Social Aspects of Strategizing Industrial Digitalization

Linnéa Carlsson
Social Aspects of Strategizing Industrial Digitalization

Linnéa Carlsson
Man ska respektera bildning, men man ska inte låta sig skrämmas av den. Om du bara visste hur jävla dåligt många akademiker skriver.
Man ska respektera bildning,
men man ska inte låta sig skrämmas av den.
Om du bara visste hur jävla dåligt många akademiker skriver.

Therese Bohman
*Andromeda* 2023, s. 47
Acknowledgments

Somehow, writing this acknowledgment was one of the most difficult things. How does one begin? How do I acknowledge all and everyone who has inspired and challenged me throughout this one hell of a journey - the PhD journey.

To my supervisors Ulrika, Anna Karin, and Monika, a heartfelt thank you. Thank you for being so patient with me, for letting me run wild and then barricading my crusade when necessary. For encouragement and for demanding more.

To all informants who have contributed with their time, thoughts, and openness. A sincere thank you. This thesis would not have been possible without your contributions. For past Fikas and for future collaborations.

To my fellow PhD candidates, I made it! Thank you for all the time we spent together in seminars, and courses, drinking coffee, the much-needed talks, and supporting each other. For us and for finishing.

To my family and friends, I will never finish school. Thank you for picking me up and celebrating every step. For always being a text or phone call away.

I would have been so much poorer had I not met the Swedish National Unions of Students (SFS). My PhD journey has been so much more than this thesis, thanks to everyone at SFS. It has been shaped by everything I have been able to do and represent- by all the socks that have been danced off together with everyone engaged in SFS. Do I love you, indeed I do.

How do I acknowledge all and everyone who has inspired and challenged me throughout my PhD journey? It was a pain in the ass, but above all, it was marvelous.

Linnéa Carlsson

November 5th, 2023
Acknowledgments

Somehow, writing this acknowledgment was one of the most difficult things.

How does one begin? How do I acknowledge all and everyone who has inspired and challenged me throughout this one hell of a journey - the PhD journey.

To my supervisors Ulrika, Anna Karin, and Monika, a heartfelt thank you. Thank you for being so patient with me, for letting me run wild and then barricading my crusade when necessary. For encouragement and for demanding more.

To all informants who have contributed with their time, thoughts, and openness. A sincere thank you. This thesis would not have been possible without your contributions. For past Fikas and for future collaborations.

To my fellow PhD candidates, I made it! Thank you for all the time we spent together in seminars, courses, drinking coffee, the much-needed talks, and supporting each other. For us and for finishing.

To my family and friends, I will never finish school. Thank you for picking me up and celebrating every step. For always being a text or phone call away.

I would have been so much poorer had I not met the Swedish National Unions of Students (SFS). My PhD journey has been so much more than this thesis, thanks to everyone at SFS. It has been shaped by everything I have been able to do and represent - by all the socks that have been danced off together with everyone engaged in SFS. Do I love you, indeed I do.

How do I acknowledge all and everyone who has inspired and challenged me throughout my PhD journey? It was a pain in the ass, but above all, it was marvelous.

Linnéa Carlsson
November 5th, 2023
Abstract

**Title:** Social Aspects of Stratégizing Industrial Digitalization

**Keywords:** Industrial digitalization; Social aspects; Dynamic Capabilities; Organizational capabilities; Stratégizing; Texturizing; Industrial Work-Integrated Learning

**ISBN:** 978-91-89325-62-3 (Printed)

978-91-89325-61-6 (Electronic)

This thesis aims to contribute to understanding how contemporary Swedish manufacturing organizations can strategize industrial digitalization with an emerging focus on social aspects. It complements earlier research by highlighting Swedish manufacturing organizations as they stand at the intersection of Industry 4.0 and Industry 5.0.

The thesis is a longitudinal case study of interviews and focus groups between early 2019 and spring 2023. The case study follows an explorative approach to give texture to industrial digitalization and to understand the social aspects of strategizing industrial digitalization. It is limited to the Swedish context and the characteristics of original equipment manufacturers.

The thesis contributes by texturizing industrial digitalization through three social aspects, which are argued to be a way for manufacturing organizations to give shape to industrial digitalization. The social aspects elaborated on and presented in this thesis are: to look beyond digital technologies, to formalize a shared understanding, and to transcend organizational structures. These social aspects are thematic but also interlinked. Together, these social aspects bring insights into how managers can guide the organizational capabilities to ensure synergy between an organization’s actions and objectives when strategizing industrial digitalization. Strategizing industrial digitalization should, therefore, be texturized by each organization to define and redefine its organizational capabilities. This means each organization's social aspects are unique, making the manufacturing organizations' capabilities unique.
Abstract

Title: Social Aspects of Strategizing Industrial Digitalization

Keywords: Industrial digitalization; Social aspects; Dynamic Capabilities; Organizational capabilities; Strategizing; Texturizing; Industrial Work - Integrated Learning


This thesis aims to contribute to understanding how contemporary Swedish manufacturing organizations can strategize industrial digitalization with an emerging focus on social aspects. It complements earlier research by highlighting Swedish manufacturing organizations as they stand at the intersection of Industry 4.0 and Industry 5.0.

The thesis is a longitudinal case study of interviews and focus groups between early 2019 and spring 2023. The case study follows an explorative approach to give texture to industrial digitalization and to understand the social aspects of strategizing industrial digitalization. It is limited to the Swedish context and the characteristics of original equipment manufacturers.

The thesis contributes by texturizing industrial digitalization through three social aspects, which are argued to be a way for manufacturing organizations to give shape to industrial digitalization. The social aspects elaborated on and presented in this thesis are: to look beyond digital technologies, to formalize a shared understanding, and to transcend organizational structures. These social aspects are thematic but also interlinked. Together, these social aspects bring insights into how managers can guide the organizational capabilities to ensure synergy between an organization’s actions and objectives when strategizing industrial digitalization. Strategizing industrial digitalization should, therefore, be texturized by each organization to define and redefine its organizational capabilities. This means each organization’s social aspects are unique, making the manufacturing organizations’ capabilities unique.

Appended Papers


Additional papers related to this thesis were also written during my time as a PhD student. These papers are not appended but are listed as other selected papers. Such papers have built on my understanding of the empirical context, and extended abstracts have been the first step of a two-step publication process. These papers are listed below:


Other selected papers

Additional papers related to this thesis were also written during my time as a PhD-student. These papers are not appended but are listed as other selected papers. Such papers have built on my understanding of the empirical context, and extended abstracts have been the first step of a two-step publication process. These papers are listed below:


1 Introduction

1.1 Research aim and research question

1.2 Positioning of thesis

1.3 List of appended papers

1.4 Thesis structure

2 Research domain

2.1 Industrial digitalization over time

2.2 Strategizing Industrial digitalization

3 Theoretical framework

3.1 From the resource-based view to the Dynamic Capabilities

3.2 Dynamic Capabilities

4 Research approach

4.1 Case study methodology

4.2 Empirical context

4.3 Data generation

4.4 Overview of the case study process

4.5 Data analysis

4.6 Reflections on the Research Process and Ethical Considerations

5 Results

5.1 Paper 1

5.2 Paper 2
# Table of Contents

Acknowledgments .................................................................................................................. iv  
Populärvetenskaplig sammanfattning (in Swedish) .................................................. v  
Abstract ................................................................................................................................. vi  
Appended Papers .................................................................................................................... vii  
Other selected papers ........................................................................................................... ix  
Table of Contents .................................................................................................................. xi  

## 1  Introduction ................................................................................................................. 13  
1.1 Research aim and research question .......................................................... 16  
1.2 Positioning of thesis ............................................................................................... 16  
1.3 List of appended papers ......................................................................................... 17  
1.4 Thesis structure ......................................................................................................... 18  

## 2  Research domain ........................................................................................................ 19  
2.1 Industrial digitalization over time ........................................................................... 19  
2.2 Strategizing Industrial digitalization ......................................................................... 23  

## 3  Theoretical framework .............................................................................................. 27  
3.1 From the resource-based view to the Dynamic Capabilities .................................... 27  
3.2 Dynamic Capabilities ............................................................................................... 29  

## 4  Research approach ..................................................................................................... 35  
4.1 Case study methodology ........................................................................................... 35  
4.2 Empirical context ....................................................................................................... 37  
4.3 Data generation ........................................................................................................... 39  
4.4 Overview of the case study process ......................................................................... 45  
4.5 Data analysis .............................................................................................................. 49  
4.6 Reflections on the Research Process and Ethical Considerations ............................. 51  

## 5  Results .......................................................................................................................... 55  
Paper 1 ................................................................................................................................. 55  
Paper 2 ................................................................................................................................. 56
Introduction
Many contemporary Swedish manufacturing organizations struggle to strategize industrial digitalization as various influences on and within the organization affect them. Influences are the intentional or unintentional effects on one or multiple individual employees in the context of an organization that results in a specific outcome (Zulu et al., 2023). It refers to how the organization ‘feels’ and how employee interactions become through employees’ expectations and interpretations based on influences of industrial digitalization.

One of the most prominent influences affecting contemporary manufacturing organizations is the perspective that they should harness digital technologies to stay competitive in current and upcoming industrial settings (Zheng et al., 2020).

Manufacturing organizations are expected to benefit from the support of the introduction or implementation of digital technologies when, for example, moving from manual to digital production planning and control or data-driven production (Lasi et al., 2014; Osterrieder et al., 2020).

Earlier research shows that how managers communicate their understanding of digital technology through behavior substantially impacts how employees perceive and respond to activities of introducing or implementing digital technologies (Edmondson, 2003).

Many managers are currently focused on comprehending the challenges, opportunities, and ongoing impacts that industrial digitalization introduces and how it affects their organizations (Björkdahl, 2020).

Naturally, the breadth and depth of efforts to comprehend the influences of industrial digitalization vary substantially among manufacturing organizations.

Not only does the presumption of industrial digitalization have different prospects depending on what area within the industrial sector the organization is active in (Marcon et al., 2022), but the understanding might even differ within an organization depending on the knowledge, and identified effects, of specific digital technologies (Galliers, 2011; Hess et al., 2016).

Another aspect of the influence of industrial digitalization is that it has started to be recognized beyond its technical stance to more of a business case question (Zulu et al., 2023).

Industrial digitalization can be contextualized to every part and aspect of the organization: its formal and informal structures and the social aspects (Matt et al., 2023).

It is necessary to acknowledge where the expectations often related to the influences of industrial digitalization stem from.

Industrial digitalization is often
1 Introduction

Many contemporary Swedish manufacturing organizations struggle to strategize industrial digitalization as various influences on and within the organization affect them. Influences are the intentional or unintentional effects on one or multiple individual employees in the context of an organization that results in a specific outcome (Zulu et al., 2023). It refers to how the organization ‘feels’ and how employee interactions become through employees’ expectations and interpretations based on influences of industrial digitalization.

One of the most prominent influences affecting contemporary manufacturing organizations is the perspective that they should harness digital technologies to stay competitive in current and upcoming industrial settings (Zheng et al., 2020). Manufacturing organizations are expected to benefit from the support of the introduction or implementation of digital technologies when, for example, moving from manual to digital production planning and control or data-driven production (Lasi et al., 2014; Osterrieder et al., 2020).

Earlier research shows that how managers communicate their understanding of digital technology through behavior substantially impacts how employees perceive and respond to activities of introducing or implementing digital technologies (Edmondson, 2003). Many managers are currently focused on comprehending the challenges, opportunities, and ongoing impacts that industrial digitalization introduces and how it affects their organizations (Björkdahl, 2020). Naturally, the breadth and depth of efforts to comprehend the influences of industrial digitalization vary substantially among manufacturing organizations. Not only does the presumption of industrial digitalization have different prospects depending on what area within the industrial sector the organization is active in (Marcon et al., 2022), but the understanding might even differ within an organization depending on the knowledge, and identified effects, of specific digital technologies (Galliers, 2011; Hess et al., 2016).

Another aspect of the influence of industrial digitalization is that it has started to be recognized beyond its technical stance to more of a business case question (Zulu et al., 2023). Industrial digitalization can be contextualized to every part and aspect of the organization: its formal and informal structures and the social aspects (Matt et al., 2023).

It is necessary to acknowledge where the expectations often related to the influences of industrial digitalization stem from. Industrial digitalization is often
referred to as a contextual concept representing an era in manufacturing organizations with an increased focus on introducing and implementing digital technologies (Matt et al., 2023). Indeed, applying digital technology can increase output and quality, decrease variance, and minimize the number of breakdowns and stoppages by making the manufacturing process more intelligent. The positive effects digital technologies can bring to output and quality in manufacturing entail great opportunities, but this is also where two conflicting perspectives nascence.

Though all the positive effects of digital technologies potentially can bring to output and quality in production, digital technologies may also add complexity to an established manufacturing organization. Due to its historical precontext, an established manufacturing organization often has a disparate production process, a more complex production flow, older machinery, and much manual work (Eriksson and Hendberg, 2021). Some researchers point out that the most significant gains of introducing digital technologies toward production might be neutralized as considerable employee resistance commonly occurs (Margherita and Braccini, 2020; Nahavandi, 2019; Xu et al., 2021). Hence, manufacturing organizations might not be able to pursue organizational change but merely introduce digital technologies (Kim et al., 2021).

Arguably, the knowledge base and understanding of the need for digital technologies is continuously growing, but so is a contrasting or complementary perspective. More recently, it has been demonstrated that it is not the technology that represents an organization’s “secret formula” to benefit enhancement efforts made using digital technologies but unique organizational resources and processes (Savastano et al., 2022). An increased focus on social aspects of industrial digitalization has recently sprouted to complement or challenge the technology-driven understanding of the enhancement efforts made using digital technologies (Khan et al., 2023). This focus, often described as value-driven, has been introduced as human-centric (Nahavandi, 2019) and figures as part of the criticism of industrial digitalization being too technology-driven (Javaid and Haleem, 2020; Lu et al., 2022; Xu et al., 2021). Technology-driven, as in the focus has been solely on an assumption of expected benefits from implementing digital technologies without questioning if and why an organization should implement them.

Such assumptions raise the question of how it affects the organizational capability to strategize industrial digitalization. That is, what bundle of abilities, skills, and accumulated knowledge are needed in the organization to perform activities that could generate value (Mishra and Agarwal, 2010).
INTRODUCTION

Although industrial digitalization historically has been technology-driven, the organizational part of this story seems to have been more dependent on lower-level complexities. To this end, Steininger et al. (2022) propose that research should prioritize understanding lower-level phenomena of an organization’s capabilities. This approach aspires to clarify the intricate relationships between digital technologies and organizational capabilities and a more in-depth perspective on how strategizing industrial digitalization is achieved. The strategic enactment may differ depending on the social context in which activities are situated (Martinho et al., 2015; Peppard and Ward, 2016).

A challenge for contemporary manufacturing organizations is navigating the influences of digitalization within the organization. But also to recognize what influences an organization’s actions and objectives when strategizing industrial digitalization (Correani et al., 2020). It could be reasoned that a more nuanced perspective on what influences an organization's ability to strategize industrial digitalization is needed. If not purely technology-driven, then what?

What influences strategizing industrial digitalization in a manufacturing organization is most likely unique to each organization. Emphasizing the social aspects, individuals’ interpretations (regardless of function) will likely guide an organization’s beliefs of what challenges, opportunities, and effects industrial digitalization will bring about. In turn, Individual employees responsible for understanding the identified effects of specific digital technologies will most likely affect employees’ general beliefs about technologically driven change and thus affect organizational capabilities (Solberg et al., 2020). However, what capabilities contribute to an organization’s ability to move from abstract to concrete actions in strategizing industrial digitalization is most likely influenced by the same aspects, regardless of uniqueness. Understanding organizational capabilities as not being fixed but evolving and changing over time could make them hard to identify. In addition, they are also stated to be shaped and responsive to the dynamic environment (Teece, 2012), which makes them fluctuate depending on an organization’s changing environment.

A still target can be hard to interpret by the individual employee and the organization. But a moving target even more so. Texturizing is herein argued to be a way to dress up industrial digitalization. Not in a sense to present something in such a way to make it appear better than it is. Instead, it is the imaginative domain given something by individuals (Gherardi and Strati, 1990). However, to add to it in such a way that it has a shape. Giving something a shape also means adding a description to it. What characteristics, attributes, or properties does something hold? To texturize is to articulate and appropriate an understanding that can be formulated through interpreted influences of industrial digitalization.
1.1 Research aim and research question

This thesis aims to contribute to giving texture to industrial digitalization and to understand the social aspects of strategizing industrial digitalization in contemporary Swedish manufacturing organizations. Hence, the phenomenon in this thesis is not entity-based but rests on how managers and employees continuously understand and interpret how an organization strategizes industrial digitalization. This approach aspires to explore the intricate relationships between influences of industrial digitalization and organizational capabilities and a more in-depth perspective on how strategizing industrial digitalization is navigated. This thesis argues the need to discover a means of articulating what industrial digitalization entails and asks:

How can social aspects of strategizing industrial digitalization in contemporary Swedish manufacturing organizations be understood and texturized?

From this outlook, an organization's capabilities are the focal point. The five appended papers of this thesis all touch upon the research question but do not have the purpose of answering it all at once. However, they all contribute to texturizing how strategizing industrial digitalization in contemporary Swedish manufacturing organizations unfolds and how influences could be navigated.

