of values and principles that have served as a foundation for several software development frameworks and practices (e.g., Scrum, eXtreme Programming [XP], etc.). Agile has become an umbrella term to refer to these frameworks and practices.

Initially, these frameworks and practices were focused on small single-team projects (Boehm & Turner, 2005; Dumitriu, Meșniță, & Radu, 2019). They have been proven to bring several benefits to software development teams, such as increased collaboration, better alignment with business needs, and a better work environment, among others (Digital.ai, 2022).

Recently, attention has been turned towards large-scale agile frameworks and practices aimed at supporting coordination among several teams. Examples of such frameworks are the Scaled Agile Framework (SAFe, Scaled Agile, 2022), Scrum@Scale (Sutherland & Scrum Inc., 2022), and Large-Scale Scrum (LeSS, The LeSS Company, 2014). Moreover, companies have broadened the adoption, implementation, and use of agile frameworks and practices in contexts beyond software development (Digital.ai, 2022; Rigby, Sutherland, & Noble, 2018),

including hardware development[1] (Cooper & Sommer, 2016; Edwards, Cooper, Vedsmand, & Nardelli, 2019).

To this end, manufacturing companies have launched *large-scale agile transformation initiatives*. For the purpose of this thesis, large-scale agile transformation refers to the process of adopting, implementing, and using agile frameworks and practices across an organization (Paasivaara, Behm, Lassenius, & Hallikainen, 2018; Pawlak, 2021; Strode, Sharp, Barroca, Gregory, & Taylor, 2022). While large-scale agile transformation initiatives promise benefits such as faster time-to-market, higher team productivity and morale, and responsiveness to change (Paasivaara et al., 2018; Rigby et al., 2018), these initiatives are associated with many challenges, such as, resistance to change, lack of evidence-based guidance in literature regarding the use of agile frameworks and practices, dependencies between agile and non-agile organizational units, among others (Conboy & Carroll, 2019; Dikert, Paasivaara, & Lassenius, 2016; Dumitriu et al., 2019; Michalides, Bursac, Nicklas, Weiss, & Paetzold, 2023).

## 1.2 Research problem

Large-scale agile transformation initiatives not only face challenges related to agile *per se*, such as difficulties in the refinement of high-level requirements and their decomposition into suitably sized stories to perform effort estimation (Dikert et al., 2016), but also challenges related to the adoption, implementation, and use of agile across the organization. Examples of these challenges are the organizational inertia that slows down the change process, and the coordination and communications between several development teams and organizational units that operate under different contextual conditions (Barroca, Dingsøyr, & Mikalsen, 2019; Dikert et al., 2016; Kovynyov, Buerck, & Mikut, 2021).

Some of the most recurrent challenges in the literature on large-scale agile transformation initiatives are related to the understanding of agile within an organization. Studies point towards misunderstanding, lack of understanding and different understandings of agile within an organization. Although the literature uses different terms to refer to these challenges (e.g., interpretation or conception of agile), for the purpose of this thesis, they will be addressed under the term *understanding*, defined as the "knowledge about a subject, situation, etc. or about how something works" (Cambridge University Press & Assessment, n.d.). In studies conducted by Eklund and Berger (2017) and Eklund and Berger (2017),

[1] The terms "hardware development" and "development of physical products" are used interchangeably to refer to the development of products that bear a physical nature (Schmidt et al., 2019). These products are characteristic of manufacturing companies.

'understanding agile along the value chain' was ranked as one of the most important challenge in scaling agile in companies developing mechatronic products. Gregory, Barroca, Sharp, Deshpande, and Taylor (2016) found that, owing to its openness to different interpretations, misunderstandings of agile is the most repetitive challenge among agile practitioners, and Dikert et al. (2016) showed that misunderstanding of agile concepts is the most prominent out of existing challenges in large-scale agile transformation. In a survey conducted by Schmidt et al. (2019), the lack of understanding of agile in middle and top management were ranked as the third and fourth most important challenges in hardware development companies. Similarly, studies have found that agile is subject to different understandings. For instance, Schmidt, Weiss, and Paetzold (2018) found that due to the immaturity of the application of agile, its understanding can differ according to whom is being questioned. Dikert et al. (2016) found that, in a multi-team environment in large-scale agile, the understanding of agile among teams differs.

Challenges related to the understanding of agile within an organization lead to frustration, unfulfilled expectations, commitment to unreasonable workloads, friction and fragmentation, increased cost of resource relocation, and lack of buy-in, thus hindering large-scale agile transformation initiatives (Cooper & Sommer, 2016; Dikert et al., 2016; Schmidt et al., 2019). Despite these challenges being crucial for the success of large-scale agile transformation initiatives, literature does not provide further insights into these challenges, for instance, regarding the nature of the understanding of agile within an organization, what the misunderstandings or different understandings are about, what their implications for a large-scale agile transformation are, etc.

Challenges related to the understanding of agile are especially significant among key roles in large-scale agile transformation initiatives, such as managers, change leaders, and consultants, as they have the power to remove barriers, allocate resources, provide support, and act as facilitators, and as mentors to motivate employees (Dikert et al., 2016; Yadav, Nepal, Rahaman, & Lal, 2017). Moreover, these challenges are important in the initial phase of a large transformation initiative, in which cooperation of key roles is crucial to develop a shared commitment and vision of the transformation initiative (Kotter, 1995).

Challenges related to the understanding of agile within an organization are expected to be exacerbated in manufacturing companies as they design, manufacture, and deliver products composed of interdependent modules that require knowledge exchange and sharing between several teams (Isaksson & Eckert, 2020). These teams are composed of organizational members with specialized knowledge in different fields (Säfsten, Johansson, Lakemond, & Magnusson, 2014), who often belong to organizational units that operate under different contextual conditions and have different priorities and goals (Barroca et al., 2019; Kovynyov et al., 2021). Based on these organisational conditions, a knowledge-based view proposes the integration of specialized knowledge as the primary role of an organization (Grant,

1996; Huang & Newell, 2003; Lawrence & Lorsch, 1967). The importance of knowledge integration for organisational competitiveness is widely recognized and has become increasingly important for organisational survival and success in today's rapidly changing environment (Huang & Newell, 2003; Tell, 2016).

## 1.3 Research purpose

It is now well established that challenges related to the understanding of agile within an organization are relevant for large-scale agile transformation initiatives. These challenges are especially important among key roles as they have the power to make decisions and take actions that impact the success of transformation initiatives. Moreover, these challenges are critical in the initial phase of implementation of a transformation initiative because is in this phase when key roles' cooperation is needed to achieve a shared commitment and vision of the initiative. Furthermore, challenges related to the understanding of agile within an organization are expected to be exacerbated in manufacturing companies because they require knowledge specialisation to design, manufacture, and deliver their products, which limits organizational members' shared and comprehensive understanding of issues. Therefore, the overall purpose of this licentiate thesis is:


**Figure 1. Research purpose**

## 1.4 Thesis outline

This thesis includes a compiled summary and three appended papers. The compiled summary is divided into the following chapters.

**Chapter 1** **Introduction** presents the background and research purpose of this study.

**Chapter 2** **Frame of reference** provides the literature on agile and large-scale agile transformation, as well as on a knowledge-based view, upon which this study is based.

**Chapter 3** **Research method** describes the research method and design, data collection techniques, and data analysis process used in the study. This chapter also describes the actions taken to ensure the research quality of the study and ethical considerations.

**Chapter 4** **Summary of appended papers** summarizes the appended papers, their findings, and contributions to the thesis. Based on these contributions, this chapter presents the connection between these papers and the research purpose of this study.

**Chapter 5** **Discussion and conclusion** presents an aggregated discussion of the papers' contributions to the research purpose. This chapter also presents the conclusion, contributions to the literature and practice of large-scale agile transformation in manufacturing companies, the study's limitations, and future research avenues.

# 2 Frame of reference

## 2.1 Agile origins, frameworks, and practices

*Agile* is defined by the Agile Alliance (2023) as "the ability to create and respond to change. It is a way of dealing with, and ultimately succeeding in, an uncertain and turbulent environment".