1.2 Positioning of thesis

The thesis is written in Informatics with Specialization in Industrial Work-Integrated Learning (I-WIL). I-WIL frames digitalization in an industrial context, focusing on studying digitalization processes and knowledge development in industrial contexts (University West, 2023).

With the growing importance of digital technologies for manufacturing organizations, informatic scholars have focused their attention on the role of digital technologies concerning organizational capabilities (Balaji and Brown, 2005; Kindermann et al., 2022; Magalhães, 2006; Steininger et al., 2022).

This thesis is based on the premise that an organization's ability to leverage digital technologies is linked to the continued definition and redefinition of resources (D’aveni et al., 2010; Teece et al., 1997). Hence, an organization's resources are framed as organizational capabilities. Organizational capabilities, the focus in all appended papers, are understood as a complex bundle of abilities, skills, and accumulated knowledge that allows an organization to perform activities that could generate value (Mishra and Agarwal, 2010). Within informatics research, various streams of capabilities have been linked, e.g., digital capabilities (Sandberg,
In this thesis, organizational capabilities are understood as a complex bundle of abilities, skills, and accumulated knowledge that allows an organization to perform activities that could generate value (Mishra and Agarwal, 2010). Here, related to industrial digitalization, organizational capabilities are needed to create value from digital technologies, such as collective behavior issues, organizational identity, culture, or context (Magalhães, 2006). Hence, digital technologies both enable organizational capabilities and require them (Savastano et al., 2022).

### 1.3 List of appended papers

The five appended papers in this thesis represent the results of this thesis and formulate the foundation of the discussion. I used the appended papers to texturize how the influences of industrial digitalization in contemporary Swedish manufacturing organizations can be understood and how it affects an organization’s capability to strategize. The five appended papers are:

1.4 Thesis structure

The thesis is divided into six chapters, excluding the introduction: Research domain, Theoretical framework, Research Approach, Results, Discussion, and Conclusion. Each chapter starts with a lighter synopsis of the chapter's main point, followed by the content.

If you have gotten this far, you have already ticked off chapter one.

The Research domain presents the background and related research, which goes through what Industrial digitalization entails and how it is understood in this thesis. In addition, related perspectives of Industry 4.0 and the emerging Industry 5.0 are presented, along with the human-centric perspective.

The Theoretical framework outlines the capability informed outlook that has been dominant in the appended papers as well as in this thesis. The dynamic capabilities framework is presented as it describes the adoption of resources for a changing environment. Herein understood as the influences of industrial digitalization.

The Research approach gives an overview of the distinct methodological stages of the thesis project. The thesis project has been framed as a longitudinal case study with an explorative approach based on two Swedish manufacturing organizations.

The Discussion focuses on three outlined social aspects argued pivotal for ensuring that strategic enactment is shifted from expectations of ‘what might be’ to a texturized foundation of strategizing industrial digitalization.

Finally, the Conclusion answers the stipulated research question, presents insights for practitioners, sets directions for future research, and acknowledges this thesis's limitations.
2 Research domain

Industrial digitalization represents an era in the industrial sector with an increased focus on introducing and using digital technologies. It is essential to clarify the retrospectives of industrial digitalization (Industry 4.0) and the influences guiding its evolution (Industry 5.0). The chapter also includes a section on strategizing industrial digitalization, i.e., the dynamic organizational process of acknowledging potential tension between exploiting existing plans, ideas, and resources while exploring new and emerging means to achieve organizational objectives through activities.

2.1 Industrial digitalization over time

To more accurately present the enhancements efforts made in the industrial sector, a variety of terms and concepts have come to specify it: these are, for example, “Industrial Digitalization” and, as mentioned: “Industry 4.0” and “The fourth industrial revolution”. Launberg (2017) describes how the writings are inconclusive, and closely related wordings or descriptions are often used. The mentioned terms and concepts are sometimes used interchangeably as a clear distinction is lacking (Osterrieder et al., 2020; Vial, 2019). For this reason, industrial digitalization is portrayed in this thesis to reflect the enhancement efforts made using digital technologies in manufacturing organizations toward production.

2.1.1 Industry 4.0

Industry 4.0 was first noted as the German government formulated “Industrie 4.0” in 2011, inspiring efforts in several other countries to improve the prospects for the national manufacturing industry (Klitou et al., 2017). The German strategy also named the broad research stream of Industry 4.0, which mainly focuses on automating production processes and introducing cutting-edge computing in a distributed and intelligent manner (Lasi et al., 2014). “Industry 4.0” often reflects the enhancement efforts made using digital technologies and “the fourth industrial revolution” to visualize the enhancement efforts from a historical perspective.

The fourth industrial revolution marks the fourth step in the evolutionary outlook of how the industrial sector has evolved with technologies. The first industrial revolution was marked by mechanization and steam power, the second by
electricity and mass production, and the third by computer and automation (Lasi et al., 2014). The evolution of the industrial sector has, as can be seen, evolved along with societal changes, and perhaps only in the third and fourth revolutions can we begin to question whether a change has occurred throughout the industrial sector (Bassi, 2017). That is, if some organizations remain in “past revolutions” and still thrive across technological discontinuities (Eiggers and Park, 2018).

In Sweden, the government established a new industrialization strategy called Smart Industry in 2016 (Näringsdepartementet, 2016, 2017). Two of the focuses in the Smart Industry were Industry 4.0, which aimed to seize the potential of digitalization, and sustainable production, which intended to strengthen the capability of sustainable and resource-efficient production. Hence, the vision of the Smart Industry strategy is to strengthen the conditions for facing the challenges of the manufacturing industry and the requirements of being more sustainable (Näringsdepartementet, 2015). While at the same time having a prosperous production utilizing the possibilities of digital technologies to become a smart factory.

The Swedish strategy acknowledges industrial digitalization’s benefits as an ongoing transformation process that changes the industrial sector and the manufacturing organization. Moreover, the Smart Industry accounts for both ecological and social sustainability. As such, the Swedish parole was argued to look beyond efficiency and connected production and aimed at fostering a viable long-term industry sector (Näringsdepartementet, 2016, 2017). Among the benefits identified is leveraging data-driven processes for organizational efficiency and responsiveness.

In policy research, the relationship between digitalization and policy implementation, like the Swedish Smart Industry, has often been seen in two contrasting ways: one where it is regarded as a vague concept open to various interpretations, and the other where it is considered a myth or a product of professional imagination (Heidlund and Gidlund, 2023; Sandberg, 2014).

### 2.1.1.1 Digital technologies in industrial digitalization

Research in the field of IS has a rich history of exploring the interplay between technology and organizational change, primarily influenced by the adoption and integration of digital technologies within organizations (Adomavicius et al., 2008).

Leveraging possibilities of Industry 4.0 is often related to combining Cyber-Physical Systems, Artificial Intelligence, machine learning, and other digital technologies that transform manufacturing organizations’ physical systems into intelligent manufacturing systems (Zheng et al., 2020). Such technologies comprise smart machines, storage systems, and production facilities capable of
autonomously exchanging information, triggering actions, and controlling each other independently. A common focus of organizations that use such technologies has been optimizing production processes or functional units to enhance a specific machine capacity with sensor-based technology through the Internet of Things (IoT) and data analytics applications (Lokuge et al., 2019). Instead of looking into how and what type of data will be helpful in beneficial decision-making, the focus is on increasing productivity when developing AI-based solutions that will enhance the numerical solution and ease massive data generation.

In light of this, digital technologies have been dominantly understood as hardware and software clusters designed to inform, automate, coordinate, and control the realization of particular organizational objectives.

This thesis argues that industrial digitalization is to be viewed as social: if digital technologies are developed by people, and people are social, digital technologies are social (Lee Kleinman, 2007). Skog (2019) argues that organizational change is, indeed, driven by digital technologies but, even more so, motivated by identifying clear opportunities and/or challenges. Often, digital technologies refer to introducing new ones and transforming existing ones, making it challenging to define the needed organizational capabilities and how to adjust them dynamically. It is not raising the issue of why digital technologies should be introduced or implemented or what interpretations have affected one’s perception.

### 2.1.2 Industry 5.0

In the last years, Industry 5.0 (I5.0) has arisen, emphasizing a threefold focus on sustainability, human-centric, and resilience (Breque et al., 2021). The sustainability part focuses on implementing and leveraging digital technologies' economic, social, and planetary bounds (Longo and Padovano, 2020; Nahavandi, 2019). Resilience is about being flexible and agile using digital technologies, and Human centricity refers to the diversity and engagement of all employees within a manufacturing organization (Adel, 2022).

Notably, the emerging I5.0 originates from a European policy initiative (Breque et al., 2021) described as more value-driven, focusing on softer, intangible values that historically have been hard to measure (Lu et al., 2022). The most significant advance of I5.0 is described as the desired interplay between humans and technology. Within this, social aspects are vital as employees are described as central to technological adoption (Davies et al., 2017). That is, the commonalities among individual employees, such as the organization’s features and/or attributes (Marcon et al., 2022).
Scholars have pointed out that this value-driven perspective stems from criticism of I4.0 being too technocratic (Javaid and Haleem, 2020; Nahavandi, 2019; Xu et al., 2021). But this type of criticism can also be found in other formulations that do not necessarily link to the focus of Industry 5.0 (See for example, Isensee et al., 2020; Marcon et al., 2022). For instance, I4.0 does not cover all aspects of how increased implementation and usage of digital technologies influence all parts of the manufacturing organization (Eriksson et al., 2023). The value-driven understanding of I5.0 acknowledges some of the fears of manufacturing organizations and scholars about technological advancement (Enang et al., 2023; Khan et al., 2023). For example, a vision often described as doable with the use of computer-controlled technology and cyber-machinery is the removal of operators in the production process. Which, in turn, would put many operators out of jobs. On the other hand, a broad research stream within I4.0 recognizes human activities and when humans may be more able to do less strenuous work while machines, or robots, could handle more strenuous tasks (Romero et al., 2016; Romero and Stahre, 2021).

I5.0, and mainly its focus on a human-centric perspective, has had much influence on scholars, but what a human-centric perspective entails is still novel and needs further exploration.

2.1.2.1 A Human-centric perspective

Discussing a human-centric perspective often accounts for how the research community focuses on the workforce – or at least the human: the alliance between technology and humans in production (Lu et al., 2022).

Rosenbrock (1990) describes that humans should never be subservient to machines or automation but should serve humans. It accounts for how to keep the individual executing an operation in the center while planning for introducing or developing digital technologies. Given this, accounts of how to keep human-centric when designing for more efficient production processes have been historically dominant since they involve leveraging digital technologies in what can be described as a co-evolution to humans (Adel, 2022). Examples of this, or prior research, are ergonomics (Zheng et al., 2020), Operator 4.0 (Romero et al., 2016), and human-robot collaboration (Jwo et al., 2021), currently being framed as a human-centric perspective. The outcome of keeping a human-centric research focus is not, per se, unwanted (Lu et al., 2022). It suggests that employees’ everyday work could be more accessible, have fewer heavier lifts, etc. It often stems from a sustainability outlook of making the workplace and work more attractive and safe. As such, a part of I5.0 is also to make production processes more available and accessible.
Reflecting on this, the socio-technical viewpoint has long been one of the driving understandings of introducing and implementing technologies and digital technologies within the field of IS. The interrelatedness of social and technical aspects sees the organization as a combination of the two. It could be argued that the socio-technical understanding could be a way to understand the desires of I5.0 (Enang et al., 2023). Human interaction, critical thinking, and interpretation are described in I5.0 as vital, and wordings such as empowerment emphasize the employee's role (Gfrerer et al., 2021). In a socio-technical understanding, the organization's behavior pattern is determined by how well the two aspects fit. The human-centric perspective emphasizes the need to acknowledge the human holistically to reach the sought efficiency of digital technologies. For instance, look beyond merely strenuous work.

If a human-centric perspective entails designing for more efficient production processes, it does not necessarily account for the influences of technical stance on a business case question (Turk, 2022). The point is that the idea of a human-centric perspective involves, but is not necessarily limited to, placing the well-being of the industry worker at the center of a production process.

This thesis takes a stance with this historical and contextual understanding of Industrial digitalization when aiming to understand and texturize industrial digitalization in contemporary manufacturing organizations.

2.2 Strategizing Industrial digitalization

Strategizing is a dynamic organizational process of acknowledging potential tension between exploiting existing plans, ideas, and resources while exploring new and emerging means to achieve organizational objectives through activities (Marabelli and Galliers, 2017). To emphasize the enactment of strategy, Galliers (2011, p. 337) describes strategizing as:

The process of strategizing is one of visioning, planning, taking action, and assessing outcomes, all with an eye to changing circumstance and imperatives, and the actions of individuals and groups outside of, or irrespective of, any formal strategy process.

It should be noted that this view of strategy enactment can be criticized for conceptualizing the organization as an actor of its own (Peppard and Ward, 2016). It is as if the organization was to absorb the action and assessment of outcomes. Notably, strategizing as a dynamic organizational process, organizations are not viewed as objects but as a social arena for employees (of all functions) to discuss shared meanings and metaphors (Cunliffe, 2008).
Herein, the term *employee* is applied in a general sense to describe all co-workers of the organization, and the organization is viewed as a backdrop and the stage at which employees strategize through identified activities (Whittington, 2003).

In this context, strategizing encompasses an organization's social dimension, including employees' expectations, how the organization "feels," and how employees interact (Martinho et al., 2015). It is based on commonalities among individual employees within an organization.

Strategizing is a most articulated process, emphasizing individual employees to become more active participants in determining the organizational purpose. Something that Spreitzer (1995) describes as "taking initiatives," "embracing risk," "stimulating innovation," and "coping with high uncertainty.". For instance, employees' beliefs about tangible and intangible resources in the context of industrial digitalization may vary. In turn, it could create different mindsets within the organization (Björkdahl, 2020). Solberg (2020) stresses that a shared mindset can be necessary to align employees’ actions with organizational objectives in strategic enactment.

Notably, gaining the ability to strategize is not only a continuous process but also a social accomplishment, as pointed out by Orlikowski (2002, p. 249):

> Knowing is not a static embedded capability or stable disposition of actors, but rather an ongoing social accomplishment, constituted and reconstituted as actors engage the world in practice.

With this understanding, regardless of function, the employee is responsible for interpreting industrial digitalization, as all employees can initiate activities for strategizing industrial digitalization. However, scholars acknowledge that not everyone is comfortable participating nor thinks of themselves as knowledgeable enough to contribute meaningfully to strategizing (Kilhammar and Ellström, 2015). It has been recognized that individuals can learn how to jointly strategize by recognizing the shared understanding (Volberda et al., 2021). For instance, the shared meaning of what industrial digitalization entails.

Creating a shared meaning often entails a broad type of participation among employees. As such, it is reasonable to note that employees' high level of participation will not automatically create a sense of shared understanding towards a desired mean (Adobor, 2019). Engaging employees to be part of the organizational process presupposes that employees are both willing and capable of making significant contributions. Something that could risk employees being left alone with interpreting the means of industrial digitalization without being comfortable doing so.
Managers have been recognized as the driving force of strategy enactment (Charias and Hess, 2016; Kane et al., 2016). However, it is also recognized that managers struggle to perceive what strategizing industrial digitalization could or should entail (Khan, 2016; Sainger, 2018). Activities toward interpreting influences of industrial digitalization are argued to emphasize increased variability and diversity of topics covered, constructs used, and relationships between them (Tekic and Koroteev, 2019). For managers, this potentially means high uncertainty in activities with strategic implications, sometimes preventing the successful identification of opportunities, analysis of strategic options, and evaluation of challenges (Meyer, 2019). It is argued that uncertainty arises when a manager tries to handle the endless stream of competing and conflicting information and actions.

Considering the above, strategizing industrial digitalization is a dynamic process that can differ depending on the social context in which identified activities are situated. It is a continuous process of interpretation to exploit existing organizational capabilities and explore new ones. Arguably, gaining the ability to strategize in line with desired outputs is a continuous process as industrial digitalization is recognized to be elusive and continuously evolving.
3.1 From the resource-based view to the Dynamic Capabilities

As digital technologies are increasingly linked to strategizing (Peppard and Ward, 2016), understanding the relationship between the presumed and needed adoption of resources is a growing concern (Cordes-Berszinn, 2013). According to the resource-based view of dynamic capabilities, the focus is on adaptation since they “… extend, modify or create ordinary capabilities” (Winter, 2003, p. 991) in an environment with a need to adapt to an elusive and fast-changing environment, such as industrial digitalization. The dynamic capabilities are primarily assessed by their contribution to resource(s) bedding for interpreted competitive advantage and, hence, the interchangeableness of new resources.

3.1.1 The resource-based view

The resource-based view focuses primarily on using existing resources (Demeter et al., 2021). For instance, digital technologies are typically implemented to improve organizational objectives. Some argue that in order to have such an impact, the organization could consider defining or redefining organizational resources (Parviainen et al., 2017). That is, tangible assets, such as machinery, and intangible assets, such as competencies, skills, and accumulated knowledge (Helfat et al., 2007).

The resource-based view of strategy enactment sought to explain intra-organizational activities. The reason for this was the gap acknowledged between theory and field observations (Teece, 1982; Wernerfelt, 1984). Many organizations within the same sector following similar routes of strategy enactment had very different outputs. This pointed to the need to understand intangible resources (broadly defined) as not static. The reasoning that resources are not fixed but may evolve and change over time could make them hard to identify. But it has also brought forward criticism.
3 Theoretical framework

This chapter describes the road from the resource-based view to Dynamic Capabilities. This is followed by an overview of the Dynamic Capabilities Framework and its components. The chapter ends with an overview of the interpretational components of Dynamic Capabilities.

3.1 From the resource-based view to the Dynamic Capabilities

As digital technologies are increasingly linked to strategizing (Peppard and Ward, 2016), understanding the relationship between the presumed and needed adoption of resources is a growing concern (Cordes-Berszinn, 2013). According to the resource-based view of dynamic capabilities, the focus is on adaption since they “… extend, modify or create ordinary capabilities” (Winter, 2003, p. 991) in an environment with a need to adapt to an elusive and fast-changing environment, such as industrial digitalization. The dynamic capabilities are primarily assessed by their contribution to resource(s) bedding for interpreted competitive advantage and, hence, the interchangeableness of new resources.

3.1.1 The resource-based view

The resource-based view focuses primarily on using existing resources (Demeter et al., 2021). For instance, digital technologies are typically implemented to improve organizational objectives. Some argue that in order to have such an impact, the organization could consider defining or redefining organizational resources (Parviainen et al., 2017). That is, tangible assets, such as machinery, and intangible assets, such as competencies, skills, and accumulated knowledge (Helfat et al., 2007).

The resource-based view of strategy enactment sought to explain intra organizational activities. The reason for this was the gap acknowledged between theory and field observations (Teece, 1982; Wernerfelt, 1984). Many organizations within the same sector following similar routes of strategy enactment had very different outputs. This pointed to the need to understand intangible resources (broadly defined) as not static.

The reasoning that resources are not fixed but may evolve and change over time could make them hard to identify. But it has also brought forward criticism.
A core argument of criticism toward the resource-based view is that the high level of abstraction in describing assets inhibits any practical examination (Peteraf et al., 2013). The point is that the connection between a resource-based view and a broader concept of strategy enactment and gaining a competitive advantage in a more generalized manner is overly restrictive (Winter, 2003). That is, what can an organization rely on in a dynamic process of strategizing? Assets are always argued to be the tipping point toward a wanted or unwanted outcome, and some scholars have argued that there is “no general rule for riches” (Winter, 2003, p. 994).

Reflecting on this, a study by Tavares Sousa-Zomer et al. (2020) suggests that responding to industrial digitalization depends on a holistic combination of intangible assets, such as an appropriate culture. In this context, the cultural values of the manufacturing organization, which is often characterized by a hierarchy and a philosophy of preventing errors, collide and shift over time. Jackson (2011) emphasized that information systems research often views culture as well-integrated rather than pluralistic or ambiguous. The social aspects that affect the organizational capabilities could thus be challenging to give room for or value since they can be hard to measure. However, the high-level abstraction viewed as criticism in the resource-based view is argued to be what allows for exploring the contradictions of what an organization has always done in response to dynamic shifts.

In response to this gap, a framework was outlined, generally referred to as “dynamic capabilities” for understanding needed capabilities defined or redefined in the resource base responding to the dynamics and elusiveness of an environment (Teece et al., 1997; Teece and Pisano, 1994). Herein referred to as organizational capabilities.

Organizational capabilities were argued to be understood as incomplete, incoherent, and somewhat opaque (Teece, 1997). In this thesis, the notion of diverseness in organizational capabilities is substantial and provides flexibility to the level of analysis. This argument is an understanding of capabilities to be constantly defined and redefined, as resources are incomplete. Opportunities for selection, variation, and retention of organizational capabilities are not one-time events but continuous activities to remain competitive. In addition, they are also stated to be influenced and responsive to the dynamic environment (Teece, 2012), which makes capabilities fluctuate to an organization’s changing environment, i.e., capabilities are dynamic.

When discussing dynamic capabilities, it is emphasized that there is a hierarchy of capabilities in how they affect one another (Sandberg, 2014). Collis (1994) states that dynamic capabilities govern ordinary capabilities’ rate of change. This would suggest that some capabilities are more prone to affect the ability to change, while
other capabilities are formulated for the sole purpose of change. As such, capabilities, regardless of function, would depend on the context in which they are formulated and used (Cordes-Berszinn, 2013; Winter, 2003). Such as the influences provoking the formulation.

In line with this, Adderio (2001) noted the importance of cross-functionality and recognized that organizations would have to integrate knowledge and capabilities across organizational boundaries. In this thesis, the notion of diverseness in organizational capabilities is thus also affected by formal and informal coordination. The primary way to address gaps and connect diverse functions, knowledge sources, and both old and new technologies is through established formal and informal coordination methods within routines of strategic enactment.

### 3.2 Dynamic Capabilities

Teece (1997) initiated the dynamic capability framework and has since been addressed by many other scholars (See, for instance: Schilke et al., 2018; Vogel and Güttel, 2013; Yeow et al., 2018). The extent to which an organization can transform existing organizational capabilities according to the changing environment depends on the ability to sense and shape potential opportunities, followed by seizing and eventually transforming potential opportunities (Kindermann et al., 2022). This view has, for instance, been examined in the longitudinal case study by Yeow et al. (2018), and by Eisenhardt and Martin (2000), who focused on framing what dynamic capabilities could be.

The foundation of dynamic capabilities is that success depends on defining and redefining organizational capabilities to reconfigure or configure an organization's resource base to a changing environment. The organizational capability to do so frames the dynamic in dynamic capabilities (Cordes-Berszinn, 2013). Overcoming inertia or stagnation in posed changes, such as industrial digitalization, is argued to require dynamic capabilities.

Although the Dynamic capabilities framework originates from the 90s', scholars still search for consensus (Pisano, 2017). Dynamic capabilities began as an approach to understanding strategic change (Helfat and Peteraf, 2009; Teece, 2007). There are significantly different interpretations of what constitutes a changing environment and the interplay of dynamic capabilities to a competitive advantage (Demeter et al., 2021). Teece (2007) introduces a rougher understanding of dynamic capabilities, focused on an organization’s capabilities to sense, seize, and transform according to the elusive environment. These three components provide roughness through an umbrella framework highlighting the most critical capabilities organizations need to reach desired objectives.
3.2.1 Components of Dynamic Capability

The dynamic capabilities of an organization could be disaggregated into *sensing, seizing, and transforming*.

Sensing capabilities can be understood as “Analytical systems (and individual capacities) to learn and to sense, filter, shape, and calibrate opportunities” (Teece 2007, p. 1342). Further, Teece (2007, p. 1322) claims that “sensing (and shaping) new opportunities [and threats] is very much a scanning, creation, learning, and interpretative activity.” Warner and Wäger (2019) argue that these processes analyze diverse information, and therefore, sensing should occur at all organizational levels. Digital technologies enable structural transformation and are becoming an expected part of products and services, creating new business models (Sebastian et al., 2017). Digital technologies can fundamentally reshape traditional business strategies by creating modular, distributed, and cross-functional processes that enable work to be done non-linearly (Bharadwaj et al., 2013; Peppard and Ward, 2016). Yoo et al. (2010) argue that digital technologies have exceeded all expectations and generated products and services even the original innovator could exceed. This implies that sensing capabilities could be an endeavor as it challenges tangible and intangible assets.

Recent research describes this shift from functional organizational silos to collaborative, co-creative work and cross-functional expertise and knowledge as a paradigm shift (Pfaff et al., 2023). However, the functional organizational silos could also be argued to be part of the formal coordination of an organization. With this in mind, it is reasonable to reflect on whether sensing capabilities could filter the organization’s ability to navigate formal and informational coordination and internal processes. As Collis (1994) points out, acknowledging the formulation of intangible assets on various levels implies that organizations also consider the necessary levels to develop capabilities.

Seizing capabilities are described as “Enterprise structures, procedures, designs and incentives for seizing opportunities” (Teece 2007, p. 1342). They allow an organization to mobilize to address and utilize identified opportunities. As such, Seizing is to address opportunities or neutralize threats. Larger, static organizations are argued to require seizing capabilities to ensure managers avoid hubris, deception, bias, and delusion (Warner and Wäger, 2019), which could affect an organization’s movements. It has been argued that it is essential that the reconciled means of industrial digitalization is supported by managers who, in turn, foster a culture of: "coherent, and comprehensive presence of values and norms that promote the implementation and use of digital technologies and data." (Björkdahl, 2020, p. 32). To endeavor seizing is an act of strategy construct, and Teece (2014) argues that it is connected to both a guiding policy and coherent
action. Seizing would then be the critical capacity for aligning as it implies organizations act upon identified opportunities. Seizing moves an organization beyond the act of understanding (sensing) and focuses on deciding what changes are to be made to capture identified opportunities. Digitalization has encouraged manufacturing organizations to seize opportunities in the digital era (Collin et al., 2015; Fitzgerald et al., 2013). In the industrial sector, the perspectives of digitalization have come to be about enabling, improving, and transforming operations, functions, models, processes, or activities by leveraging digital technologies (Gürdür et al., 2019). However, Teece (2007) points out that all organizations can sense an opportunity, yet not all can seize the opportunity.

The transforming capability refers to “Continuous alignment and realignment of specific tangible and intangible assets” based on governance, knowledge management, decentralization, and co-specialization (Teece 2007, p.1342). Whereas sensing and seizing capabilities help an organization to create and discover new opportunities, transforming capabilities underpin the realization of potential strategic change (Warner and Wäger, 2019). As Warner and Wäger (2019) point out, transformation is more challenging because the changing environment remains uncertain, with low or no identified required competencies. Despite this, the transforming capability is essential to align as it reconfigures the existing structure and helps formulate strategic implications (Helfat et al., 2007). For example, many incumbent firms craft digital strategies that leverage digital technologies and existing structures but lack the necessary competencies and technologies (Warner and Wäger, 2019).

When referring to dynamic capabilities in a strategic approach, Teece (2014) argues that it is crucial for managers to delineate strategic considerations and priorities to enhance organizational performance. With a high level of uncertainty, strategic enactment is argued to include the art of imagining a future and endeavoring to build it (Teece and Leih, 2016). As such, sensing becomes vital for diagnosis and essential to strategizing (Teece, 2007). But this perspective also reflects a macro-level analysis emphasizing the crucial role of dynamic capabilities in strategic management (Teece et al., 1997).

In contrast, a micro-level analysis focuses on people and materials when discussing an organization’s resource base (Helfat et al., 2007; Helfat and Peteraf, 2003). Most contemporary manufacturing organizations experience some impact of digital technologies on established ways of organizing. Generally, these technologies send a ripple effect throughout the organization and affect a large set of employees, functions, and multi-layered platforms of hardware, software, and data (Peppard and Ward, 2016). Teece (2007) acknowledges this roughness by expanding the understanding of dynamic capabilities based on micro-foundations (distinct skills, processes, procedures, organizational structures,
decision rules, and disciplines). Hence, micro-foundations are a base for the further development of perspectives within the organizational capability outlook.

3.2.1.1 **Interpretational components of dynamic capabilities**

In information systems research, dynamic capabilities are often linked to technological, organizational, and managerial routines (Steininger et al., 2022) to describe mediations of organizations’ resource bases. However, voices are raised arguing that the focus on technology-informed capabilities and the intra-organizational process is too big, thus lacking the perspective of how social aspects influence the outcome of transformative initiatives (Poláková-Kersten et al., 2023).

Lin et al. (2016) present a decade-long interpretation effort of the originally blurred components, which seem to have arrived at a common pattern. The summary interpretation underscores the significance of considering external and internal perspectives, emphasizing the varying capabilities required at different stages in the strategic enactment process. It is suggested that such capabilities may be characteristic of employees but should also be embedded, maintained, and updated in the organization’s processes (Demeter et al., 2021; Lin et al., 2016).

Although the core of dynamic capabilities is the resource-based view, Lin et al., (2016) argue that most of the different interpretations of what constitutes the interplay of dynamic capabilities relative to the internal and external environment are related to interpretational acts. Interpretation occurs in different stages, in which the individual is exposed to different information and experiences (Edwards, 2002). To exemplify this understanding, sensing capability is a cognitive or mental process through which organizations perceive environmental changes and how to implement them (Wang and Ahmed, 2007; Wu et al., 2012).

Other scholars point toward the same need for interpretational components. For instance, Iyengar et al. (2015) argue that dynamic capabilities should be nurtured through organizational actions that promote learning within the organization rather than assuming that dynamic capabilities evolve by no means of interference or actions. Although both tangible and intangible assets are recognized within the framework, this highlights the need for understanding the context and how it influences capabilities. On the same note, de Vasconcellos et al. (2021) suggest that the transforming capability depends on managing relationships within an organization. However, this takes the individual employee outside the familiar meaning system, and the individual can find herself in situations where familiar ways of interpreting and acting are unreliable (Björkdahl, 2020; Solberg et al., 2020).
3.2.1.1 Interpretational components of dynamic capabilities

In information systems research, dynamic capabilities are often linked to technological, organizational, and managerial routines (Steininger et al., 2022) to describe mediations of organizations' resource bases. However, voices are raised arguing that the focus on technology-informed capabilities and the intra-organizational process is too big, thus lacking the perspective of how social aspects influence the outcome of transformative initiatives (Poláková-Kersten et al., 2023). Lin et al. (2016) present a decade-long interpretation effort of the originally blurred components, which seem to have arrived at a common pattern. The summary interpretation underscores the significance of considering external and internal perspectives, emphasizing the varying capabilities required at different stages in the strategic enactment process. It is suggested that such capabilities may be characteristic of employees but should also be embedded, maintained, and updated in the organization’s processes (Demeter et al., 2021; Lin et al., 2016).

Although the core of dynamic capabilities is the resource-based view, Lin et al., (2016) argue that most of the different interpretations of what constitutes the interplay of dynamic capabilities relative to the internal and external environment are related to interpretational acts. Interpretation occurs in different stages, in which the individual is exposed to different information and experiences (Edwards, 2002). To exemplify this understanding, sensing capability is a cognitive or mental process through which organizations perceive environmental changes and how to implement them (Wang and Ahmed, 2007; Wu et al., 2012). Other scholars point toward the same need for interpretational components. For instance, Iyengar et al. (2015) argue that dynamic capabilities should be nurtured through organizational actions that promote learning within the organization rather than assuming that dynamic capabilities evolve by no means of interference or actions. Although both tangible and intangible assets are recognized within the framework, this highlights the need for understanding the context and how it influences capabilities. On the same note, de Vasconcellos et al. (2021) suggest that the transforming capability depends on managing relationships within an organization. However, this takes the individual employee outside the familiar meaning system, and the individual can find herself in situations where familiar ways of interpreting and acting are unreliable (Björkdahl, 2020; Solberg et al., 2020).
Research approach

This chapter presents the longitudinal case study of two Swedish manufacturing organizations. This presentation consists of the case study methodology, the empirical context, an overview of data generation, an overview of the case study process, an overview of data analysis, and ends with a reflection on the research process and ethical considerations.

The five appended papers represent partial results of the case study, which is to be summarized as a whole in this thesis.

4.1 Case study methodology

The case study formulated in this thesis was longitudinal, stretching from 2019-2023. The purpose of formulating a case study is to provide a detailed yet holistic portrait of a phenomenon (Walsham, 1995). Using a case study involves examining a current phenomenon in its real-world context, mainly when it is challenging to distinguish between the phenomenon and its surroundings (Yin, 2018).

It formulates a basis for capturing a phenomenon's complexity, meaning, and perceptions in a real-life context (Goldkuhl, 2019). Herein, this was the act of capturing the elusiveness of industrial digitalization and giving it texture. To give texture is described by Gerardi and Strati (1990) as creating a sense of togetherness and ownership, mutual understanding, and misunderstanding of organizational life. If something is texturized, it is related to an understanding. A part of the elusiveness could be argued as stripped off.

In this thesis, texturizing was a way to describe and convey my understanding of informants' interpretation of the influences of industrial digitalization. This means that when it comes to texturizing industrial digitalization, it depends on the influences interpreted to affect the organizational capabilities. If the influences were to shift, so would the interpretation. The texture is based on what expectations or interpretations informants assign to it. To texturize is thus to give specifics of industrial digitalization. Much like the structures of threads, fibers, etc., give texture to a fabric.

To be able to texturize how industrial digitalization in contemporary manufacturing organizations might look like, the case study was explorative (Yin, 2018). Meaning that it changed direction and focus because of new data and insights. For instance, I have let the data and the empirical field guide me jointly.
4 Research approach

This chapter presents the longitudinal case study of two Swedish manufacturing organizations. This presentation consists of the case study methodology, the empirical context, an overview of data generation, an overview of the case study process, an overview of data analysis, and ends with a reflection on the research process and ethical considerations.

The five appended papers represent partial results of the case study, which is to be summarized as a whole in this thesis.

4.1 Case study methodology

The case study formulated in this thesis was longitudinal, stretching from 2019-2023. The purpose of formulating a case study is to provide a detailed yet holistic portrait of a phenomenon (Walsham, 1995). Using a case study involves examining a current phenomenon in its real-world context, mainly when it is challenging to distinguish between the phenomenon and its surroundings (Yin, 2018). It formulates a basis for capturing a phenomenon’s complexity, meaning, and perceptions in a real-life context (Goldkuhl, 2019). Herein, this was the act of capturing the elusiveness of industrial digitalization and giving it texture. To give texture is described by Gerardi and Strati (1990) as creating a sense of togetherness and ownership, mutual understanding, and misunderstanding of organizational life. If something is texturized, it is related to an understanding. A part of the elusiveness could be argued as stripped off.