Based on this concept, Beck et al. (2001) established the Manifesto for Agile Software Development. It uncovered values and principles that sought to provide an alternative to the classical heavyweight way to develop software (see Figure 2). Agile became an umbrella term for a set of frameworks and practices based on the Manifesto's values and principles. Examples of these frameworks are Scrum, XP, and the Dynamic System Development Method (DSDM, Agile Alliance, 2023; Edwards et al., 2019). These frameworks are focused on single, small, self-organizing, cross-functional teams that develop solutions through an iterative and incremental process (The LeSS Company, 2014). In software development, agile frameworks and practices have been proven to bring benefits such as happier and more engaged employees, faster time to market, increased productivity, and improved software quality (Scaled Agile, 2022).


**Figure 2. Manifesto for Agile Software Development**

Nevertheless, challenges related to the alignment and cohesion across teams and interdependencies between software development and other organisational units have underpinned the attention towards large-scale agile frameworks and practices that support the coordination between several teams (Edison, Wang, & Conboy, 2022; Sutherland & Scrum Inc., 2022). Examples of such frameworks are SAFe (Scaled Agile, 2022), Scrum@Scale (Sutherland & Scrum Inc., 2022), and LeSS (The LeSS Company, 2014).

SAFe is configured at three levels: essential, large solution, and portfolio. The essential level describes the minimal elements to deliver a solution, the large-solution level is focused on building and evolving the largest solutions, and the portfolio level is focused on the value streams that constitute the portfolio. All these three levels lay upon 'the foundation element,' which includes Lean-Agile Mindset, Core Values, and SAFe Principles, among others (Scaled Agile, 2022).

Scrum@Scale is based on Scrum. It describes a framework with several components (e.g., Product and Release Feedback, Metrics and Transparency, Continuous Improvements, Cross-team Coordination, etc.) organized in two cycles, namely the Scrum Master cycle and the Product Owner cycle. All of these components are based on a value-driven culture (composed of the values of openness, courage, focus, respect, and commitment). In Scrum@Scale, the team of Scrum teams (Scrum of Scrums) operates as if it were a Scrum team following the Team Process described in the Scrum Guide (Schwaber & Sutherland, 2020). However, it works with scaled versions of artifacts (Executive Action Team [EAT] Backlog), events (scaled versions Sprint Planning and Sprint Review, The Scaled Daily Scrum, and The Scaled Retrospective), and Scrum accountabilities (Scrum of Scrum Master and the EAT, and the Chief Product Owner and the Executive Meta Scrum [EMS]). The teams composing the Scrum of Scrums must deliver a fully integrated increment of a product at the end of each sprint.

LeSS is also based on Scrum and encompasses two frameworks according to the number of teams involved: LeSS (2-8 teams) and LeSS Huge (8+ teams). These two frameworks share common elements, such as one product owner that owns the one product backlog, and one common Sprint for all the teams that ends in one potentially shippable increment. The LeSS framework basically looks like a one-team Scrum, with the difference that the Scrum Master is shared among three teams, and each team has a separate Sprint Backlog. Additionally, in the LeSS Huge, team division is based on Requirement Areas, which are major areas of customer concern. In the one product backlog, a 'Requirement Area' attribute is added, and each item is classified into one Requirement Area. Moreover, the LeSS Huge framework introduces a new role: the Area Product Owner, who focuses on its own Area Product Backlog.

A common characteristic of these frameworks is that they define values, team structures (including roles and responsibilities), and practices (including events and/or artifacts) (Conboy & Carroll, 2019). It is claimed that these frameworks and practices need to be adapted to the needs and unique situations of organizations (Drutchas & Eppinger, 2023; Edison et al., 2022; Paasivaara et al., 2018; Pawlak, 2021). However, they provide little guidance on how to tailor them in practice, under what circumstances they are best suited, or how agile teams interact with the organizational environment (Dikert et al., 2016; Edison et al., 2022; Paasivaara et al., 2018; Pawlak, 2021). Moreover, they provide limited guidance on how to implement them. SAFe is one of the few frameworks that includes an

implementation roadmap describing a strategy and an ordered set of activities to achieve its implementation (Scaled Agile, 2022). Scrum@Scale states that, for its implementation, it is critical to develop a scalable reference model, which is a small set of coordinated teams that deliver every sprint (Sutherland & Scrum Inc., 2022).

## 2.2 Large-scale agile transformation

Looking to replicate the benefits gained in software development at the wide organizational level, the attention of companies has been turned towards the implementation of large-scale agile frameworks and practices beyond software development (Rigby et al., 2018). Companies have begun to launch *large-scale agile transformation initiatives*. *Large-scale agile* describes the use of agile frameworks and practices in large teams, large multi-team projects, or the whole organization (Dingsøyr & Moe, 2014). *Transformation* refers to the transfer from traditional organizational structures (siloed, structural hierarchies), governance structures (top-down decision-making), ways of working (Stage-Gate or Waterfall models and practices), to the use of agile frameworks and practices (Pawlak, 2021). Large-scale agile transformation is a comprehensive organizational transformation initiative (Brosseau, Ebrahim, Handscomb, & Thaker, 2019).

According to literature, large-scale agile transformations can take different approaches. The most common approach is the stepwise approach (Brosseau et al., 2019). In this approach, organizations run multiple rounds of pilots to learn and improve before committing to scaling up agile across the organization (Brosseau et al., 2019).

Researchers have proposed models to support and promote large-scale agile transformation initiatives. Examples include a sequential model proposed by Pawlak (2021) based on literature findings in large-scale agile implementation and a ten-stage model presented by Denning (2019) based on the mapping of several agile transformation journeys. Moreover, Paasivaara et al. (2018) presented the three main phases of a large-scale agile transformation at Ericsson. In the latter study, the authors found that insufficient training and coaching may lead to a lack of common direction in a large-scale agile transformation initiative. Hutter, Brendgens, Gauster, and Matzler (2023) offered a dynamic capabilities-based framework for scaling agile at the organizational level; the framework presented agile centre of competence as a key accelerator for large-scale agile transformation initiative. In addition to these models, Dikert et al. (2016) point to several success factors in large-scale agile transformation, including management support, team self-organization, training and coaching, among others.

### 2.2.1 Large-scale agile transformation in manufacturing companies

Large-scale agile transformation has mostly been studied in software-dominant companies, while research on non-software-dominated companies is scarce (Strode et al., 2022). Particularly, manufacturing companies deal with different contextual conditions that must be considered in large-scale agile transformation initiatives (Lindlöf & Furuhjelm, 2018). For example, hardware development, which characterizes manufacturing companies, differs from software development. Hardware development deals with product complexity in terms of quantity and integration of parts, high prototyping costs in early development stages, and long-term development cycles, among others (Conforto, Salum, Amaral, da Silva, & de Almeida, 2014).

Examples of studies on large-scale agile transformation in manufacturing companies include: the single case of Saab Aeronautics (Lindlöf & Furuhjelm, 2018), Ocado Technology (Drutchas & Eppinger, 2023), and LEGO (Sommer, 2019); the comparative multiple case presented by Eklund and Berger (2017); and the surveys conducted by Schmidt et al. (2019) and Michalides et al. (2023).

Lindlöf and Furuhjelm (2018) conducted a qualitative study based on an insider-outsider approach to the transition to large-scale agile in Saab Aeronautics, a large Swedish company in the aircraft industry. More specifically, the case was focused on the development of a fighter jet, which involves approximately 2000 engineers organized in both software and hardware development teams. Their study showed that the synchronized delivery of inputs/outputs between teams and the empowerment of teams in planning play a crucial role in gaining the benefits of agile in a large-scale context. Similarly, using a field study approach, Drutchas and Eppinger (2023) documented practices for the successful implementation of large-scale agile at Ocado Technology, an online grocery ordering and delivery company that continually improves its mobile robots based on software and hardware development. The study described two adjustments made to a large-scale agile framework: a problem-based approach to backlog decomposition and a flexible resource allocation by forming ad hoc teams in each sprint. Another case study was conducted by Sommer (2019). It described the orchestration of large-scale agile transformation in the LEGO Group. The transformation took place in two large digital departments and followed the open-source change approach. The transformation encompassed changes across five transformation categories: organizational structure, mandate, financial process, performance measures, and delivery process.