In this thesis, texturizing was a way to describe and convey my understanding of informants’ interpretation of the influences of industrial digitalization. This means that when it comes to texturizing industrial digitalization, it depends on the influences interpreted to affect the organizational capabilities. If the influences were to shift, so would the interpretation. The texture is based on what expectations or interpretations informants assign to it. To texturize is thus to give specifics of industrial digitalization. Much like the structures of threads, fibers, etc., give texture to a fabric.

To be able to texturize how industrial digitalization in contemporary manufacturing organizations might look like, the case study was explorative (Yin, 2018). Meaning that it changed direction and focus because of new data and insights. For instance, I have let the data and the empirical field guide me jointly
with an openness towards various frameworks. Hence, the case study was explorative in the means of keeping an open mind towards data, methods, and theories. For instance, in paper 2, the Co-workership wheel (Andersson et al., 2020) influenced my thinking. In paper 4, it was technological frames (Orlikowski and Gash, 1994), and in papers 1, 3, and 5, it was dynamic capabilities.

The exploration was an abductive engagement with the data and theoretical reasoning (Alvesson and Sköldberg, 2008). The abduction aided in interchangeably developing, verifying, and understanding events seen in the data.

In qualitative research, research questions, methods, and theories influence one another, meaning the research process is rarely linear (Gilje and Grimen, 2007). It highlights the dynamic relationship between empirical data derived from “real-world issues”, obtained through inductive reasoning and the theoretical insights drawn deductively by examining the data from a theoretical standpoint (Braun and Clarke, 2013).

Criticism against using case studies mainly points toward the researcher's subjectivity in choosing a certain case (Flyvbjerg, 2006). For instance, what prior knowledge will she bring into the case study that could affect the exploration? For this reason, it is often argued that a case study can never fully represent a phenomenon, and one should be careful to conclude unless other indications point in the same direction (Flyvbjerg, 2001). The main point is that a case study would give too much scope for the researchers' interpretation. However, subjectivism is not exclusive to the case study methodology. As Flyvbjerg (2006, s. 235) argues:

> The element of arbitrary subjectivism will be significant in the choice of categories and variables for a quantitative or structural investigation, such as a structured questionnaire to be used across a large sample of cases.

In light of this, the exploratory nature of a case study gives rise to both freedom of excursion and the need for the researcher to be meticulous in her process (Malterud, 2016). One way to be meticulous is to plan and prepare. This thesis project formulated a data management plan, conducted a risk analysis, and planned room for fluctuance by formulating a longitudinal case study. As a note, in Dynamic capabilities theory-related literature, there is a consensus that “to study change, one needs longitudinal data” (Laaksonen and Peltoniemi, 2018, p. 187). In terms of being meticulous, it implies that one needs to prepare enough time and resources to be able to follow the intended phenomenon.

Another way to approach the criticism is to view subjectivity as inevitable. Understanding the case study approach implies that the researcher is to engage in
any necessary "getting-your-hands-dirty" type of empirical work (Gioia et al., 2013). It implies that the researcher is to interpret what is at hand and what makes up the context. I believe that the interpretation of "getting your hands dirty" varies among researchers, and their levels of experience often influence this divergence. In this thesis, “Getting your hands dirty” was the work of constantly having a dialogue with the respondent organizations. Necessarily not formally, as in requesting interviews. Instead, relationship-building activities include participating in joint meetings, emailing, or calling about worldly things. It was a tedious trust-building exercise. It also fed into my subjectivity as every interaction mentioned shaped and re-shaped, my understanding of the empirical context.

A vital objective for the trust-building exercises is the ability to generate data within the case study. A part of this is also how the generation or collection of data is viewed. While harvest-ready data exists, data generated from interviews is not easily collected but generated by the researcher. The point made by Goldkuhl (2019), which also resonates with this thesis project, is the emphasis that qualitative data results from researchers actively creating situations and performing activities that generate data. For instance, through trust-building exercises. This understanding of data generation is not another phrasing of saying that data is fabricated but brings awareness to the researcher entering an empirical context (Stenbacka, 2001). She arranges situations, such as interviews, to produce data indicating a studied phenomenon as authentic as possible within the empirical context.

4.2 Empirical context

When it comes to selecting the case and, through this, the empirical context, it becomes essential to distinguish what makes up the context. In this case study, the prior knowledge of the organizations was essential to initiate contact and not act naïve towards the organizational efforts of opening up and continuing to engage (Robinson, 2014). This is because the context also frames what is at the focal point for my interpretation.

In this thesis, the focal point for analysis is not entity-based. It rests on how managers and employees continuously understand and interpret how an organization pursues industrial digitalization. Thus, the empirical context is the organization. Focusing on how managers and employees continuously understand and interpret industrial digitalization, then also draw attention to how digital technologies are introduced and implemented throughout the organizational structure. That is the broader social and institutional context (Tilson et al., 2010).

The data for the case study comes from two manufacturing organizations where industrial digitalization is a key subject. Both manufacturing organizations, Alfa
and Beta (pseudonyms), were selected based on expectations about the information content (Goldkuhl, 2019). Employees at various functions discuss a) what it is and b) how it concerns them. The two manufacturing organizations are similar in that they are global international industries, so-called original equipment manufacturers (OEMs) with production, business sales, and services in a local and global chain of production plants. Hence, they both deal with the question of strategizing industrial digitalization beyond a singular organization, i.e., various plants. Further, the two organizations are organized in a traditional and functional structure, operating at a centralized headquarters supported by decentralized business functions. The specifics of the organizational context are discussed in each appended paper.

Below is an elaboration of the two manufacturing organizations that figured as respondent organizational in this case study.

### 4.2.1 The manufacturing organization Alfa

The manufacturing organization Alfa manufactures gas turbines for industrial turbomachinery. The organization operates in the Swedish energy sector with two plants, employing roughly 2500 individuals in Sweden.

In this case study, the two Swedish plants have partaken. The two plants are geographically separated, located circa 300 km apart. The centralized plant, located in the southeast, consists of two main units focusing on either manufacturing or service. The manufacturing unit produces large-sized and heavy gas turbines and the needed high-quality components. The service unit performs maintenance of said gas turbines and their components.

The manufacturing unit consists of a geographically separated production flow. One of the production units, which mostly performs manual operations, welding, and machining and has a low automation grade (one robot) compared to the centralized plant, is located in southwest Sweden. This unit is herein referred to as local Alfa.

The centralized plant is also the Swedish headquarters, housing support functions such as IT, Economics, and HR. From the centralized plant, communications and coordination with global offices take place. Hence, being the leading distributor and formulator of policies and guidelines.

Local Alfa was the entry point for data generation. Local Alfa allowed me to immerse myself in the organization while remaining distant. Later in the research process, organizational contacts invited me to Alfa (southeast) and thus opened
up the whole Swedish organization to me. In this light, Alfa has been the primary field access in this case study, included in Papers 1-5.

4.2.2 The manufacturing organization Beta

Beta is a manufacturing organization that produces and develops engine parts for the aerospace sector. The Swedish organization operates in a local and global production chain and employs around 2000 individuals.

In this case study, the local plant in southwest Sweden has partaken. The plant has two branches, both focusing on engines. One focuses on airplane engines, and the other on space engines. In this case study, the airplane branch has been the contact point.

The local plant is the engine headquarters, and houses support functions such as IT, Economics, and HR. But also a research department. From the centralized plant, communications and coordination with global offices take place. Hence, being the primary distributor and formulator of policies and guidelines. Consequently, policy and routine coordination span across different geographic locations originating from Sweden.

Beta was, together with Alfa, the entry point for data generation. However, in 2020, the COVID-19 pandemic started affecting societal habits, and most manufacturing organizations closed to outside visitors. My access to Beta became limited as the organization was heavily affected by close-down and temporary lay-offs. In addition, informants from Beta could not participate in digital interviews due to internal data security restrictions. As such, Beta is only included in paper 1 since the contact was heavily restricted. Despite this, the contact with Beta remained throughout the thesis project.

4.3 Data generation

Data generation consisted of the generation of primary data to be analyzed. But it was also about generating data that helped me understand the organization. For example, I never practiced on-site observing for long periods but visited various parts of the organization. I had close and regular contacts and participated in meetings but never had a “standing invitation” on agendas. This section will go through these two parts of the data generation, starting with primary data generation.
4.3.1 Generation of primary data

Since a case study aims to describe and illustrate an instance of a phenomenon, it often includes interviews and occasionally focus group studies (Goldkuhl, 2019). This is also true for the case study in this thesis. Primary data generation consists of introductory interviews, two rounds of interviews, follow-up interviews, and two rounds of focus groups, see Table 1.

Table 1: Overview of primary data generated in the case study.

<table>
<thead>
<tr>
<th>Type of activity</th>
<th>Type of informants</th>
<th>No. of informants</th>
<th>Total hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductory interviews (Spring 2019)</td>
<td>Eight managers from Alfa and Beta</td>
<td>8</td>
<td>~8 hours</td>
</tr>
<tr>
<td>Interviews Alfa and Local Alfa (February 2020 – December 2020)</td>
<td>Management team members</td>
<td>11</td>
<td>~10 hours</td>
</tr>
<tr>
<td>Interviews Alfa and Local Alfa (January 2021 – March 2022)</td>
<td>Production managers</td>
<td>11</td>
<td>~7 hours</td>
</tr>
<tr>
<td>Focus groups local Alfa (April 2022)</td>
<td>Five Shop floor team leaders; four Shop floor operators</td>
<td>9</td>
<td>~3 hours</td>
</tr>
<tr>
<td>Focus groups local Alfa (September 2022-January 2023)</td>
<td>Six support functions; four site management team members; six technicians</td>
<td>16</td>
<td>~5 hours</td>
</tr>
<tr>
<td>Follow-up interviews Alfa (February 2023-May 2023)</td>
<td>Production managers</td>
<td>6</td>
<td>~6 hours</td>
</tr>
</tbody>
</table>

The primary data listed in Table 1 is the data generated in the case study with the intention of analyzing it. Within the thesis project, 36 interviews with 34 informants were conducted, lasting between 45 and 90 minutes (see Table 1). Rather than continuing to set up interviews, it seemed necessary to unfold the history of the local Alfa production site to reach lower-level intricates. Unfolding drama with characters, events, and storylines to describe the imaginative domain belonging to employees (Gherardi and Strati, 1990). As such, five workshops, with 25 informants, were held covering five functions within the local Alfa site (See Table 1). In total, 45 unique informants participated in this case study.

The following sections will go through how interviews and focus groups were conducted.


**RESEARCH APPROACH**

### 4.3.1.1 Interviews

The overall purpose of the interviews conducted within this thesis project was a) to capture informants' interpretation and understanding of industrial digitalization and b) how strategizing industrial digitalization could look like. Using interviews as a tool for data generation was deemed flexible and adjustable, as the research approach was an exploration and iteration of findings (Lee and Baskerville, 2003; Robinson, 2014). At the same time, interviews provided in-depth and detailed information about the informants' interpretation and understanding of industrial digitalization in various settings studied throughout the case.

Informants was approached by email. The email contained information about the thesis project, themes to be touched upon in our interview, what it means to be an informant (Vetenskapsrådet, 2022), and finally, what time would suit them best for me to visit them. In 2019, interviews took place at the informants' workplace. Interviews were set in, for the informant, a familiar place. The intention was to create a situation close to an ordinary practice and a safe conversation space.

When the COVID-19 pandemic eventually affected social interactions, interviews needed to be held digitally using Microsoft Teams. The platform was chosen based on the organization's needed security credentials. The benefit of conducting interviews digitally was the flexibility of time. Digital interviews were experienced effectively by informants as they could log in and connect to the interview in a fast-paced manner (Thunberg and Arnell, 2022). The risks with digital interviews was deemed equal to having them face-to-face. For instance, the risk of informants answering to please or even according to what is deemed socially acceptable is argued to remain when interviews are held digitally (Thunberg and Arnell, 2022). Similarly, the disadvantage of interviewing non-relevant informants is not a question of medium but of sampling (Noy, 2008).

The digital interviews opened possibilities. First, the format allowed for automatic audio and video recording. Since the recordings were made in Microsoft Teams, it also allowed the informant access to the recorded material. Second, it eased the relationship with Alfa, who is roughly 300km away. Digital interviews allow flexibility in this sense, but given the distance, it is plausible that time and money was saved on traveling.

### 4.3.1.2 Focus groups

To enrich the understanding of how strategizing industrial digitalization unfolds, I explored how organizational history potentially affects the possibility of implementing digital technology (Eriksson et al., 2024). Notably, using focus groups in information systems research is not novel (Belanger, 2012; Nili et al., 2017), nor in combination with interviews. In this case study, focus groups enabled managers and employees to reflect on activities and events throughout a
set period identified through the interviews. Focus groups followed up on the informants' interpretation and understanding of industrial digitalization and how strategizing industrial digitalization could look like.

The focus groups were designed to engage informants in a discussion of reflective understanding of how the informants view industrial digitalization and how it impacts strategizing aspects on various levels within the organization. Each focus group lasted about 1.5 hours, and the generated material consisted of audio and video recordings and scribbled paper. Focus groups were run in a workshop format and had two parts.

During the 1.5-2-hour focus group sessions, participants were placed in a half circle around a table, see Figure 1. The focus group leader (Me, except for one workshop) circled the table and moderated the workshop to limit the risk of single participants dominating the discussions. The other researchers focused on notetaking and video and audio recording, occasionally asking follow-up questions.

First, individuals collectively pinned down activities they interpreted as related to industrial digitalization. To do so, informants were asked to consider what activities or events, directly or indirectly, affected the organizations' ability to operationalize industrial digitalization since 2015. The reason for choosing 2015 was based on the previous managerial interviews, in which local Alfa indicated several digital initiatives, development projects, and organizational changes took place no earlier than 2015. This exercise was done collectively on a long paper on a conference table. See Figure 1. The choice of a historical perspective in these focus groups allowed informants to collaborate and, through dialogue, reflect on past events (Mauthner and Doucet, 2003). The group collaborated to complete

Figure 1. Overview of focus group set-up (Carlsson, in press).
the task, stimulating the development of dialogue within the groups (Säfsten and Gustavsson, 2019).

Secondly, informants were asked to overview the pinned-down activities or events and discuss how they considered initiatives and prospects for each activity in four rounds, marking their positive interpretations with a plus sign (+) or negative interpretations with a minus sign (−), see Figure 2. Different colors (blue, black, green, and red) were used for each conceptual pair of the co-workership wheel (Andersson et al., 2020), which inspired the second part of the workshop.

Figure 2. Overview of the second part of the focus groups – Group exercise (Eriksson et al., 2024)

The focus groups became a social interaction where informants were encouraged by the researchers but also encouraged each other to express more nuanced opinions (Goldkuhl, 2019). An example of this is the response given by informants after closing the formal part of the workshops, and Fika was served. Here, informants described how they had enjoyed being surprised by seeing how much the organization had done:

I have not worked here for such a long time, so I can now see why some of my suggestions are being shot down.
(Technical manager, focus group four)

Because of this, the focus groups formed an event for knowledge sharing within each group (Säfsten and Gustavsson, 2019).

As with everything, there are disadvantages. With the focus groups, it was sometimes hard to guide the conversations without interrupting or abrupting the informal tone. For example, some informants would get stuck on getting the exact dates for the events and activities that occurred. Admirable, but also breaking the flow for the others in the group.

4.3.2 Understanding the context

As mentioned earlier, the primary data generation was continuously followed by activities that allowed for a deeper understanding of the context (Klein and Myers, 1999). Understanding the context was vital to getting a grip on sayings and slurs
that figured in interviews and focus groups. It also established an understanding of the organizational historical context and everyday practice.

To do so, I took part off various documented contents (see Table 2), and not documented.

Table 2: Overview of documented secondary data.

<table>
<thead>
<tr>
<th>Type of secondary data</th>
<th>Type of information</th>
<th>Total amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meetings with and about respondent organizations (April 2019-October 2022)</td>
<td>Touchdowns and discussions of the road ahead (colleagues from University West and informants from respondent organizations).</td>
<td>2-10 participants</td>
</tr>
<tr>
<td>Learning seminars (April 2023)</td>
<td>Support functions</td>
<td>3 participants</td>
</tr>
<tr>
<td>PowerPoint (&quot;digitalization project&quot;)</td>
<td>Overview of the digitalization project</td>
<td>1 PowerPoint</td>
</tr>
<tr>
<td>Internal documents</td>
<td>Alfa Vision and Policy documents</td>
<td>7 documents</td>
</tr>
<tr>
<td>Informing interview (September 2021)</td>
<td>Drawing and walkthrough of Alfa organizational structure</td>
<td>2 informants</td>
</tr>
<tr>
<td>Project meetings: The digitalization project</td>
<td>Production manager AM, German support function</td>
<td>2 participants</td>
</tr>
</tbody>
</table>

Documented secondary data was material I could store locally on my computer. For example, informing interviews held via Microsoft Teams such that I could record and take screenshots to store overviews of organizational charts. Meeting notes from meetings with and about respondent organizations and learning seminars to return for information without formally analyzing it. But also internal documents and printed materials such as the Alfa Corporate magazine, which is distributed twice a year and covers articles, internal news, and “hot topics” regarding automation, the sector, and the organization.