In a longitudinal multiple-case study of six mechatronic companies, Eklund and Berger (2017) documented 26 practices that support the integration of teams in the context of large-scale agile in mechatronics companies. The authors sorted these practices according to the agile principles (cf. Beck et al., 2001) and five agile maturity levels: collaborative, evolutionary, effective, adaptive and encompassing.

A survey conducted by Schmidt et al. (2019) reported, among other things, that large-scale agile transformation is a process that can take more than five years in manufacturing companies and that large-scale agile diffusion progress decreases among transformation levels; in other words, the higher the transformation level, the fewer companies are involved in it. This diffusion progress decreases even further in large companies.

Recently, Michalides et al. (2023) conducted an empirical study focusing on challenges of large-scale agile in physical products. The study encompassed empirical data from an online survey sent to 128 experienced participants and a literature review, including 45 publications in large-scale agile in physical product development. The results of the study showed that dependencies in the collaboration of agile and non-agile organizational units, synchronization, dependencies in the collaboration of agile organizational units, and coordination are the biggest challenges in large-scale agile in physical product development.

Moreover, the study of LEGO suggested that agile values must be at the center of agile transformation initiatives, and that implementing agile processes and tools without changing behavior and mindset should be avoided because teams end up 'doing agile' without 'being agile' (Sommer, 2019); similarly, Pawlak (2021) asserts that large-scale agile transformation "is more about being agile than doing agile" (p. 67). Moreover, a study conducted by Berger and Eklund (2015) suggested that changing the overall mindset in the organization should be an initial step in scaling agile outside software development teams.

These studies also indicated that there is no 'textbook' implementation of large-scale agile frameworks and practices, rather that some modifications are needed for them to be adapted to the context of each organization, e.g., backlog's form and decomposition, frequency of daily or stand-up meetings, team conformation, resource allocation, etc. (Drutchas & Eppinger, 2023; Lindlöf & Furuhjelm, 2018; Sommer, 2019). Understanding organizations' particular contexts is crucial for successful transformation initiatives (Sommer, 2019).

In general, the literature on large-scale agile transformation in manufacturing companies asserts that every transformation initiative is unique. However, experiences from other organizations can provide important insights or key lessons that support and guide other companies contemplating or striving for large-scale agile transformation (Drutchas & Eppinger, 2023; Lindlöf & Furuhjelm, 2018; Sommer, 2019).

### 2.2.2 Challenges related to the understanding of agile within an organization.

Large-scale agile transformation is fraught with several challenges (Dikert et al., 2016; Gregory et al., 2016; Gregory, Barroca, Taylor, Salah, & Sharp, 2015; Paasivaara et al., 2018). Some of the most prominent are related to the understanding of agile within an organization. Studies point towards misunderstanding, lack of understanding and different understandings of agile within an organization. For instance, the study conducted by Gregory et al. (2016), which included insights from agile practitioners and business representatives who took part in different agile conferences and events, showed that the most repetitive challenge is that agile is subject to misunderstanding due to its openness to different interpretations. Similarly, through a systematic literature review that included experience reports and case studies of software organizations introducing large-scale agile frameworks and practices, Dikert et al. (2016) found that difficulties in agile implementation were partly due to a misunderstanding of agile concepts. In their longitudinal study of six Nordic companies, Eklund and Berger (2017) related misunderstanding of agile concepts with the 'understanding agile along the value chain' as the third most important challenge in scaling agile in companies developing mechatronic products.

In the survey conducted by Schmidt et al. (2019), which included 122 companies—most of them dominated by hardware development—lack of understanding of agile in middle and top management are ranked third and fourth most important, out of twenty-two, challenges in the application of agile among the surveyed companies. Moreover, the empirical study presented by Michalides et al. (2023) showed that the understanding of agile values and principles is a significant challenge when scaling agile in hardware development.

These studies have also identified different understandings of agile. Dikert et al. (2016) found that the understanding of agile among teams differs. Moreover, Schmidt et al. (2018) showed that because of the immaturity of the application of agile, it is subject to different understandings according to whom is questioned, and Schmidt et al. (2019) claimed that there is a high chance that practitioners have different understandings of agile when it is scaled in manufacturing companies.

Challenges related to the understanding of agile within an organization hinder the successful implementation of large-scale agile transformation initiatives. Misunderstandings of agile can lead to frustration, unfulfilled expectations, commitment to unreasonable workloads (Dikert et al., 2016), or lack of management buy-in (Cooper & Sommer, 2016; Schmidt et al., 2019). Different understandings in a multi-team environment create friction, fragmentation, increased cost of resource relocation between teams (Dikert et al., 2016), and affect collaboration at the interfaces of different organizational units (Michalides et al., 2023).

## 2.3 Knowledge-based view: Knowledge specialisation, knowledge boundaries, and knowledge integration

The design, manufacturing, and delivery of products offered by manufacturing companies require *knowledge specialisation* in different fields (Säfsten et al., 2014). This knowledge specialisation leads to *shared knowledge frames* in *epistemic communities.* Shared knowledge frames are systems of meaning (based on ways of working, educational backgrounds, mental maps, etc.) that lead different epistemic communities focus on different aspects of knowledge, and to filter, interpret, and understand the same information differently (Dougherty, 1992). Epistemic communities consist of individuals with a shared knowledge frame (Håkanson, 2010) and are found in organizational units, subsystems, professions, occupations, and so on. (Håkanson, 2010; Lawrence & Lorsch, 1967; Tell, 2016). Epistemic communities develop specific attributes to meet the requirements of their relevant external environment, including differences in attitudes and behaviours, goal orientation, time perspective, emphasis on interpersonal skills, and the type and extent of formalization of the structure, among others (Lawrence & Lorsch, 1967).

The aforementioned shared knowledge frames result in *knowledge boundaries* among epistemic communities, which limit the possibility of epistemic communities to achieve a shared and comprehensive understanding of issues (Dougherty, 1992; Tell, 2016). Carlile (2004) argues that the relative complexity of knowledge boundaries is defined by three properties of knowledge at the boundary: *difference*, which refers to the difference in the amount of accumulated knowledge between epistemic communities; *dependence*, which refers to the conditions under which epistemic communities must take each other into account in order to achieve goals; and *novelty*, which refers to how novel the circumstances are, or how novel the common knowledge used to represent the differences and dependencies are for the epistemic communities. Knowledge boundaries are then represented by Carlile (2004) as a vector that begins where the differences and dependencies are known; as novelty increases, the vector spreads and the complexity and effort required to manage the knowledge boundaries increase. Based on these properties, the author presents a framework that includes three types of knowledge boundaries: syntactic, semantic, and pragmatic.

Another author who presented types of knowledge boundaries was Tell (2016). The author classified knowledge boundaries as individual, domain-specific, task-oriented, temporal, and spatial. Individual knowledge boundaries are characterized by the tacit elements of individuals' knowledge that they use to make sense of the world. Domain-specific knowledge boundaries refer to knowledge that results from experiential learning through interactions with others; these knowledge boundaries often include canonical principles to which the domain community adheres. Task-oriented knowledge boundaries relate to task organization and task execution

capabilities, which are often considered organizational routines. Spatial knowledge boundaries result from local contexts and conditions including language, culture, and traditions. Finally, temporal knowledge boundaries result from time and the order in which the knowledge is applied.

Although knowledge specialisation, and knowledge boundaries that result from it, are key to organizational efficiency and innovation, they create a need for *knowledge integration* across boundaries (Grant, 1996; Lawrence & Lorsch, 1967; Tell, 2016). According to Grant (1996), knowledge is the most strategically important resource of a firm. According to the author, if knowledge resides in a specialized form among organizational members, the primary role and essence of a firm is the integration of knowledge. Knowledge integration is defined by Huang (2000) as "an ongoing collective process of constructing, articulating and redefining shared belief through the social interaction of organizational members" (p. 15).

### 2.3.1 Knowledge integration mechanisms

Recognizing the importance of knowledge integration, authors have proposed several integration mechanisms to support it. According to Grant (1996), knowledge integration is determined by two mechanisms: direction, which involves the codification of tacit knowledge into explicit rules, standard procedures, etc., that embody the knowledge of multiple specialists; and organizational routines, which involve sequential patterns of interaction, working arrangements, etc., that minimize the need to communicate knowledge. Similarly, Huang and Newell (2003) highlighted the importance of an organizational structure that facilitates the sharing of codes and narratives among different organizational units. The findings presented by Dougherty (1992) showed that organizational routines can reinforce the separation of thought worlds by limiting their integration. Instead, the author suggested mechanisms that seek to create a shared understanding from different perspectives, such as interdisciplinary responsibility for activities and customer focus. These are aligned with the mechanisms proposed by Patnayakuni, Rai, and Tiwana (2007), which point towards formal (e.g., participatory decision-making) and informal (e.g., informal communication) integrative practices.

Moreover, Lawrence and Lorsch (1967) suggested the creation of integrative subsystems composed of influential, equally oriented expert members to facilitate collaboration between subsystems (or organizational units). Huang and Newell (2003) proposed mechanisms such as the development, maintenance, and nurturing of social capital.

Juxtaposing types of knowledge (i.e., tacit, articulated, and codified) and learning activities (i.e., search, acquisition, assimilation, accumulation, and transformation), Tell (2016) proposed a matrix with 15 integration mechanisms; the matrix includes a few of the aforementioned mechanisms, and adds others such as boundary objects

(e.g., prototypes and drawings), exact replications (e.g., routine replications by franchises), and socialization (mimicking behaviours). Similarly, Carlile (2004) proposed three approaches for sharing and assessing knowledge across boundaries: transferring knowledge, referring to the creation of a common lexicon; translating knowledge, referring to the creation of common meanings; and transforming knowledge, referring to the development of common interests.

Furthermore, Huang and Newell (2003) noted that knowledge integration is facilitated by prior experiences from other organization-wide initiatives (e.g., implementing TQM or a common IT platform), which fosters generative learning by constantly evaluating them.

## 2.4 Summary of frame of reference

Figure 3 shows a summary of the frame of reference. This thesis explores the key roles' understanding of agile through a knowledge-based view (Carlile, 2004; Dougherty, 1992; Grant, 1996; Huang & Newell, 2003; Lawrence & Lorsch, 1967; Tell, 2016). While the concepts of knowledge specialisation, epistemic communities, and knowledge boundaries are used to explore the key roles' understanding of agile, the concepts of knowledge integration and integration mechanisms are used to explore their implications for large-scale agile transformation initiatives in manufacturing companies.

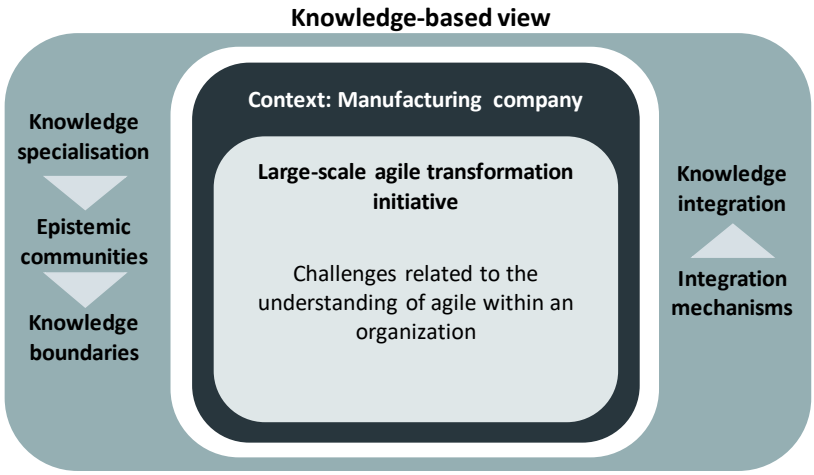


**Figure 3. Summary frame of reference**

# 3 Research method

This chapter describes the research method and design employed, data collection techniques used, and data analysis process followed in this study. This chapter also discusses the actions taken to ensure the research quality of this study and its ethical considerations.

## 3.1 Research method and design

Based on the research purpose, case study was chosen as research method. It allows the exploration of less-explored phenomena, such as large-scale agile transformation initiative in manufacturing companies (Säfsten & Gustavsson, 2020; Siggelkow, 2007; Yin, 2018). Furthermore, a single-case design was chosen to reduce extraneous variation (Eisenhardt, 1989) by ensuring that participants belonged to the same organization and were involved in the same large-scale agile transformation initiative. Single case-study has been used by several researchers studying large-scale agile transformation in manufacturing companies (cf. Drutchas & Eppinger, 2023; Lindlöf & Furuhjelm, 2018; Sommer, 2019). In this study, the context is a manufacturing company, the case is a large-scale agile transformation initiative, and the unit of analysis is key roles' understanding of agile.

The case was selected based on theoretical logic of sampling to contribute to the existing literature on large-scale agile transformation initiatives in manufacturing companies (Eisenhardt, 1989; Säfsten & Gustavsson, 2020). The selected case fulfilled the criterion of being set on a manufacturing company that designs, manufactures, and delivers products that bear a physical nature. Some of the typical characteristics associated with the case include, (Siggelkow, 2007; Yin, 2018), the company's motivation behind its implementation, that is, to improve the alignment between IT and other organizational units (cf. Barroca et al., 2019; Sommer, 2019); its implementation approach, that is, a stepwise approach (cf. Brosseau et al., 2019); and IT's previous experience with the use of agile frameworks and practices (cf. Schmidt et al., 2019).

### 3.1.1 The case and its context

The case is set in the context of a large manufacturing company. The company is a leading manufacturing company with more than seven thousand employees and centers located in different countries. The company offers products and services to customers in several segments such as oil and gas, automotive, aerospace, medical, and energy. Its large investments in R&D, together with close collaboration with customers and partners, allow it to launch several products in the market each year.

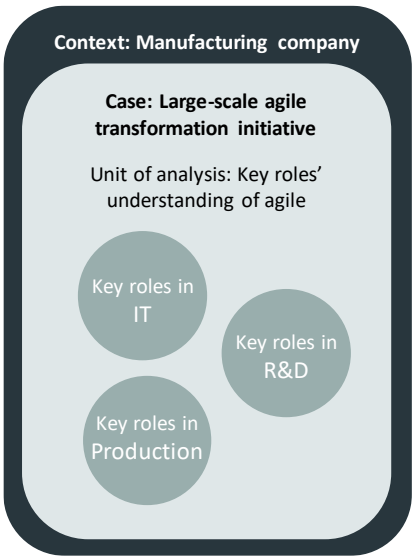


**Figure 4. Case study design**

Due to the need to adapt to the rapid pace of change and increasing digitalization that request IT to get closer with other organizational units, the company's top management decided to start a large-scale agile transformation initiative based on the adoption of "agile ways of working" in the company. IT was decided to be the leader of the transformation initiative because of its experience working with agile.

The transformation initiative is based on a business capability model; however, it is not intended to change the company's current organizational structure. Each capability is supposed to link strategy and execution, meaning what needs to be done to meet current or future organizational challenges and objectives. The transformation initiative involves the formation of agile teams based on organizational capabilities. Each organizational unit has one or more associated capabilities. Each capability has a Capability Owner and one or several Application Product Teams. The latter is an agile team with a set capacity and budget; it is cross-functional in the sense that it has representatives from both a specific organizational unit and IT. Each Application Product Team is composed of an Application Product Owner, a Team Lead, and a Product Team.

The transformation is supposed to follow a stepwise approach: one organizational unit at a time. When the study was conducted, the transformation had started with R&D, discussion had begun with Global Sales, and was planned to be extended to Production.