Material that benefited my understanding but was not recorded or stored in terms of formal notes was all the informal meetings I had with the organizations. During the years of the case study, I had close contact with Alfa, the AM team at Alfa, and local Alfa. Close contact can, of course, be subjective. In this case study, it meant periods of weekly meetings, periods of monthly meetings, informal email contact, and occasional Teams calls to sort out one’s mind. Notes were taken not for field-note purposes but as general notes to keep the memory up to speed.

A part of understanding the organization was also reporting findings to the organizations. These occasions became a tandem situation where I could further
problematize, and the respondent organizations could respond to and validate findings. One could say that I tested the plausibility of what I had encountered.

### 4.4 Overview of the case study process

The case study spans from early 2019 to spring 2023. This section overviews the case study process based on data access, data generation, and paper development, visualized in Figure 3.

<table>
<thead>
<tr>
<th>Paper</th>
<th>Data</th>
<th>Org.</th>
<th>Research question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10 interviews, managers</td>
<td>Local Alfa, Beta</td>
<td>What are managers' perceptions of industrial digitalization related to organizational capabilities for strategy formulation?</td>
</tr>
</tbody>
</table>
| 2     | 35 interviews, employees | Alfa | (i) How can challenges of industrial digitalization be understood through the perspectives of employees?  
(ii) What are the implications of employees' perspectives when organizations are navigating the depicted challenges of industrial digitalization? |
| 3     | 17 Interviews, employees | Local Alfa | How can the dynamic capability framework be applied to understand the transformative requirements for implementation of digital tools in production planning? |
| 4     | 14 Interviews, managers | Alfa | How may strategizing organizational capabilities for industrial digitalization be understood through managers' perceptions of digital technology applications? |
| 5     | 9 Interviews, managers; 5 Focus groups, employees | Local Alfa | How can the transforming capability be understood through micro-foundations in the context of industrial digitalization? |

In the first paper (Table 3), I discussed the engagement and the continuous negotiation managers seemed to have while simultaneously desperately seeking a way to strategize industrial digitalization. I asked managers how they had worked with digital technologies and what industrial digitalization meant to them. Given that it was the initial stage of the longitudinal case study (see Figure 3), the goal was to explore managers’ perceptions of industrial digitalization related to organizational capabilities for strategy formulation. Thus, I conducted in-depth
interviews to establish an understanding of the informant’s perception of industrial digitalization. Perception as in beliefs and experience. What formulated the way industrial digitalization was regarded?

Although the manager seemed to desperately seek an understanding of industrial digitalization, I also wondered how industrial digitalization was conveyed and managed throughout formal and informal organizational processes. In my first round of interviews, I became interested in how the organization navigated the challenges. I thought it mattered how individuals within an organization spoke about the phenomena. I argued that acquiring data from a broader focus would allow me to unveil essential social aspects relative to organizational capability.

In paper two (Table 3), I opened up to discuss not only the managers but the individual in terms of the employees. Throughout the case study, the term employees indicated when all individuals within an organization, regardless of function, were referred to. Paper 2 displays that the seeking orientation managers displayed could potentially depend on who is taking responsibility for industrial digitalization within the organization. How is industrial digitalization being interpreted, and who is (allowed) doing the interpretation? When I processed the question of who is taking responsibility for industrial digitalization, I also encountered employees saying that they needed to implement or introduce digital technologies to prosper.

During interviews, informants from Alfa and local Alfa mentioned several initiatives for introducing or implementing digital technologies. By the time the first interview round was done, some of the initiatives mentioned by informants in the earliest interviews should have been implemented or evaluated. In meetings with the respondent organizations, I discussed this with colleagues who also had noticed something similar in their interviews guided toward production. We contemplated how initiatives can be formulated repeatedly without reaching a state of change. That is, what happens with initiatives when dropped?

In paper three (Table 3), a more validating example of how employees’ previous experiences and anticipation of digital technologies matter was formulated. Paper three tells the story of how local Alfa aspires to implement digital tools for production planning and control but does not reach this aspiration. We encountered that local Alfa did not prioritize to reflect upon whether they should digitalize or not.

As mentioned above, encounters drove the explorative approach of this case study process. These encounters were made possible through the relationship I gradually built with the two organizations, particularly Alfa and local Ala. For example, my contacts at local Alfa suggested that their colleagues at Alfa welcome
me. Likewise, in 2022, a smaller Alfa Additive manufacturing (AM) project focusing on the "digitalization project" (Pseudonym) with an Alfa employee from Germany reached out, see Figure 3.

In paper four (Table 3), I discussed in several "digitalization project" meetings what organizational capabilities Alfa experiences to have. In meetings, my contacts from Alfa showed interest in how the dynamic capabilities framework could be used to understand what capabilities they needed to succeed with the "digitalization project". It was an effort to guide the conversation away from this ordered work without challenging the relationship with Alfa. But it also sparked a question of how much emotions are tied to such processes. The fourth paper brought attention to the disparate view on strategizing organizational capabilities. The paper focused on an organization's ability to create a shared understanding of why the organization needs to implement digital technologies and the internal structures that allow sharing such means.

In paper five (Table 3), I put words to what I had learned in the previous four papers through a mixed data set of interviews and focus groups made at local Alfa. The initial contradictions in anticipation of digital technologies and output are linked to how informants understand industrial digitalization. It is necessarily not limited to the level of individuals or a specific function within an organization, but rather the historical and cultural context.

In summary, the red thread that goes through all five appended papers is that they offer understanding and insight into the dynamic process of strategizing industrial digitalization. The papers touch upon various social aspects: they describe both managers’ and employees’ perspectives and the change within the organization, and what is experienced to cause a ripple effect on development and behavior within the organization. It is these social aspects that the appended papers put to words as an effort to give texture to industrial digitalization. Texture, as in how it is dressed up, by the meaning added to it, who is giving it meaning, and what influences are linked to it.

I learned two lessons from my case study process. First, it is essential to conduct research together with organizations that intend to give time for individuals to participate as informants on transparent premises. That is, not on the premises of what I, as a researcher, might want to hear. Second, while outcomes cannot be controlled when generating data, my role as a researcher has the potential to create a space for discussions in the organization that potentially otherwise would not occur.
Data analysis

Previously mentioned data analyzed in the appended papers have primarily been inspired by theoretical thematic analysis or a mind-mapping approach. Before I outline my approach to interpreting the data, I will clarify the role of the theoretical framework of organizational capabilities as a red thread throughout the appended papers that allowed me to be creative with what I experienced and interpreted through the case study (Holmström and Truex, 2011). On the note of interpretation, my iterative and recurring familiarization with the data during coding, organizing, and writing has been part of my interpretation process. Hence, my analytical interest led my process.

The initial theoretical understanding of organizational capabilities guided the emerging process, and other frameworks were subsequently applied to build on the exploration of what influences organizational capabilities (Walsham, 1995). The approach of other frameworks, e.g., Co-workership (Andersson et al., 2020) Paper 2), and Technological frames (Orlikowski and Gash, 1994) Paper 4), allowed me to analyze the data with openness and to revise the assumption rather than being held back by theoretical assumptions (Holmström and Truex, 2011; Walsham, 1995). That said, analyzing data that is rich, varied, and complex is not an easy task. To phrase Langley (1999, p. 691):

"To process data is messy. Making sense of them is a constant challenge."

Nonetheless, analyzing qualitative data is dynamic and sometimes intuitive (Baxter and Jack, 2008). What is essential is that the method of analysis fits the purpose of the study and answers the research question (Braun and Clarke, 2013).

The following section presents the two analytical approaches used in the appended paper:

4.5.1 Thematic analysis

Thematic analysis (TA) is an analytical approach used for identifying, organizing, and offering insight into patterns of meaning across a data set (Braun and Clarke, 2006, 2022). When focusing on meaning, one can see and make sense of collective or shared meanings and experiences. The thematic analysis is an iterative and reflexive process: the researcher becomes familiar with data materials, creates codes for notable activities, searches for similarities to form themes, checks themes, and then decides upon them (Braun and Clarke, 2019), see Figure 4.

The framing of themes in TA is based on exploration rather than extracting the content of the data as if the truth is hidden within (Braun et al., 2019; Braun and
4.5 Data analysis

Previously mentioned data analyzed in the appended papers have primarily been inspired by theoretical thematic analysis or a mind-mapping approach. Before I outline my approach to interpreting the data, I will clarify the role of the theoretical framework of organizational capabilities as a red thread throughout the appended papers that allowed me to be creative with what I experienced and interpreted through the case study (Holmström and Truex, 2011). On the note of interpretation, my iterative and recurring familiarization with the data during coding, organizing, and writing has been part of my interpretation process. Hence, my analytical interest led my process.

The initial theoretical understanding of organizational capabilities guided the emerging process, and other frameworks were subsequently applied to build on the exploration of what influences organizational capabilities (Walsham, 1995). The approach of other frameworks, e.g., Co-workership ((Andersson et al., 2020) Paper 2), and Technological frames ((Orlikowski and Gash, 1994) Paper 4), allowed me to analyze the data with openness and to revise the assumption rather than being held back by theoretical assumptions (Holmström and Truex, 2011; Walsham, 1995). That said, analyzing data that is rich, varied, and complex is not an easy task. To phrase Langley (1999, p. 691):

[To] process data is messy. Making sense of them is a constant challenge.

Nonetheless, analyzing qualitative data is dynamic and sometimes intuitive (Baxter and Jack, 2008). What is essential is that the method of analysis fits the purpose of the study and answers the research question (Braun and Clarke, 2013).

The following section presents the two analytical approaches used in the appended paper:

4.5.1 Thematic analysis

Thematic analysis (TA) is an analytical approach used for identifying, organizing, and offering insight into patterns of meaning across a data set (Braun and Clarke, 2006, 2022). When focusing on meaning, one can see and make sense of collective or shared meanings and experiences. The thematic analysis is an iterative and reflexive process: the researcher becomes familiar with data materials, creates codes for notable activities, searches for similarities to form themes, checks themes, and then decides upon them (Braun and Clarke, 2019), see Figure 4. The framing of themes in TA is based on exploration rather than extracting the content of the data as if the truth is hidden within (Braun et al., 2019; Braun and
Clarke, 2006). For this reason, TA seems to be favored as users interpret it as oriented toward induction and deep analysis (Humble and Mozelius, 2022).

Reflexive TA, applied in this thesis, can be described as iterative. First, themes were identified without predetermined frameworks (Säfsten and Gustavsson, 2019). This allowed for creativity with the data, focusing on reflexive practice in the analytical process. Then, identified themes were reviewed through a potential theoretical framework to texturize an understanding of studied phenomena, see Figure 4. As such, TA allowed the use of theoretical frameworks as part of the iterative analysis process and as part of the final product of the research. In line with what Walsham (1995, p. 6) describes, "theory is both a way of seeing and a way of not seeing". However, it can still be somewhat fuzzy and hard to grasp, given that the data should guide initially and later, if desired, related to a theoretical framework.

![Figure 4. Example of the analytical process using thematic analysis](image)

TA was applied as an analytical approach in papers 2 and 3 and inspired the analytical process in paper 4. However, In paper 1, a qualitative content analysis was applied (Kohlbacher, 2006). In content analysis and thematic analysis, themes, patterns, and codes should be identified and grouped in two ways: inductively or deductively (Braun and Clarke, 2006). Thematic analysis is understood as rooted in the older tradition of content analysis, sharing many presented principles and procedures (Braun and Clarke, 2021; Humble and Mozelius, 2022).

### 4.5.2 Mind mapping

The mind-mapping approach was only applied in paper 5 but was also inspired by the analytical process of TA.

The mind mapping approach was appropriate to provide structures and mental models that support understanding information of mixed data sets (Fearnley, 2022; Wheeldon and Faubert, 2009). Mind mapping analysis primarily aims to identify, illustrate, and analyze perspectives, relationships, and differences across qualitative datasets (Fearnley, 2022). Something that was of much use when I, in
the fifth paper, focused on exploring micro-foundations in the transforming capability.

The first step of the analysis was to familiarize myself with the data to convey a sense of the experiences shared by informants (Gilgun, 2005). This was followed by an initial coding of the data sets by critically asking why and how the story within the dataset enrolled the way it did, based on organizational change initiatives that affect an organization’s ability to deploy digital technologies in industrial digitalization. These codes then formulated the initial interpretations based on a capability-informed outlook, see Figure 5.

Even if the mind mapping approach is an outlier, it takes on the capability-informed outlook as the other appended papers. It formulates an iterative process of theoretical frameworks and analysis (Walsham, 1995).

4.6 Reflections on the Research Process and Ethical Considerations

Research ethics is about those values and norms that guide the individual and exist for research results to be accepted by the research community and benefit society (Säfsten and Gustavsson, 2019). Throughout this case study, I have met many individuals and been invited to their workplaces. What was recorded and stored for analysis is one thing. I want to reflect on what happened when the recorder was off and what happened in entrusted spaces.

When I first entered the field, I had the idea to look into how to implement industrial digitalization from a strategic perspective. My thoughts on this were naïve, as it turned out when I did my initial interviews.

Criticism of case studies often focuses on possible subjective case choices. It is as if the researchers’ prior knowledge of the context and phenomena intended to be studied would influence the choice of case negatively (Flyvbjerg, 2001, 2006). My subjectivity guided the selection of organizations, but the initial formulated research questions stemmed from what I now view as naivety toward the practice.
I write naivety, and it might be read as a negative thing. But it refers to a lack of experience. Schultze’s (2000) confessional narrative focuses on instances or circumstances where self-reflection was pivotal in shaping decisions during the research process. My entry point refers to my initial anticipation of the respondent organizations’ everyday practice. The initial naivety became a learning and reflective checkpoint. This was not negative. Instead, it kept the case study open and explorative.

Another reflection is the high degree of access. I had the opportunity to navigate between various organizational units and their functions. Hence discreetly moving between hierarchies. I was never a chameleon but rather a capybara – accepted by most near the waterhole. Continuously understanding the context was a priority to prevent causing discomfort or disruption within the organization that would not have occurred otherwise due to my involvement (Gilje and Grimen, 2007).

A part of respecting the high degree of access was ensuring that data management and informed consent followed suitable ethical procedures.

### 4.6.1 Ethical considerations in data management

In the early phase of the thesis project, a data management plan was formulated following the guidance of the Swedish Research Council (Vetenskapsrådet, 2022). The data management plan contained information about the type of data to be generated and stored.

In this thesis, no sensitive personal data has been intentionally asked for nor stored. However, respondent organizations have remained anonymous in this thesis since both managers’ and individual employees’ sayings contain what can be interpreted as somewhat harsh criticism toward management and organizational procedures (Gioia et al., 2013).

The research approach does not consist of methods intended to involve any form of physical intervention on individuals. In the interviews, no questions were asked about sensitive personal information, and all research participants were provided with information about the study and consent to participate. In focus groups, informants were asked to sign an informed consent. In interviews, informants were asked to consent to being recorded and then to participate in the interview. Fully following the recommendations provided by the Swedish Ethical Review Authority (Etikprövningsmyndigheten, n.d.)

One of the questions that needs to be reflected upon is using AI-based transcription tools. Most of the interviews were manually verbatim transcribed. However, ten were transcribed using an AI-based tool. An account is created on
the website to which my data is linked to access the AI tool. Then, the audio or video file is uploaded and managed using the AI analysis tools on the website. The tool automatically generates a text file that can be edited online or downloaded in the preferred format. I chose to download it in the Docx file format. Transcriptions were, however, always checked manually, and I have chosen to delete the files from the website after completing the raw material.

4.6.2 Ethical considerations of informed consent

All informants were initially sent a letter of invitation with information about the purpose of my research and their requested effort—participation in an interview or focus group. As qualitative research tends to unfold unexpectedly, it can be hard to predict all the needed initial information and analyses to be made (Yin, 2018). In my best attempt, I have tried to account for such events as much as possible by continuously giving feedback to informants about publications and tentative results through informal conversations and formal meetings – aiming for transparency and resonance (Tracy, 2010).

I have kept the results transparent to Alfa and the informants. Both for validation and verification and for allowing collaboration and reflexive elaboration (Bloor, 1997). It has also been a way of building trust. Informants can experience unease, neglect, or the research process as time-consuming. For this reason, I wanted to be as transparent as possible with everyone, regardless of hierarchy, without harming the ones I had already spoken to. In a few cases, informants have expressed unease or unwillingness to be recorded. I can only assume why.

In certain instances, when I asked a question, the informant did not respond directly. Instead, they began to inquire about the source of my information or how I learned specific details. I imagine that informants either a) felt that I knew more than acceptable or b) were worried that I transported information between functions that could stir up emotions. For example, certain informants used more vivid language than others, and I have omitted particularly inappropriate phrasing or signatures. In addition, some informants felt more at ease conversing with me, resulting in more colorful expressions. I adopted such expressions in some interview situations, hoping to “speak the same language”. Only to find out that, in some instances, it caused distress. I do not believe I exploited the gathered data.

The interview arrangement resembles a dialogue akin to a dance in which the informant and I share just enough to sustain the rhythm. Nevertheless, it is necessary to consider where to draw the line since I am entrusted in their space. More importantly, during such events, the auditive or visual recordings were turned off to be discussed if the unease was due to segments in the interview guide relative to their function or position or my sayings. Such discussions have
always taken place in favor of the informant since they put themselves out there (Walsham, 2006; Yin, 2018). In all cases, informants agreed to turn the recording on. I could, of course, dwell on the fact that asking about their interpretation of industrial digitalization in a few cases seemed so loaded that some informants were hesitant to participate.

All generated data were anonymized - leaving names and organizations out. In some cases, the positions of the informants have been clustered into a function to neutralize the data further. For example, this was necessary when I focused on a single focus group instead of the whole organization. I cannot dismiss the possibility that the informants may identify themselves or their colleagues in the text.

Results

This chapter presents the results of this thesis, consisting of the five appended papers. The five appended papers contribute to giving texture to industrial digitalization and to understanding the social aspects of strategizing industrial digitalization in contemporary Swedish manufacturing organizations.

Papers 1, 2, and 5 are more descriptive and incorporate industrial digitalization in a broader organizational and social context. Paper 3 and 4 reflect the use of digital tools in production planning and a digitalization project in the AM workshop.

Paper 1


This paper focuses on managers’ perceptions of organizational capabilities for strategy formulation related to industrial digitalization. This paper aims to identify how industrial digitalization influences and challenges organizational capabilities of formulating a digital strategy. The paper reveals that the studied companies (local Alfa and Beta) have a limited maturity concerning knowledge, skills, and resources for industrial digitalization, which is argued to be needed to formulate a digital strategy. To that end, we find that managers are seeking orientation based on the need for an ability to articulate, appropriate, and involve industrial digitalization opportunities. The paper introduces “seeking” as a core capability in the dynamic capability framework. As such, the paper contributes to the existing dynamic capability framework by adding the core capability seeking illustrated in an elaborated and holistic ‘dynamic capability loop’. The loop frames industrial digitalization as a continuous process closely integrated with strategy formulation.
5 Results

This chapter presents the results of this thesis, consisting of the five appended papers. The five appended papers contribute to giving texture to industrial digitalization and to understanding the social aspects of strategizing industrial digitalization in contemporary Swedish manufacturing organizations.

Papers 1, 2, and 5 are more descriptive and incorporate industrial digitalization in a broader organizational and social context. Papers 3 and 4 reflect the use of digital tools in production planning and a digitalization project in the AM workshop.

Paper 1


This paper focuses on managers' perceptions of organizational capabilities for strategy formulation related to industrial digitalization. This paper aims to identify how industrial digitalization influences and challenges organizational capabilities of formulating a digital strategy.

The paper reveals that the studied companies (local Alfa and Beta) have a limited maturity concerning knowledge, skills, and resources for industrial digitalization, which is argued to be needed to formulate a digital strategy. To that end, we find that managers are seeking orientation based on the need for an ability to articulate, appropriate, and involve industrial digitalization opportunities. The paper introduces "seeking" as a core capability in the dynamic capability framework. As such, the paper contributes to the existing dynamic capability framework by adding the core capability seeking illustrated in an elaborated and holistic 'dynamic capability loop'. The loop frames industrial digitalization as a continuous process closely integrated with strategy formulation.
Paper 2


In this paper, we argue that the findings give valuable implications for manufacturing organizations navigating the challenges of industrial digitalization to sense and seize the benefits of Industry 4.0 technologies, i.e., digital technologies. The study provides an in-depth case study analysis of employees’ perspectives using the co-workership wheel to identify challenges related to industrial digitalization. Results from this longitudinal explorative case study indicate the importance of an adaptive culture and a focus on learning and competence while navigating industrial digitalization.

The paper emphasizes the importance of adaptive culture, learning, and competence in influencing organizational development and implementation. Manufacturing organizations need to tailor their structures and cultures to meet the demands of industrial digitalization. Within this, we argue that employees should understand how to integrate and manage digital technologies, requiring organizational approaches for learning and competence.

This paper provides insights into organizations’ challenges and responsibilities in industrial digitalization. The findings highlight the need for a human-centric perspective and the synchronization of technologies with overall production.

Paper 3


In this paper, we address the fact that many manufacturers are still to move fully into the era of I4.0, as they have semi-automated production, older machinery, and a large amount of manual work. Despite the long-time existence of digital Production Planning and Control (PPC) systems and recent developments in I4.0, e.g., Internet of Things and big data analysis, manually updated spreadsheets are still used to a large extent. To that end, we focused on the implementation processes to understand the transformative requirements of moving from analog planning to next-generation digital tools for PPC.
RESULTS

The results are narratively presented to explain and illustrate how local Alfa moves back and forth through the phases of the Dynamic capabilities framework as they strive towards improving PPC. The paper provides insight that if the production characteristics are unclear to employees, the organization can neither sense or seize how to use new technology nor be capable of trustworthy decision-making to transform production planning and control sustainably and resiliently.

In relation to industrial digitalization, the paper contributes a deeper insight into how traditional manufacturing companies navigate industrial digitalization, struggling to merge human and technology perspectives while moving from manual to digital production planning and control.

Paper 4


In this paper, I explored strategizing organizational capabilities for industrial digitalization by focusing on managers’ technological frames. This study explores how managers’ frames of digital technology applications can inform the strategizing of organizational capabilities for industrial digitalization. The case study focuses on Alfa's digitalization project, which aimed to achieve an autonomous additive manufacturing workshop. However, the study finds that Alfa failed to consider the socio-cognitive aspects, leading to challenges in capturing value from the project.

The paper shows that despite strategies and efforts for an autonomous AM workshop, Alfa failed when overlooking the socio-cognitive aspects. The study identifies three socio-cognitive aspects that influence strategizing organizational capabilities: affective individualism, affective collectivism, and structural framing. It emphasizes the importance of shared understanding and emotional bonds within an organization for successful strategizing.

In relation to organizational capabilities, the paper contributes and expands on the understanding of what affects an organization’s ability to strategize.
Paper 5


In this paper, I explore the pivotal role of micro-foundations in manufacturing organizations transforming capability. Micro-foundations encompass skills, processes, procedures, organizational structure, decisions, and disciplines and are crucial in distinguishing an organization's competitive advantage.

The case study, focusing on Local Alfa from 2019 to 2023, incorporates interviews and focus groups with a total of 30 participants. The paper adopts a human-centric perspective to decipher how a manufacturing organization’s strategic intentions of industrial digitalization can be operationalized. The analysis reveals that the interplay between social and structural aspects within micro-foundations is vital for strategic enactment, especially when viewed through the lens of the organization’s informal and cross-functional collaboration. Hence, the paper contributes to understanding how the implications of individual and shared understandings of digital technology affect strategizing industrial digitalization.
6 Discussion

It is essential to problematize and give a “language” of expression to how industrial digitalization influences an organization’s capability to strategize it. This thesis aimed to texturize and understand manufacturing organizations’ social aspects of strategizing industrial digitalization. Given the dynamic environment, the organization's capabilities were the focal point of analysis in the appended papers for understanding the needed dynamic capabilities for strategizing industrial digitalization. While doing so, it also gave an alternative perspective to the technology-driven understanding of industrial digitalization (Eriksson et al., 2024) that continues to affect contemporary Swedish manufacturing organizations' capability to strategize.

A cross-disciplinary approach has been applied in the appended papers built on extensive and longitudinal data generation to explore social aspects of strategizing industrial digitalization. By highlighting the individual employee and shared expectancies of digital technologies and industrial digitalization, new reflections appear on what constitutes to affect and make up organizational capabilities.

6.1 Social aspects of strategizing industrial digitalization

This thesis has followed an ever-present and dynamic phenomenon in today's manufacturing organization: industrial digitalization. Due to timeliness, it was possible to capture contemporary manufacturing organizations at the intersection of Industry 4.0 and Industry 5.0. Hence, unfolding the social aspects in this intersection when aiming to understand and texturize how strategizing industrial digitalization displays.

Strategizing industrial digitalization is predominantly studied and described from a technocratic perspective (Javaid and Haleem, 2020; Nahavandi, 2019; Xu et al., 2021). The general meaning of the phrasing industrial digitalization, when most of us use it, relates to digital technologies’ effects on organizational processes and, ultimately, the implications within a manufacturing organization (Matt et al., 2023). If glancing at informants’ sayings, they often apply metaphors to describe the elusiveness of industrial digitalization. Such as a bike you run along and struggle to get on (Carlsson et al., 2022) or a boat you are all alone in (Carlsson, in press). Arguably, the thesis shows a blend of enthusiasm and uncertainty that marks the organization's capability to strategize industrial digitalization—often driven by a
willingness to engage in digitalization efforts without an evident strategic enactment. The intense focus on technology when defining or redefining capabilities is narrow and often overlooks intricate relationships between individuals, functions, and the organization. This thesis shows that various influences of industrial digitalization give rise to conscious and unconscious effects on the organizational capability to strategize industrial digitalization.

The organization is an arena where the individuals’ expectations and understanding form a collective anticipation and presumption of industrial digitalization—formulating their understanding. Their joint understanding of industrial digitalization becomes the language of expression of the influences affecting them, which formulates how industrial digitalization is texturized by the individual employee.

In line with previous research (Zheng et al., 2020), managers look at industrial digitalization as an improvement measure in the production process with a constant focus on technology and function. Manufacturing organizations typically prioritize the improvement of production processes or functional units. This thesis shows that willingness to engage in digitalization efforts without an evident strategic enactment led to industrial digitalization being a process of stacked introductions of digital technologies, resulting in fragmented and often uncoordinated implementations that lacked a unified vision and direction (Eriksson et al., 2022, 2024).

The research presented here reveals that social aspects are an intricate part of an organization’s intangible assets and create a base on which organizational capabilities are formulated. If strategizing industrial digitalization is a question only related to the organizational structure and the tangible assets, that is something only to be interpreted or anticipated by managers or managerial functions; it risks employee rejection. In addition, if strategizing industrial digitalization relies solely on social aspects and intangible assets, it denies the formal structures and depends on the willingness of individuals. As such, this thesis shows that social aspects are interlinked and formulate a “language” of expression that can texturize how influences of industrial digitalization affect an organization’s capability to strategize industrial digitalization (Figure 6). This alignment of social aspects is herein argued pivotal for ensuring that strategic enactment is shifted from expectations of ‘what might be’ to a texturized foundation.
The social aspects are argued to be thematic but also to be interlinked. They are presented accordingly: To look beyond digital technologies, to formulate a shared understanding of industrial digitalization, and to transcend organizational structures.

### 6.1.1 To look beyond digital technologies

Understanding the influence of industrial digitalization through value-driven rationality as opposed to technocratic is herein argued to entail the stipulation to look beyond digital technologies. If one glances at the vision of a fully automated production, there are still arguments that humans remain (Endsley, 2017; Longo and Padovano, 2020). However, many manufacturing organizations have moved, or strive to move, from craftsman-like qualifications to more technical qualifications. The human is not set aside, but the view on the role of the individual has shifted. Hence, the evolving requirements for teamwork, responsibility, and a shared understanding of production processes signify a shift from qualifications that heavily rely on specific processes to qualifications that are less dependent on those processes (Fasth and Tengblad, 2023; Pfaff et al., 2023). This rebranding of what prerequisites are needed to reach a prosperous production might also change what influences of industrial digitalization count to care for.

Texturizing industrial digitalization by looking beyond digital technologies is for manufacturing organizations to shape the strategic enactment of industrial digitalization beyond a technocratic stance.

This thesis recognize that due to the technology-driven understanding, the social aspects have significantly a smaller discussion space. The interactions with digital technologies are not managed through how employees in each function interact with the technology-driven change but through the presumptive result of wanted
digital technologies. To exemplify, Alfa envisions the optimal industrial digitalization to be when the production is fully automated, and no humans are needed to be involved (Carlsson, 2023). Another example shows how local Alfa tested different digital technologies for production planning and control of production. However, they did not always follow it all through and sometimes returned to manual planning and applying, e.g., Excel (Eriksson et al., 2022). This thesis accentuates that a reflecting practice was frequently missing, and the organization often focused on technological requirements alone. Indeed, the examples delineate from one another, but both show that organizations continuously strive to adjust to how digital technologies could extend the function of production. A part of it is linked to what could be described as organizations' sweet desire for digital technologies.

The sweet desire is recognized through the argumentation of why digital technologies should be introduced or implemented in the first place. It is sometimes more important for manufacturing organizations to do something rather than nothing (Carlsson et al., 2022). With the apprehension that the organization would fall behind competitors or risk being viewed as non-digitalized, informants interpret it as a more desirable strategic enactment to do something. Or anything. The texture is thus based on characteristics and attributes of a 'nice-to-have' vision- of a sweet desire for digital technologies.

It is worth highlighting that the incentives to implement digital technologies are not necessarily problematic, nor are digital technologies as such. This thesis shows that it is the one-sided anticipation that the incentives are merely technology-driven, for example, to only account for the tangible assets of an organization when striving to implement digital technologies. Much like the incentives to implement digital technologies are not necessarily problematic, this attraction to digital technologies could be a positive engine that drives an organization's strategizing of industrial digitalization forward. For example, the fear of missing out has also created a highly innovative pace; the organization is not afraid to try new initiatives (Carlsson, 2023; Eriksson et al., 2022), and employees point out that digital technologies are not solely causing distress (Carlsson, in press). But if the focus remains on tangible assets, this drive could go missing.

It shifts the discussion away from what the contemporary organization needs to do to approach industrial digitalization or, more importantly, why to do it. This thesis shows that although the incentives to strategize are essential, they are dependent on the first trembling steps of managers seeking out what industrial digitalization entails to the organization (Carlsson et al., 2021). A way to understand this shift from a technology-driven understanding to a softer and more value-driven one is to look at what sprouted I5.0.
I5.0 marks a significant departure from previous industrial revolutions by placing human-centricity at the forefront of manufacturing processes (Adel, 2022). One can view human-centricity as comprehensive when considering the complex patterns and contrasting trends within various manufacturing organizational styles (Xu et al., 2021), and it stands in contrast to prior notions regarding the role of humans in production (Kamble et al., 2018; Osterrieder et al., 2020). To support human-centricity, it could be argued that there is a need for continuous workplace learning and to create a system that uses employees’ skills (Johansson et al., 2017). In this context, I5.0 represents an innovative manufacturing paradigm that strives to build an industry based on core principles of human-centricity, resilience, and sustainability as a response to the limitations of Industry 4.0 (Lu et al., 2022; Nahavandi, 2019; Wan and Leirmo, 2023).

Much research has been devoted to how industrial digitalization changes organizations (Schumacher and Sihn, 2020). Informants in the respondent organizations often asked me what industrial digitalization means for the manufacturing organization as if I could hand over a playbook (Carlsson et al., 2021). The respondent organizations were not interested in influences of industrial digitalization. Today, industrial digitalization occupies a self-explained place in most manufacturing organizations, much like ‘management’ or ‘leadership’ takes place in business administration. My point is that I was expected to have answered something like, “A contemporary Swedish manufacturing organization must digitalize its processes if it wants to stay prosperous and competitive.

In light of this, to look beyond digital technologies is essential for a rigorous analysis of the potential organizational challenges for strategizing industrial digitalization. Acknowledging the social aspects could allow an organization to adapt digital technologies to suit the contemporary organization and not the image of what it should be. Similarly, the idea that it is better to do something rather than nothing could encompass the emptiness of industrial digitalization. That is, anything that adds value to the manufacturing organization brought by digital technologies is industrial digitalization. The problem is not that it adds value but that it is hard to define the organizational capabilities needed if strategizing industrial digitalization is based initially on a hollow, sweet desire for digital technologies.

Hence, looking beyond digital technologies to texturize industrial digitalization is also the need to formalize a shared understanding of why industrial digitalization should be approached as a manufacturing organization.
6.1.2 To formulate a shared understanding of industrial digitalization

Previous research described that a shared understanding of industrial digitalization is necessary to align employee actions with organizational objectives toward strategic implications (Schoemaker et al., 2018). This is because a relatively homogeneous manufacturing organization could respond heterogeneously to industrial digitalization (Eggers and Park, 2018). Matt et al. (2023) refer to it as the lack of commitment and motivation among individual employees.

Engaging employees to be part of strategizing presupposes that employees are both willing to participate in sharing understanding and capable of making significant contributions on their own. Not written patronizingly but with the assumption that all employees have the same access to knowledge and information. If employees do not have access to the same knowledge and information, it could risk them being left alone with interpreting the means of industrial digitalization without being comfortable doing so.

Engagement also assumes a commitment. It can be hard to be committed and motivated if the role of responsibility is unclear (Carlsson et al., 2022). For example, managers who shift industrial digitalization away from strategy enactment are exempt from handling it. However, shifting focus away from strategy enactment is necessarily not an act of dodging responsibility. It could be a way to avoid losing face in discussions where strategizing industrial digitalization has to be defended. It could result from employees not being comfortable with interpreting the means of industrial digitalization. Arguably, the respondent organizations were not interested in the influences of industrial digitalization. They were interested in what it was and how the positive effects of digital technologies could be harnessed (Carlsson, 2023). Some managers could perceive digital technologies as enhancing their production, while others in the same organization perceive the specific digital technology as threatening or challenging their organization. This thesis demonstrates that managers and individual employees have to be comfortable taking on the discussion but also challenging current perceptions. But it is also acknowledged that this could metaphorically shatter the sense of identity within functions or the organization.