The study focuses on key roles as they have the power to remove barriers, allocate resources, provide support, act as facilitators, and as mentors for motivating employees in the large-scale agile transformation initiative (Dikert et al., 2016; Yadav et al., 2017). These key roles are represented by managers, change leaders, and consultants involved in the initiative in three organizational units: IT, R&D and

Production. Key roles in IT were considered because they are the leaders of the transformation initiative and, as mentioned, the motivation behind the transformation initiative is for IT to get closer to other organizational units. Key roles in R&D and Production were considered because these two organizational units play an important role in the design and manufacturing of the components of the products offered by the company.

## 3.2 Data collection

Semi-structured interviews and documents were used as data collection techniques.

### 3.2.1 Semi-structured interviews

As the implementation of large-scale agile transformation initiatives relies on people's actions and interactions, interviews were chosen as data collection technique. Interviews are suitable for gaining deeper insights into the experiences of individuals regarding a phenomenon (Säfsten & Gustavsson, 2020; Yin, 2018). More specifically, semi-structured interviews were conducted for this study because they provide flexibility, allowing a better exploration of the key roles' understanding of agile (Kallio, 2016).

Semi-structured interviews present challenges regarding interviewer's expectations and potential bias. Two actions were taken in this regard. First, the interviews followed a defined interview guide; second, the interviews were conducted by two out of the three interviewers involved in the study.

Twenty interviews were conducted in total. The interviewees were selected based on criteria-based sampling logic (Säfsten & Gustavsson, 2020). They are key roles (managers, change leaders, consultants, etc.) in the large-scale agile transformation initiative. All the interviews were conducted in English using a video conference tool. The interviews were conducted individually, with the exception of a group interview with two interviewees at their request. The interviews were audio- and video-recorded and transcribed. During the interviews, the researchers took notes on the interviewees' responses. These notes served to complement the transcripts. The interviews lasted between 40 and 110 minutes. Table 1 provides further information about the interviews.

**Table 1. Overview of interviews**

| ORG. UNIT | INTERVIEWEES | INTERVIEW | DURATION |
|---|---|---|---|
| IT | Senior manager | Individual | 01:05:53 |
| IT | Functional manager | Individual | 00:42:44 |
| IT | Portfolio manager | Individual | 01:01:08 |
| IT | Consultant | Individual | 00:40:10 |
| IT | Functional manager | Individual | 00:51:15 |
| R&D | Functional manager | Individual | 01:16:21 |
| R&D | Senior expert | Individual | 00:56:44 |
| R&D | Senior expert | Individual | 00:55:21 |
| R&D | Change leader | Individual | 01:02:16 |
| R&D | Change leader | Group | 02:01:46 |
| R&D | Project manager | Group | 02:01:46 |
| R&D | Senior manager | Individual | 01:01:49 |
| Production | Senior manager | Individual | 00:34:26 |
| Production | Project manager | Individual | 00:51:31 |
| Production | Change leader | Individual | 00:50:43 |
| Production | Portfolio manager | Individual | 00:58:43 |
| Production | Project manager | Individual | 00:50:36 |
| Production | Chief manager | Individual | 00:59:35 |
| Production | Change manager | Individual | 00:52:44 |
| Production | Portfolio manager | Individual | 00:49:52 |

### 3.2.2 Documents

Documents were used as data collection technique to corroborate or complement the information provided during the semi-structured interviews. These documents included private and public digital materials from the company. These documents provided information regarding the organizational structure, organizational roles, management models, ways of working, and general information about the transformation initiative, among others. Therefore, they were a valuable source of background information regarding the organization, its transformation initiative, people involved in the decision-making process, and so on.

Previous studies have used other data collection techniques for the study of large-scale agile transformation that were not used in this study. For instance, Schmidt et al. (2019) sought to provide insights into the understanding of agile in the context of hardware development using a survey as a data collection technique. By asking participants to associate agile with a set of characteristics (e.g., communicative, responsive, beneficial), the study identified different understandings of agile. However, participants' understandings were limited to the provided set of characteristics, and it is difficult to ensure that the characteristics had the same meaning for all participants. Therefore, semi-structured interviews were considered a more appropriate data collection technique because they allow further elaboration of the interviews' answers using follow-up questions, supporting deeper insights into their understanding of agile. Observations have also been used as data

collection technique to study large-scale agile transformation initiatives (e.g., Sommer, 2019). This technique could have provided further insights into the case in its context, for instance, by attending meetings regarding the large-scale agile transformation initiative. Although it was considered for the present study, the COVID-19 pandemic prevented its inclusion as a data collection technique during the planning phase of the study. Workshops were used to present and discuss findings with the participants, rather than as a data collection technique.

In addition to rigorously using data collection techniques, good interpretative skills from the researchers were needed to ascertain the meaning of the data collected from the interviews and documents. The next subchapter describes the data analysis process followed in this study.

## 3.3 Data analysis

The data analysis was based on data collected from previously described interviews and documents; however, different datasets were used according to the papers' foci (see Chapter 0). For instance, Paper II only considered key roles in organizational units related to hardware development (i.e., R&D and Production), whereas Paper I and III covered key roles in all studied organizational units.

Data analysis was performed by following the general Qualitative Data Analysis Process proposed by (Miles, Huberman, & Saldaña, 2020), which includes three interactive streams of activities: Data Condensation, Data Display, and Drawing and Verifying Conclusions.

In general, Data Condensation activities followed the thematic analysis proposed by Braun and Clarke (2006). In Paper I, descriptive codes were assigned to units of data in the extended notes of the interviews. These codes were then grouped into themes based on their content similarity. As interviewees sometimes used different words to refer to the same content, documents were used to corroborate the wording and assign congruent terms to the themes. The product development system (PDS) proposed by Morgan and Liker (2006) was used as a conceptual framework for organizing and presenting the themes.

Similarly, for Papers II and III, codes were assigned to the units of data of the interview transcripts. These codes were grouped into themes according to word and content similarities. Documents also served to corroborate the wording and to assign congruent terms to the themes. In both papers, these themes were grouped into Scrum components, Scrum has been identified as the most popular agile framework in the manufacturing industry (Schmidt et al., 2019 ). The Scrum components are *values*, *teams*, *events*, and *artifacts* (see Figure 5). These components and their associated fundamental elements of agile were used as a conceptual framework for

organizing and presenting the findings. According to the Scrum Guide (Schwaber & Sutherland, 2020), the component *values* lists the values that must be followed to guide the team regarding their work, behaviour, and actions; the component *teams* describes the team's characteristics, its associated roles, and responsibilities; the component *events* lists a series of meetings included in the framework; and the component *artifacts* involves representations of work that enhance the visibility of key information

For Data Display activities, the graphic displays proposed by Miles et al. (2020) were used as formats. For Paper I, a graphic display that condensed the findings based on the PDS was used to support the paper's discussion and conclusion. In Paper II, a graphic display was used to visualize the connection between elements of agile in a coherent manner, thus supporting the comparison between them. For Paper III, a graphic display, inspired by the data model structure proposed by Gioia, Corley, and Hamilton (2013), was used to present an organized and coherent visualization of the progression of the data analysis. Additionally, a matrix or grid heat map was used to support the identification of data patterns.


**Figure 5. Scrum components and their associated fundamental elements of agile (from Schwaber & Sutherland, 2020)**

Finally, for Drawing and Verifying Conclusions, several tactics for making sense of the data proposed by Miles et al. (2020) were used. In Paper I, *clustering* and *noting themes* that contributed to the paper's purpose were used as tactics. In Paper II, the tactic *comparing* codes was used to serve the paper's objective. In Paper III, in addition to using *clustering* and *noting themes*, part of the analysis was based on *counting* the repetition of codes. Finally, *use of conceptual frameworks* (i.e., PDS and Scrum components) was a tactic use in all the papers.

## 3.4 Research quality

The concepts of content validity, external validity, and reliability (Säfsten & Gustavsson, 2020; Yin, 2018) were used as criteria to identify the actions that ensure the research quality of this study.

### 3.4.1 Content validity

Content validity refers to how well the content of a measuring instrument measures what is intended to be measured (Säfsten & Gustavsson, 2020). Content validity was strengthened through the performance of the following actions: 1) to triangulate data sources using two data collection techniques (interviews and documents); 2) to triangulate by involving three researchers in the data collection and analysis, allowing the interpretation of data from different perspectives; 3) to ensure respondent validation by conducting a workshop to present and discuss the findings with the interviewees, receiving regular feedback from the company's contact person, and sending drafts of the papers to be reviewed by the organization before being sent for publication; and 4) to ensure that the findings of the papers build upon existing literature on large-scale agile transformation.

### 3.4.2 External validity

External validity is related to the extent to which it is possible to make statements about the scope and transferability of findings (Säfsten & Gustavsson, 2020). It is important to mention that the chosen research method and design aim for analytical generalization (Yin, 2018). To strengthen the external validity of the study, the following actions were taken: 1) to select the case based on theoretical logic of sampling (Eisenhardt, 1989; Säfsten & Gustavsson, 2020) with typical characteristics (Siggelkow, 2007; Yin, 2018); 2) to use PDS and Scrum components as frameworks to ensure conceptual coherence of the data; and 3) to use a knowledge-based view to support the argumentation and exploration of the study's findings.

### 3.4.3 Reliability

Reliability refers to the extent to which the measures and measurements can be repeated by others at different times and still provide the same results (Säfsten & Gustavsson, 2020; Yin, 2018). To enhance the reliability of the present study, the following actions were taken: 1) to video- and audio-record and transcribe the interviews; 2) to collect and conserve data in a systematic manner in an archive; and 3) to document the data analysis process followed in the papers.

Table 2 presents a summary of the research method and design, data collection techniques, data analysis, and research quality.

**Table 2. Research method summary**

| RESEARCH METHOD | DESCRIPTION |
|---|---|
| Research method and design | Single case study<br>Case: Large-scale agile transformation initiative.<br>Unit of analysis: Key roles' understanding of agile |
| Data collection techniques | Semi-structured interviews and documents |
| Data analysis | Qualitative Data Analysis Process: 1) Data Condensation, 2) Data Display, and 3) Drawing and Verifying Conclusions. |
| Research quality | Content validity: Triangulation of data sources and researchers; respondent validation; and building upon existing literature in large-scale agile transformations.<br>External validity: to select the case based on theoretical logic of sampling; use conceptual frameworks (PDS and Scrum components); to use a knowledge-based view in support of exploration of findings and argumentation.<br>Reliability: video- and audio-recording, and transcription; systematic data collection and archiving; document data analysis process. |

## 3.5 Ethical considerations

Ethical issues were continuously considered in this study. Since it was not performed according to a method with the purpose of affecting people physically or mentally, the study was not subject to ethical review according to the Swedish Ethical Review Act (2003:460). Nevertheless, the involved researchers analysed potential harms that the study's participants and company could have been exposed to during and after the study, and actions were taken to mitigate these harms.

### 3.5.1 Actions to mitigate harm to the participants

According to Bryman and Bell (2011), harm to participants encompasses physical harm, harm to the development of self-esteem, stress, harm to career prospects, future employment, among others. To mitigate these potential harms, the following actions were taken: before data collection, the participants were informed about the use and purpose of the data intended to be collected and were given the right to decide whether or not they wanted to participate in the study. During data collection, the participants were asked for permission to use a recording device and were given the right to withdraw from the study anytime they wished. After data collection, actions were focused on maintaining the anonymity and confidentiality of the participants.

### 3.5.2 Actions to mitigate harm to the company

This study was based on an investigation of industrial practices; therefore, access to the company's private and public information was required. The parties involved signed a non-disclosure undertaking. This undertaking established the terms and conditions for the use and disclosure of the company's confidential information. Moreover, the company was able to withdraw from the study at any time and review and approve papers before being published.

### 3.5.3 Affiliation and interest conflicts

The present study was funded by Lund University. No conflict of interest was identified.

# 4 Summary of appended papers

This chapter presents a summary of the three appended papers, their findings, and their contributions to the thesis. The connection between the appended papers and the research purpose is described at the end of the chapter.

## 4.1 Paper I

**Introduction**

Agile is gaining interest among manufacturing companies; however, the literature on large-scale agile transformation initiatives in manufacturing companies is still immature, and only a few in-depth empirical studies have been conducted in this context. Therefore, Paper I presents a study that aimed to identify and describe factors to be considered while adopting agile in a manufacturing company by exploring the experiences of different functions (organizational units).

**Findings**

The findings presented in Paper I identify and describe ten factors to be considered in the adoption of agile in a manufacturing company. These factors were categorized using the PDS introduced by (Morgan & Liker, 2006), which is composed of three subsystems: people, process, and technology and tools. Out of these ten factors, four were related to the subsystem people (see Figure 6).

**Contribution to thesis**

One of the ten identified factors is ‘understanding of the agile approach’. The findings showed that the understanding of agile within the organization differs according to the teams’ maturity level working with agile, and the function (organizational unit) to which they belong. The understanding of agile varies along visual management, cross-functional work, continuous development, iterative ways of working, mindset, and so on.

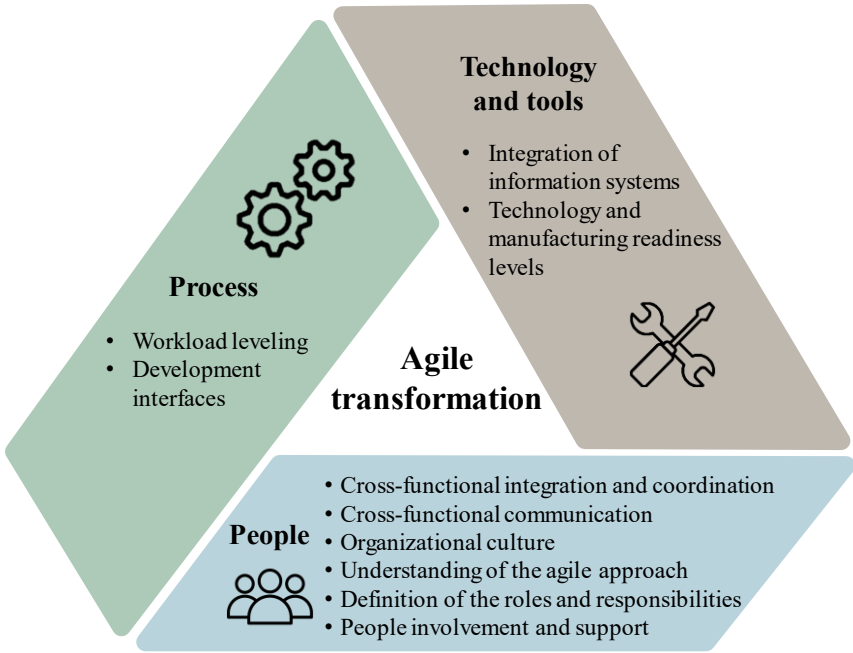


**Figure 6. Factors to be considered while adopting agile in a manufacturing company (Paper I)**

## 4.2 Paper II

### Introduction

One of the challenges in the adoption, implementation, and use of agile in hardware development is the lack of understanding of agile among hardware development managers (Schmidt et al., 2019). This challenge is especially problematic at the managerial level, as managers are among the most influential stakeholders in the implementation and use of agile in manufacturing companies (Edwards et al., 2019). Despite the importance of this challenge, the literature provides little detail on managers' understanding of agile. Therefore, Paper II sought to explore the manager's level of understanding of agile, with the premise that the "right" understanding of the agile is dictated by the fundamental elements presented on the agile frameworks' guides. The study aimed to answer the following question: What are the similarities and differences between the fundamental elements of agile and the elements mentioned by managers in hardware development? The study limited the fundamental elements to those presented in the Scrum Guide (cf. Schwaber & Sutherland, 2020), by far the most employed agile framework in hardware

development (Schmidt et al., 2019) and the basis of Scrum@Scale LeSS (see subchapter 2.1).

### Findings

By comparing the fundamental elements of agile and those mentioned by managers, the findings in Paper II showed that managers in hardware development add, omit, and modify elements in their understanding of agile. They add elements such as the use of Steering Group meetings as a remnant of the control paradigm of the Stage-Gate model; they omit most of the fundamental elements related to *values* or the use of backlog; and they modify the team size and the forms that results can take after each sprint.