Texturizing industrial digitalization by formulating a shared understanding allows manufacturing organizations to articulate and appropriate it mutually.

Through this thesis, it is evident that discussing who is formally allowed to be committed and motivated is equally essential to discussing the ability to formulate a shared understanding of industrial digitalization. Nevertheless, the question of
who is formally allowed to be committed is also a question of whose interpretation of the influences of industrial digitalization counts.

For instance, strategizing industrial digitalization is often subject to how specific functions, such as Chief digital officers (Singh and Hess, 2017; Taylor and Vithayathil, 2018), or managers in general, enable and later deem digital technologies to be an enabler of production processes. The present work illustrates that some managers had difficulty dividing their attention between the everyday tasks that needed to be carried out and finding forums to articulate the means of industrial digitalization (Carlsson et al., 2021).

Like previous research, a central challenge when introducing or implementing digital technologies is how they are to be embraced by employees, regardless of function (Margherita and Braccini, 2020). However, introducing or implementing digital technologies as such is, as the thesis shows, not always experienced to be the biggest challenge. In strategizing, incongruences in managers' and employees' interpretations and understandings are not automatically linked to an individual or function. Employees' pre-formulated understanding plays a big part in whether digital technology can be successfully implemented (Carlsson, in press; Eriksson et al., 2022). In respondent organizations, before a specific digital technology was introduced, employees expressed frustration and negativity towards it. This frustration seemed to stem from digital technologies. However, when unpacked, it came from intricate relationships fostered within the organization between functions. It was a response to industrial digitalization, which had resulted in a number of stacked introductions of digital technologies. It was easier for individual employees to put words to the frustration if one said it came from implementing a specific digital technology than initiating a discussion of organizational aspects (Carlsson, in press). Such discussions risked being shut down as they were not perceived to have anything to do with introducing digital technologies. All individuals appeared to be battling under the same flag which made it challenging to delineate needed activities for implementing digital technologies.

The challenges of organizing and continuously supporting the pursuit of industrial digitalization in a flexible style and, in addition, dealing with potential negative perceptions among employees are rooted in the ability to formulate a shared understanding (Carlsson et al., 2021, 2022; Carlsson, 2023). Similar to the understanding that employees can learn how to jointly strategize if they are able to recognize the shared meaning (Volberda et al., 2021).

It is essential for the manufacturing organization to put much effort into untangling the means of industrial digitalization as a collective. The responsibility would not be an individual chore but a shared one. A manager's perception is
crucial, but a significant gap between various functions influences decision-making and interactions among various functions. The thesis shows that negative perceptions of specific digital technology affect informal choices and employee interactions (Carlsson, in press). Respondent organizations often relied on individual employees to sense opportunities related to digital technologies, making the capability to sense internal and external opportunities or challenges socially bound. For instance, in the case study, a lack of shared understanding of production processes hinders the successful implementation of new approaches and digital tools (Eriksson et al., 2022). Forums for creating a reflective practice did not exist. Individual employees often experienced frustration that could be argued to stem from their inability to effectively communicate and articulate the added value digital technologies were expected to deliver (Carlsson et al., 2021). This inability was similar to a language barrier. Different organizational functions would have different ways to convey the same expected output of a particular digital technology. In other instances, the same function would represent different expected outputs of the same digital technology. Such indications make it vital for managers to consider where reflections could and should occur to ensure a shared understanding.

If suggesting the recognition of forums for reflection, it is also necessary to question what counts as a shared understanding. The thesis shows that managers seem less keen to prioritize creating a shared understanding of industrial digitalization. To this end, is it a forum for reflection as long as managers account for engaging employees? Of course, one can involve employees by asking for opinions in various forums (Fasth and Tengblad, 2023). Or do employees, regardless of level, need to be involved in interpreting the means of industrial digitalization? This type of involvement might not lead to effective conversations on articulating and appropriating the means of industrial digitalization. However, it might be a starting point for creating a common terminology. There is a need to formulate shared articulated examples, which could help move industrial digitalization from the abstract to the concrete. It could texturize industrial digitalization to the unique requirements of the organization.

Further, there is also a potential that engaging employees to participate could formulate branches of strategic conversations within the organizations. Related research showed the importance of cross-functionality and recognized that organizations would have to integrate knowledge and capabilities across organizational boundaries (Adderio, 2001). Individual employees may be unable to take an organizational perspective and instead argue for solutions that align with their or the function’s interests rather than the organization’s.

What words to describe and articulate should be used when uncertain? This question creates a situation where employees interpret the need and why to
approach industrial digitalization alone without feeling the need to anchor with others. The dynamic process of strategizing is not isolated to identifying suitable digital technologies. It also should include understanding lower-level phenomena of an organization’s capabilities. That is the social occurrences that exist. The events can be observed with the senses but are sometimes hard to trace or pinpoint to a cluster of activities formally. The lower-level phenomena are the diverse needs of the organization's social dynamics, often overseen as the focus remains technology-driven when formulating a shared understanding of industrial digitalization.

6.1.3 To transcend organizational structures

To transcend organizational structures is to extend beyond the boundaries of function and hierarchy (Savastano et al., 2022). To transcend is to surpass a limit's range, surpassing its restrictions. Previous research shows how digital technologies can fundamentally reshape traditional business strategies by creating modular, distributed, and cross-functional processes that enable work to be done non-linearly (Bharadwaj et al., 2013; Peppard and Ward, 2016). Hence, it can even override formal hierarchies within the organization. This shift from functional organizational silos to collaborative, co-creative work and cross-functional expertise and knowledge is argued to be a paradigm shift (Pfaff et al., 2023). Alternatively, as Cordes-Berszinn (2013) describes it, traditional organizational structures could filter the organization's capability to use the opportunities of digital technologies in internal processes. To transcend organizational structures is herein argued to be essential to understanding how digital technologies reshape traditional business strategies and how hierarchies and knowledge are upheld and viewed.

This thesis demonstrates that organizational structures were not treated as tools when implementing digital technologies but were viewed as a hemming aspect, occasionally interpreted as excessively rigid (Carlsson, 2023, in press), and a source of suspicion (Carlsson et al., 2022). The strategic enactment of industrial digitalization differs from business development processes as it often impacts multiple organizational levels and functions (Yeow et al., 2018). The hierarchy is not necessarily unclear, but procedures for handling digital technology initiatives were experienced as unclear to each function (Carlsson, in press). It can be compared to a high-rise building without a lift to transport people. There are stairs leading to specific levels, but the higher the levels, the more tiresome it is to climb them.

The hierarchy as such in manufacturing organizations is not alien. The separation of functions and levels is a form to structure the organization’s logistics and decision-making bodies (Cordes-Berszinn, 2013; Marabelli and Galliers, 2017). It
is not the separation that inherently generates the feeling of rigidity among individual employees. Instead, as this thesis shows, collaboration and cross-functionality cannot swiftly act as a lift between functions. The lift is not broken; a wire has yet to be installed. The illustrative wire is the recognition that not every function operationalizes or implements digital technologies similarly, and it is tiresome to climb the stairs of collaboration (Carlsson, in press). Not every function has the same need. The wire illustrates the overarching understanding of why industrial digitalization should be approached, transcending all levels and functions.

In this thesis, the sharing of understanding between organizational functions points towards tensions about where responsibility should be placed, as previously discussed. Individual employees demonstrated higher levels of active engagement in cultivating a shared understanding within specific organizational areas instead of actively contributing to developing a shared understanding that spans the entire organization. Notably, the creation of a shared understanding within functions is needed. However, if the function is a brick of many, it is herein argued to result in silos if not anchored with other functions (Carlsson, 2023). This aligns with what Chaniás and Hess (2019) describe as endangering efforts to be overruled by internal politics. But it also provokes questions such as, who ensures that the understanding transcends organizational structures? Or is it a collective chore?

It is essential to note that not all managers have a keen interest in digital technologies (Carlsson et al., 2022). More significantly, some may not even realize their role in guiding industrial digitalization within their organizational hierarchy. This thesis does not demonstrate who should be responsible but points out that it should not be solely based on interest. In line with previous research (Skog, 2019; Solberg et al., 2020), it shows that mindset often plays an essential part whether digitalization is discussed or not. This insight should guide managers not only to make the strategic enactment a topic on agendas but also an endeavor to characterize and add properties to it. Potentially to avoid conflict in internal politics.

The uncertain prospects of benefits from digital technologies pose a crucial obstacle for where in the organizational structure to place the responsibility. This is also when strategizing industrial digitalization could depend on a sole driver (Carlsson et al., 2021). As such, the texture of industrial digitalization would be based on an individual employee's interest. Dependency on interest makes it a curious weakness: how do organizations prevail in engagement without suffocating creativity in formal structures that prevent them from being dependent on a single individual? Those with no interest in pursuing industrial digitalization will most likely not partake in creating resistant and noncompliant
informal structures. Hence, even if the pursuit is presented as an undertaking that everyone is interested in, not everyone will have the experience, knowledge, or competence to do so (Hess et al., 2016). As such, the interpreted influences that affect organizational capabilities could be based on individual employees’ blasé attitudes. Much like seizing capabilities should be avoided based on a manager’s hubris, deception, bias, or delusion (Warner and Wäger, 2019), interpreting the means of industrial digitalization should be avoided based on the assumption that everyone is interested in digital technology (Carlsson, 2023, in press; Carlsson et al., 2022).

In line with previous research, this thesis shows that emotional bonds that may affect the strategic enactment of industrial digitalization are often forgotten in favor of technological introduction (Raffaelli et al., 2019). Many employees hold an affective bond to industrial digitalization based on previous organizational events. Hence, characteristics and attributes given to industrial digitalization were based on past events. The historicity formulated an emotional bond to why or why not a particular digital technology. Examples of negative cognition in the case study were fear, low technological self-esteem, and scapegoating (Carlsson et al., 2022). The framing of organizational challenges identified the need for manufacturing organizations to give space for informal coordination if the formal one was not to be prioritized. The thesis shows that the organization depends on informal coordination among its employees because of its inability to gather human knowledge, engagement, and preconceptions that transcend organizational structures. With a high degree of formal structures, it is argued that the dependency on resistant and noncompliant informal structures is enough to harbor purposes that do not always conform with those of the formal. Informal coordination becomes the tangent where abilities flow between social and structural aspects of an organization.

To this end, texturizing industrial digitalization by transcending organizational structures allows manufacturing organizations to balance formal and informal structures.
Conclusion

This final chapter concludes the social aspects of strategizing industrial digitalization and clarifies how this thesis contributes to managers’ strategic enactment. In addition, future research and limitations are outlined.

This thesis has explored how social aspects of strategizing industrial digitalization can be understood and texturized. The understanding of industrial digitalization is based on an empirical standpoint derived through a longitudinal case study. Texturizing industrial digitalization through social aspects is argued to be a way for manufacturing organizations to give shape to industrial digitalization. The social aspects elaborated on and presented in this thesis are:

- To look beyond digital technologies,
- To formalize a shared understanding,
- And to transcend organizational structures.

These social aspects are thematic but also interlinked. Texturizing industrial digitalization by looking beyond digital technologies is for manufacturing organizations to shape industrial digitalization beyond a technocratic stance. Texturizing industrial digitalization by formulating a shared understanding allows manufacturing organizations to articulate and appropriate it mutually. Texturizing industrial digitalization by transcending organizational structures allows manufacturing organizations to balance formal and informal structures.

Together, these social aspects bring insights into how managers can guide the organizational capabilities to ensure synergy between an organization’s actions and objectives when strategizing industrial digitalization. Strategizing industrial digitalization is a massive endeavor for each organization, and the emphasis on social aspects in this thesis brings guidance, not instructions. Strategizing industrial digitalization should be texturized through each organization’s social aspects to define and redefine its organizational capabilities. This means each organization’s social aspects are unique, making the manufacturing organizations’ capabilities unique.

Managers and employees alike are recognized to influence an organization’s ability to strategize industrial digitalization through their beliefs of the challenges, opportunities, and effects of industrial digitalization. Manufacturing organizations are encouraged to take a much more extensive account of the social aspects to strategize industrial digitalization. As such, texturizing industrial digitalization through social aspects can empower managers to reflect on what influences their unique dynamic organizational capabilities.
7 Conclusion

This final chapter concludes the social aspects of strategizing industrial digitalization and clarifies how this thesis contributes to managers' strategic enactment. In addition, future research and limitations are outlined.

This thesis has explored how social aspects of strategizing industrial digitalization can be understood and texturized. The understanding of industrial digitalization is based on an empirical standpoint derived through a longitudinal case study. Texturizing industrial digitalization through social aspects is argued to be a way for manufacturing organizations to give shape to industrial digitalization. The social aspects elaborated on and presented in this thesis are: to look beyond digital technologies, to formalize a shared understanding, and to transcend organizational structures. These social aspects are thematic but also interlinked.

Texturizing industrial digitalization by looking beyond digital technologies is for manufacturing organizations to shape industrial digitalization beyond a technocratic stance. Texturizing industrial digitalization by formulating a shared understanding allows manufacturing organizations to articulate and appropriate it mutually. Texturizing industrial digitalization by transcending organizational structures allows manufacturing organizations to balance formal and informal structures. Together, these social aspects bring insights into how managers can guide the organizational capabilities to ensure synergy between an organization’s actions and objectives when strategizing industrial digitalization.

Strategizing industrial digitalization is a massive endeavor for each organization, and the emphasis on social aspects in this thesis brings guidance, not instructions. Strategizing industrial digitalization should be texturized through each organization’s social aspects to define and redefine its organizational capabilities. This means each organization's social aspects are unique, making the manufacturing organizations' capabilities unique. Managers and employees alike are recognized to influence an organization’s ability to strategize industrial digitalization through their beliefs of the challenges, opportunities, and effects of industrial digitalization. Manufacturing organizations are encouraged to take a much more extensive account of the social aspects to strategize industrial digitalization. As such, texturizing industrial digitalization through social aspects can empower managers to reflect on what influences their unique dynamic organizational capabilities.
Texturizing was never intended to be the primary novelty of this thesis. However, it became an essential tool to describe my attempt to understand managers’ and employees’ interpretation of industrial digitalization. It was a way to give characteristics and attributes to the influences affecting contemporary manufacturing organizations in the intersection of Industry 4.0 and Industry 5.0.

7.1 Future research

Recent research has begun to theorize how social aspects potentially affect organizational capabilities. In line with this and in addition to, this thesis has demonstrated that the social aspects inform an organization’s capabilities to strategize industrial digitalization. The decisive factor for the extent to which a result is transferable is linked to case studies’ unique characteristics. However, the characteristics also lay the ground for what can be studied next (Flyvbjerg, 2001). Hence, the identified social aspects are encouraged to be explored further in relation to a capability informed outlook with questions such as: could identified social aspects be the foundation of social capabilities within manufacturing organizations? Can such potential social capabilities be a starting point for discussing what conditions the learning factor of I-WIL is?

The results of this thesis are deemed useful in similar contexts but open for future research to explore if identified social aspects are transferrable to other types of industries—for instance, more highly automated industries such as automotive or smaller- to medium-sized organizations.

With the emerging Industry 5.0, future research questions could focus on detangling if there is a distinction between social aspects and the human-centric perspective. For instance, the human-centric perspective emphasizes the need to acknowledge human strengths and competencies to reach the sought efficiency of industrial digitalization. In other words, what are the effects on, let us say, operators’ daily work if the number of breakdowns is minimized, or how are operators cognitively responding to not having to answer to breakdowns as frequently? In such a scenario, it is not the designing of the production process that is human-centric but the accounting of the remaining change process. This view accentuates the understanding that often influences the industrial organization discussed in this thesis. The technocratic one.

Arguably, the result presented in this thesis could be a starting point for a more extensive and critical discussion of what a human-centric perspective could entail in the Swedish manufacturing sector. It could also be a starting point for discussing what a human-centric perspective entails in I-WIL.
Another aspect for future research is delineating what social aspects could comprise in a different scenario compared to other countries. Future studies should be conducted in national (and international) contexts where social aspects are less stressed than in Northern countries.

7.2 Limitations

Lee and Baskerville (2003) point out that neither quantitative nor qualitative descriptions of a case dependent on descriptive statements can generate generalizable insights. However, the theoretical reasoning of various influences of industrial digitalization, the social aspects, and organizational capabilities can be generalized to similar contexts. On the same note, the research approach with case study methodology, data generation, and analysis of data may be generalized to similar contexts (Yin, 2018).

Nevertheless, as in any research that progresses over a long period, the thesis project has been iterative and evolved along circumstances and access. After the effects of the COVID-19 pandemic, the case study focused on one manufacturing organization (Alfa and Local Alfa) instead of two (Alfa and Beta). However, this limitation is somewhat offset by the relationship with the local Alfa production site, which generated extended contacts with the rest of the Swedish Alfa organization.
References


References


REFERENCES


REFERENCES


Rosenbrock, H.H. (1990), Machines with a Purpose, Oxford University Press.