### Contribution to thesis

Paper II showed that the key roles' understanding of agile does not exactly reflect what is presented as agile in the literature. Key roles add, omit, or modify the fundamental elements of agile in their understanding of it. One interpretation of this finding is that the key roles' understanding of agile is adapted to the context of the organizational unit to which they belong.

## 4.3 Paper III

### Introduction

When launching large-scale agile transformation initiatives, companies face the challenges of implementing agile across organizational units with different competencies, contextual conditions, divergent goals, etc. The design, manufacturing, and delivery of physical products, which characterise the manufacturing industry, require highly specialized organizational units. Knowledge boundaries resulting from specialisation tend to impact the implementation of organizational initiatives. Nevertheless, their impact on the implementation of large-scale agile transformation initiatives has scarcely been addressed in previous studies on large-scale agile transformation in manufacturing companies. Therefore, the purpose of Paper III was to examine implications of knowledge boundaries between organizational units in the initial phase of the implementation of a large-scale agile transformation initiative in a manufacturing company.

### Findings

The findings presented in Paper III showed that key roles representing different organizational units (i.e., Production, R&D, IT) emphasize different agile components. *Events* seemed to predominate among key roles in Production, *events* and *artifacts* among key roles in R&D, and *values* and *teams* among key roles in IT.

### Contribution to thesis

The different emphases that key roles place on different agile components are aligned with the specificities of their epistemic community (experience, work practices, environmental constraints, etc.), resulting in knowledge boundaries that limit key roles' shared and comprehensive understanding of agile, and thus call for knowledge integration across boundaries (Carlile, 2004; Tell, 2016).

Knowledge integration points to two aspects that must be considered in the context of large-scale agile transformation initiatives, flexibility and dynamism. Inspired by the notions of acting and interacting, as proposed by Enberg (2007), a conceptual model that illustrates the need for flexibility and dynamism in the context of large-scale agile transformation initiatives is presented in Figure 7. The acting notion accounts for flexibility and refers to the individual work of organizational units. Here, organizational units have their own cycles to internalize the agile components; this includes using agile practices to understand the different agile components and how to apply them. Organizational units can use different agile components as starting point according to their experience, work practices, environmental constraints, etc. In addition to their internal cycles, organizational units must engage in a collective process. Thus, the interacting notion accounts for dynamism and refers to iterative and reinforcing cycles to build, articulate, and redefine shared knowledge about agile among organizational units. This notion encompasses the use of different integration mechanisms, such as joint evaluations of the agile transformation initiative, sharing accountability for the initiative, and mimicking behaviours.

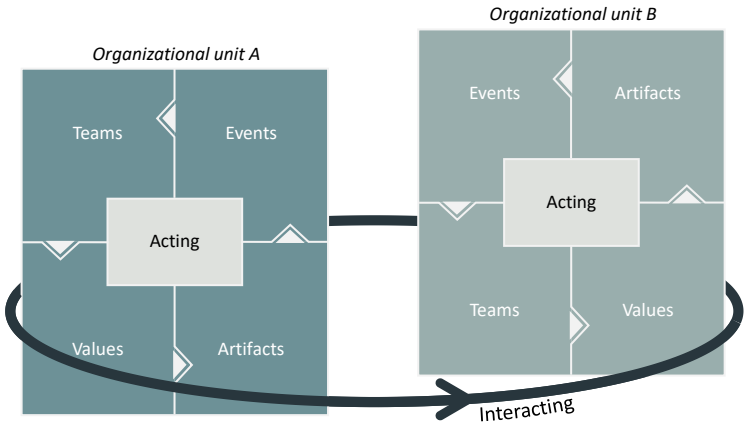


**Figure 7. A conceptual model illutrating flexibility and dynamism in the initial phase of implementation of a large-scale agile transformation (Paper III)**

## 4.4 Connection between papers and research purpose

Paper I showed initial indications that key roles' understanding of agile is related to the maturity working with agile and the organizational unit to which they belong. Paper II showed that key roles create their own understanding of agile by adding, omitting, and modifying fundamental elements of agile in such a way that it is adapted to their context. These modifications are reflected in Paper III, which elaborated on the contributions of Paper I by showing that key roles emphasize different agile components depending on the specificities of the epistemic communities presented in organizational units. By examining these findings through a knowledge-based view, Paper III discussed their implications for the implementation of large-scale agile transformation initiatives in manufacturing companies.

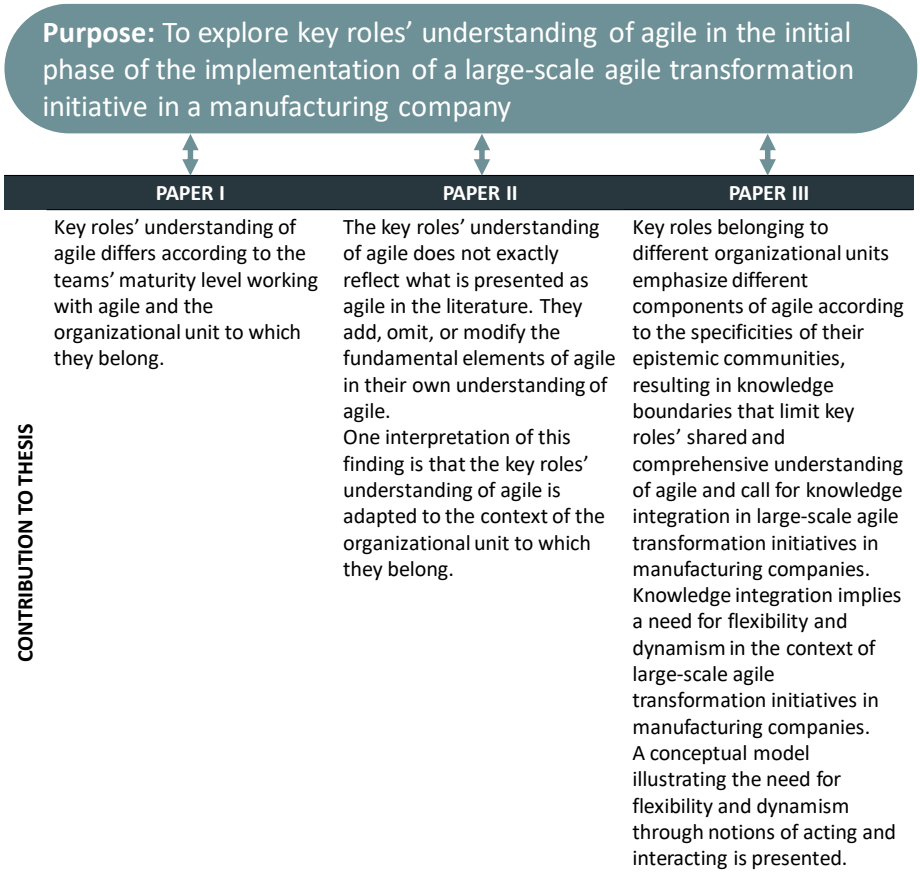


**Figure 8. Connection between papers and research purpose**

# 5 Discussion and conclusion

This chapter discusses the findings presented in this thesis. Moreover, it presents the thesis' conclusion, contributions to the literature and practice of large-scale agile in manufacturing companies, the limitations of this study, and future research avenues.

## 5.1 Discussion of findings

By exploring key roles' understanding of agile through a knowledge-based view, this study shows that, due to knowledge specialisation, shared knowledge frames in epistemic communities (composed of systems of meaning and thought worlds that encompass ways of working, experiences with frameworks and practices, educational backgrounds, use of terms and concepts, organizational goals, etc.) are bound to be reflected in the key roles' understanding of agile.

Shared knowledge frames in epistemic communities lead key roles to filter (i.e., add, omit, and modify) elements of agile in such a way that their understanding is adapted to their organizational units' context. The filtering of elements of agile is reflected in the different emphases that key roles place on different agile components, according to the specificities of their epistemic communities presented in the different organizational units.

Shared knowledge frames in epistemic communities result in knowledge boundaries that limit the key roles' shared and comprehensive understanding of agile. Moreover, as manufacturing companies are composed of several organizational units with their own epistemic communities, this results in challenges related to the understanding of agile within such an organization, which have been identified as critical challenges in the large-scale agile transformation literature (cf. Dikert et al., 2016; Schmidt et al., 2019).

These knowledge boundaries call for knowledge integration across boundaries, which implies flexibility and dynamism in the context of large-scale agile transformation initiatives (Carlile, 2004; Grant, 1996; Huang & Newell, 2003; Tell, 2016). The conceptual model presented in Paper III (see Figure 7) illustrates flexibility and dynamism through the notions of acting and interacting (cf. Enberg, 2007).

In accordance with previous studies that highlight the importance of self-organization for the success of large-scale agile transformation initiatives (cf. Dikert et al., 2016), the conceptual model illustrates that organizational units construct their own understanding by using different agile components as starting points according to their contextual conditions (acting notion). Nevertheless, as pointed out by Paasivaara et al. (2018), allowing self-organization without integration mechanisms, such as coaching and training, leads to a lack of common direction and a suboptimal large-scale agile transformation initiative. In line with latter study, the model illustrates a collective and integrative process of articulating and redefining a shared understanding of agile among the organizational units through integration mechanisms as a part of a large-scale agile transformation initiative (interacting notion).

As an alternative to the sequential models presented in the literature (cf. Denning, 2019; Paasivaara et al., 2018; Pawlak, 2021), the conceptual model illustrates an iterative and ad hoc implementation of a large-scale agile transformation initiative in a manufacturing company. Adapting large-scale agile transformation to the organizational context is critical for the success of these transformation initiatives (Denning, 2019; Drutchas & Eppinger, 2023; Hutter et al., 2023; Lindlöf & Furuhjelm, 2018; Pawlak, 2021; Sommer, 2019).

## 5.2 Conclusion

By exploring the key roles' understanding of agile in the initial phase of implementation of a large-scale agile transformation initiative, it is concluded that shared knowledge frames in epistemic communities are bound to be reflected in the key roles' understanding of agile. These shared knowledge frames lead key roles to filter (add, omit, and modify) elements of agile, which is mirrored on the different emphases that the place on agile components, and result in knowledge boundaries that limit key roles' shared and comprehensive understanding of agile.

Finally, knowledge boundaries call for flexibility and dynamism when implementing large-scale agile transformation initiatives in manufacturing companies. While flexibility shows that organizational units may have different starting points in the transformation initiative depending on their contexts, dynamism reflects the importance of a collective process to reach a shared and comprehensive understanding of agile among key roles in the organization.

## 5.3 Contributions to the literature and practice of large-scale agile transformation in manufacturing companies

The study provides further evidence to the existing literature that indicates the relevance of challenges related to the understanding of agile within an organization in large-scale agile transformation initiatives (cf. Dikert et al., 2016; Gregory et al., 2016; Schmidt et al., 2019). Moreover, this thesis contributes to the literature on large-scale agile transformation initiatives in manufacturing companies by exploring the key roles' understanding of agile through a knowledge-based view.

The conceptual model contributes to the literature by illustrating flexibility and dynamism in large-scale agile transformation initiatives in manufacturing companies. On the one hand, flexibility, illustrated in the acting notion of the model, shows an alternative and contrasting implementation path to the one presented in the literature that suggests establishing values and principles as a starting point to avoid a "shallow adoption" of agile (cf. Berger & Eklund, 2015; Gregory et al., 2016; Sommer, 2019). This flexibility shows that organizational units may use different agile components as starting points, according to their contextual conditions.

On the other hand, dynamism, illustrated in the interacting notion of the model, encompasses the use of different integration mechanisms. By bringing integration mechanisms to large-scale agile transformation initiatives, the model considers several mechanisms that can complement those presented in the literature on large-scale agile transformation in manufacturing companies, such as training courses, coaching, agile centres of competence and agile networks (cf. Conboy & Carroll, 2019; Dikert et al., 2016; Hutter et al., 2023; Paasivaara et al., 2018; Pawlak, 2021; Sommer, 2019). These integration mechanisms include, for instance, mimicking behaviours and practices used by other organizational units, using analogies to explain agile components and elements to different organizational units, and having a shared accountability for the large-scale agile transformation initiative.

In general the findings further supports literature that indicates that there is no 'textbook' implementation of large-scale agile transformation, but rather that it needs to be adapted to the context of each organization (cf. Drutchas & Eppinger, 2023; Eklund & Berger, 2017; Hutter et al., 2023; Lindlöf & Furuhjelm, 2018).

The study presented in this thesis also contributes to the practice of large-scale agile transformation initiatives in manufacturing companies. It suggests that knowledge boundaries may influence the initial phase of implementation of large-scale agile transformation initiatives in manufacturing companies. In practice, this means that key roles of these transformation initiatives should support organizational units to experience and internalize the different agile components according to their

contextual conditions, and that simultaneously they should also support actions for open and continuous communication between the parties involved, such as sharing narratives of the initiative, joint responsibility and constant evaluation of the initiative.

This study can serve as an inspiration for manufacturing companies considering the implementation of large-scale agile transformation initiatives (Drutchas & Eppinger, 2023; Edwards et al., 2019; Lindlöf & Furuhjelm, 2018; Sommer, 2019). The presented agile components (*values*, *teams*, *events* and *artifacts*) may serve as a guide for other manufacturing companies to explore the understanding of agile within their own large-scale agile transformation initiatives. The emphasis that Production, R&D, and IT had on different agile components might also appear in other manufacturing companies.

## 5.4 Limitations and future research

This study was focused on key roles in Production, R&D, and IT. Nevertheless, large-scale agile transformation is an organization-wide initiative, and epistemic communities are expected to be present in other organizational units as well. Therefore, further research could explore key roles' understanding of agile in other organizational units such as sales, marketing, and finance. Moreover, the present study focuses on key roles owing to their relevance in large-scale agile transformation initiatives. Since the explored key roles included managers, change leaders, and consultants, this study provides a strategic and tactical perspective on the transformation initiative. This perspective can be complemented with further research studies that explore other roles' understanding of agile, for example, developers, engineering designers, manufacturing engineers, sales representatives, etc., which can provide an operational perspective of transformation initiatives. Furthermore, this study was focused on the initial phase of the implementation of a large-scale agile transformation initiative because of its importance for its success. As longitudinal studies on large-scale agile transformation are scarce, another interesting study could explore how understanding of agile changes throughout the phases of a large-scale agile initiative and how it impacts the initiative. These further research studies would contribute to a more comprehensive exploration of the understanding of agile within an organization.

This study was specifically focused on challenges related to the understanding of agile within an organization. However, large-scale agile transformation initiatives present other critical challenges that deserve attention. Some of these critical challenges are related to the management of dependencies among teams, organizational units, or organizations. Efficient management of dependencies is essential for the on-time delivery of results, efficient resource allocation, etc.; thus,

it is critical for the success of large-scale agile transformation initiatives. Although these challenges might be exacerbated in manufacturing companies, as they deal with product complexity in terms of quantity and integration of parts and long development cycles, empirical research studies addressing these challenges in manufacturing companies are still scarce. Studies that explore, for instance, what dependencies exist in large-scale agile transformation, how to manage these dependencies or in which contexts the coordination mechanisms presented in agile frameworks are beneficial, can advance the literature and practice of large-scale agile transformation initiatives in manufacturing companies.

In general, research on large-scale agile transformation initiatives in manufacturing companies is welcome as it is still an incipient phenomenon. Therefore, empirical studies that confirm and extend existing findings based on companies with different endogenous and exogenous characteristics (e.g., size, product offering, implementation phase, previous experience with agile) or failure cases could contribute to the literature and practice of large-scale agile transformation initiatives in manufacturing companies.

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Silvia has a background in engineering management and innovation. Her research focuses on how manufacturing companies transform their organizational structures, people, technology, and processes to improve the efficiency and effectiveness of their product development systems. Her research includes cases of large-scale agile transformation initiatives in companies that design, manufacture and deliver complex products.

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