REFERENCES

University West. (2023), “Industriellt arbetsintegrerat lärande - Att ta ny teknik till fungerande praktik”, available at: https://www.hv.se/forskning/forskningsmiljoer/kk-miljon-primus/industriellt-


REFERENCES


Appended Papers
Paper 1

Desperately seeking Industrial Digital Strategy: A dynamic capability approach

Linnéa Carlsson, Monika Hattinger, Anna Karin Olsson, and Ulrika Lundh Snis.

Published in "International Journal of Information Systems and Change Management"

Inderscience Publishers Ltd., 2022

Printed and published with permission
Desperately seeking industrial digital strategy: a dynamic capability approach

Linnéa Carlsson*
School of Business, Economics and IT, University West, SE-461 86 Trollhättan, Sweden
Email: linnea.carlsson@hv.se
*Corresponding author

Monika Hattinger
Department of Engineering Science, University West, SE-461 86 Trollhättan, Sweden
Email: monika.hattinger@hv.se

Anna Karin Olsson and Ulrika Lundh Snis
School of Business, Economics and IT, University West, SE-461 86 Trollhättan, Sweden
Email: anna-karin.olsson@hv.se
Email: ulrika.snis@hv.se

Abstract: This study focuses on managers' perceptions of organisational capabilities for strategy formulation related to industrial digitalisation. A qualitative case study based on ten interviews in two manufacturing companies explores managers' perceptions of industrial digitalisation. A dynamic capability framework, consisting of the organisational capabilities sensing, seizing, and transforming opportunities, is applied to recognise and analyse nuances in managers' interpretation of prevailing organisational capabilities. Findings reveal that the studied companies have a limited maturity concerning knowledge, skills, and resources for industrial digitalisation which is needed in order to formulate a digital strategy. An additional core capability was discerned, i.e., 'seeking'. Seeking includes actions for articulating, appropriating, and involving in the very early phases of understanding and formulating a digital strategy. This article contributes to the existing dynamic capability framework by adding the core capability seeking illustrated in an elaborated and holistic 'dynamic capability loop'. The loop frames industrial digitalisation as a continuous process closely integrated with strategy formulation.

Keywords: digitalisation; industry 4.0; industrial digital strategy; strategy formulation; industrial digitalisation; organisational capability; management; manufacturing industry; dynamic capability framework; case study.
Desperately seeking industrial digital strategy: a dynamic capability approach

Linnéa Carlsson*
School of Business, Economics and IT, University West, SE-461 86 Trollhättan, Sweden
Email: linnea.carlsson@hv.se
*Corresponding author

Monika Hattinger
Department of Engineering Science, University West, SE-461 86 Trollhättan, Sweden
Email: monika.hattinger@hv.se

Anna Karin Olsson and Ulrika Lundh Snis
School of Business, Economics and IT, University West, SE-461 86 Trollhättan, Sweden
Email: anna-karin.olsson@hv.se
Email: ulrika.snis@hv.se

Abstract: This study focuses on managers’ perceptions of organisational capabilities for strategy formulation related to industrial digitalisation. A qualitative case study based on ten interviews in two manufacturing companies explores managers’ perceptions of industrial digitalisation. A dynamic capability framework, consisting of the organisational capabilities sensing, seizing, and transforming opportunities, is applied to recognise and analyse nuances in managers’ interpretation of prevailing organisational capabilities. Findings reveal that the studied companies have a limited maturity concerning knowledge, skills, and resources for industrial digitalisation which is needed in order to formulate a digital strategy. An additional core capability was discerned, i.e., ‘seeking’. Seeking includes actions for articulating, appropriating, and involving in the very early phases of understanding and formulating a digital strategy. This article contributes to the existing dynamic capability framework by adding the core capability seeking illustrated in an elaborated and holistic ‘dynamic capability loop’. The loop frames industrial digitalisation as a continuous process closely integrated with strategy formulation.

Keywords: digitalisation; industry 4.0; industrial digital strategy; strategy formulation; industrial digitalisation; organisational capability; management; manufacturing industry; dynamic capability framework; case study.

Biographical notes: Linnéa Carlsson is a doctoral student within the field of information systems specialising in industrial work-integrated learning, University West. Her recent publications cover issues such as industrial digitalisation, dynamic capabilities, and industrial work-integrated learning.

Monika Hattinger is an Assistant Professor in Informatics and Work-Integrated Learning at University West in Sweden. She is the Project Manager for ongoing projects related to digitalisation of industrial production systems, work practices and organisational change under the umbrella industrial work-integrated learning (I-WIL). Her research interest today covers industrial digitalisation, Industry 4.0, internet of things (IoT), and artificial intelligence in the context of production and manufacturing organisations. Her recent publications include competence development, e-learning design, inter-organisational collaboration and co-production of knowledge.

Anna Karin Olsson is an Associate Professor in Business Administration at School of Business, Economics and IT, University West in Sweden. This university has a special profile in work-integrated learning. She has a Doctoral in Business Administration from School of Business, Economics and Law, University of Gothenburg in Sweden. She teaches at all levels from Bachelor to PhD. Her recent publications cover issues such as university-society research collaboration, work-integrated learning, industrial digitalisation, social media, women entrepreneurs, urban regeneration, place innovation, and stakeholder collaboration.

Ulrika Lundh Snis is a Professor in Informatics and Work Integrated Learning at University West in Sweden. Her research interests cover the role of both human and organisational competence and learning in relation to digitalisation. She has managed many externally funded research projects in collaboration with both public and private organisational partners. Her recent publications include the management of knowledge, competence and learning processes in organisational contexts where digitalisation is ongoing.

1 Introduction

Digitalisation is a global movement with a series of actions and activities in transformation processes (Chanias et al., 2019; Karimi and Walter, 2015; Yeow et al., 2018). Digitalisation in an industrial context poses great challenges to the whole organisation. Industrial digitalisation is an instance of digitalisation reflecting efforts made in the manufacturing industry. It is a complex, contemporary phenomenon pushing organisations to effectively plan and manufacture goods and services in real-time and on-demand in new ways (Liu et al., 2011; Lorenz et al., 2015). Various interconnected technologies for real-time and smart production, referred to as Industry 4.0 (I4.0) technologies (Lasi et al., 2014), include information, computing, communication, and connectivity, applied to industrial production processes (Zheng et al., 2020). Adopting
I4.0 technologies allows for enhanced interconnections between employees, management, and production (Santos et al., 2021).

Hence, scholars acknowledge industrial digitalisation as a large-scale influence promising manufacturing organisations to reap the opportunities of I4.0 technologies of industrial production (Vial, 2019). However, for manufacturing organisations to act upon such opportunities pushes them to transform the whole organisation and businesses in new ways. Employees are argued to be more focused on integrating, managing, and controlling machines, work, and tasks. Such changes may stimulate the transformation of the production process, causing organisations to go beyond prevailing organisational structures as technologies may be replaced by new ones (Rueckel et al., 2020).

It is known that organisational capabilities and management abilities to connect to transformative processes generated by industrial digitalisation need to be considered throughout the whole organisation (Yeow et al., 2018). Earlier research shows that managers are less certain how they can benefit from I4.0 technologies and, in turn, industrial digitalisation (Andersson et al., 2018; Kane et al., 2016, 2017; Wellener et al., 2019). In this transformative context, management perceives the organisational environment as dynamic and elusive, making it hard to shape and strategise for organisational capabilities (Singh and Hess, 2017).

1.1 Problematisation

Formulating a digital strategy is not without problems and can be triggered at various levels and developed in different ways. Research reports discrepancy in knowledge when management analyse potential opportunities and challenges with I4.0 technologies (Chanias et al., 2019; Kane et al., 2016; Lokuge et al., 2019). Digital strategy formulations concern to what extent digitalisation strategies challenge established business strategies. It has been argued that attention needs to be drawn towards how and why digitalisation affects an organisation (Bharadwaj et al., 2013).

To formulate a digital strategy Yeow et al. (2018) suggest that it pass through three different phases for creating organisational capabilities: exploratory, building, and extending. When exploring, the formulation process is initiated when the organisation senses new opportunities and threats and begins to articulate a new strategy. Warner and Wäger (2019) propose using digital sensing to scan, screen and interpret future digital scenarios. This is an approach argued to require cross-functional teams and rigid strategic planning (Warner and Wäger, 2019). A digitally immature organisation often lacks a common understanding of the effects of industrial digitalisation (Bharadwaj et al., 2013; Kohli and Johnson, 2011), posing challenges for organisational transformation (e.g., business model, strategies, and actions for adopting I4.0 technologies). Addressing and utilising I4.0 technologies is argued to be part of a strategic formulation to generate effects on enabling, improving and transforming operations, functions, models, processes, or activities for a more profitable production (Zheng et al., 2020).

Research points to the fact that managers lack the ability to formulate a digital strategy, which may hinder an organisation’s readiness for industrial digitalisation (Chanias et al., 2019; Lokuge et al., 2019; Sony and Naik, 2019). Lavie (2006) describes this as a knowledge gap to recognise what capabilities are essential when responding to technological change. In this article focus is on why I4.0 technologies should be
implemented, instead of what type, hence the implementation process within an organisation.

Consequently, managers need to integrate, build, and reconfigure internal and external capabilities to address a strategy that responds to industrial digitalisation (Hess et al., 2016; Yeow et al., 2018). In other words, formulating a competitive strategy for digitalisation is crucial for accommodating a perceived changing environment and transformative processes. Yet, it is reported that even if managers inherently are motivated and understand the potential of I4.0 technologies, they face challenges when trying to formulate strategies that aim to transform structures, business models, and processes (Hess et al., 2016). Such identified struggles are major challenges when managers are to identify organisational capabilities while building structures (Warner and Wäger, 2019). Knowledge and information processed within the organisation can help managers question, support, and inform a strategy formulation (Galliers, 2011).

Our argument is built upon the assumption that industrial digitalisation addressed by manufacturing companies needs a more continuous holistic approach including the human and organisational perspectives and not only the technological perspectives. Formulating a strategy should encompass a holistic approach of strategy formulation and is essential in a continuous transformation process.

1.2 Research aim and question

Given the above, this article aims to identify how industrial digitalisation influences and challenges organisational capabilities of formulating a digital strategy. To address this issue, the focus is on industrial managers’ perceptions. The following research question is addressed:

- What are managers’ perceptions of industrial digitalisation related to organisational capabilities for strategy formulation?

The following section outlines the dynamic capability framework (Teece et al., 1997) and how it is addressed in relation to strategy formulation. The methodology describes the case study of the manufacturing industry followed by results from ten qualitative in-depth interviews with managers. This article concludes with a discussion of the results and implications for future research.

2 Theoretical framework

The dynamic capability framework was initiated by Teece et al. (1997) and has since been addressed by many other scholars (Eisenhardt and Martin, 2000; Helfat and Raubitschek, 2018; Teece, 2007, 2014; Teece et al., 1997; Vogel and Güttel, 2013; Yeow et al., 2018). The framework was created to help describe an organisation’s ability to deal with the dynamics of a changing environment (Teece et al., 1997). When an organisation tries to handle the endless stream of competing and conflicting information and actions, the framework can support management in building a competitive advantage. What is unique about the framework is that it focuses on short-term efficiency in terms of strategy formulation and has an evolutionary timeframe on creating and maintaining the ability to respond to threats and opportunities affecting the organisation (Teece, 2018).
Dynamic capabilities are activities channelling resources and organisational capabilities to maintain competitiveness. Resources refer to the strength or weakness of an organisation, such as knowledge of technology and routines, and capabilities to manage products and services. Such resources are both tangible and intangible and require an organisation to build, integrate, and reconfigure capabilities to remain competitive in a changing environment (Teece, 2014; Teece et al., 1997). The dynamic capability framework consists of activities clustered into three core capabilities: sensing, seizing, and transforming, see Table 1.

Table 1  The dynamic capability framework

<table>
<thead>
<tr>
<th>Core capabilities</th>
<th>Capability actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensing</td>
<td>Scanning</td>
</tr>
<tr>
<td></td>
<td>Learning</td>
</tr>
<tr>
<td></td>
<td>Calibrating</td>
</tr>
<tr>
<td>Seizing</td>
<td>Selecting</td>
</tr>
<tr>
<td></td>
<td>Designing</td>
</tr>
<tr>
<td></td>
<td>Committing</td>
</tr>
<tr>
<td>Transforming</td>
<td>Leveraging</td>
</tr>
<tr>
<td></td>
<td>Creating</td>
</tr>
<tr>
<td></td>
<td>Accessing</td>
</tr>
<tr>
<td></td>
<td>Releasing</td>
</tr>
</tbody>
</table>


We argue in line with Teece (2007, 2014, 2018, 1997) that it is necessary to consider the environment when exploring dynamic capabilities. Given these various perspectives of the dynamic capability framework, he highlights a holistic and broad perspective on organisations’ core capabilities.

2.1 Sensing – the capability to identify new opportunities

Sensing, the first core capability, refers to an organisation’s ability to identify and create business opportunities. Teece (2007, p.1322) maintains that ‘sensing (and shaping) new opportunities is very much a scanning, creation, learning, and interpretative activity’. Warner and Wäger (2019) argue that these processes are an act of analysing diverse information. Therefore, sensing should occur at all organisational levels, as this could help bring insight and information about environmental trends to middle and top-level management. When referring to dynamic capabilities related to strategic work Teece (2014) states that sensing is ‘a strong element of diagnosis, which is important to strategy’ (p.341). Sensing further includes three capability actions: scanning, learning, and calibrating (Teece, 2014; Yeow et al., 2018).

Scanning refers to an organisation’s efforts to explore opportunities in the market, gather information from internal and external sources, and then filter relevant actions (Yeow et al., 2018). However, such an action could be hard for managers to cover due to the disruptive or long-term effects the I4.0 technologies may bring. Thus, I4.0 technologies are fundamentally reshaping traditional strategies by creating modular,
distributed, and cross-functional processes that require work to be carried out in a
nonlinear way (Bharadwaj et al., 2013).

Learning, the second action, includes actions undertaken by organisations to evaluate
potential opportunities by, e.g., monitoring performance or gaining more insight to assess
and identify specific areas for further actions (Teece, 2014; Yeow et al., 2018). Learning
is categorised as the synthetisation of actions that give rise to new knowledge and
learning.

Calibrating, the third action, is when an organisation calibrates opportunities and
reallocates resources, engages in further know-how after probing specific actions to identify
implications for future actions and competitive advantages in line with an envisioned
future.

### 2.2 Seizing – the capability to address and utilise opportunities

Seizing, the second core capability, refers to an organisation mobilising to address
opportunities and then utilising them. Warner and Wäger (2019, p.323) refer to seizing as
‘to address opportunities or neutralise threats, incumbents require seizing capabilities that
ensure leaders avoid hubris, deception, bias, and delusion and that allow firms to
experiment with decentralised boundaries, digital platforms, and new business models’. Seizing is an act of strategy construct, and Teece (2014) argues that it should be
connected to a guiding policy and coherent action. Seizing would then be the critical
capacity for aligning a digital strategy as it implies an organisational ability to act upon
identified opportunities. Seizing moves an organisation beyond the act of understanding
(sensing) to focus on deciding what specific changes are to be made to capture identified
opportunities.

Furthermore, Teece (2007) argues that all organisations could sense an opportunity
yet not all can seize opportunity. Yeow et al. (2018) suggest that seizing includes the
following actions enhancing capability: selecting among options, designing, and
committing (Yeow et al., 2018). Selecting constitutes the actions organisations take when
selecting among several options available to design its structure. This could also be the
choice of different services, platforms, or products. Designing denotes an organisation’s
activities to plan and design new structures and processes (Yeow et al., 2018), e.g., to
construct a digital business structure. Lastly, committing action refers to the decisions
taken by organisations to implement preferred designs, such as options of services,
products, platforms, and business structures (Yeow et al., 2018).

### 2.3 Transforming – the capability to change and realise opportunities

Transforming, the third capability, refers to an organisation’s ability to be flexible, align
new gained insight and activities, and hence internally change. Whereas sensing and
seizing capabilities enable creating and discovering new opportunities, transforming
capabilities underpin the realisation of strategic change (Bharadwaj et al., 2013; Warner
and Wäger, 2019). However, as Warner and Wäger (2019) point out, digital
transformation is challenging because the changing environment remains uncertain in
combination with few or no identified required competencies. Transforming consists of
four capability actions: leveraging, creating, accessing, and releasing (Yeow et al., 2018).
Leveraging focuses on a new use of existing resources, e.g., aligning existing resources
and knowledge with a new strategy. Creating is an action that covers the craft of
combining new resources and processes generating new knowledge. Accessing is the use of external resources needed to complement existing resources, e.g., incumbent firms need to craft digital strategies that leverage digital technologies and existing structures but may lack both competencies and technologies needed (Warner and Wäger, 2019). Releasing is the action of dropping no longer needed resources in a new digital business strategy, e.g., workforce, routines, and structures (Hess et al., 2016; Sebastian et al., 2017).

3 Research approach and method

The study reported in this article was designed as an interpretative qualitative case study (Baxter and Jack, 2008), and conducted from management and organisational perspectives of two international manufacturing companies. The two companies are partners in a university-industry collaborative research project that constitute the empirical setting of this study.

Case study research is appropriate for research concerned with identifying patterns of action and studying organisational contexts when emphasis is put on managers’ perceptions, experiences, and understandings of a certain phenomenon (Maxwell, 2013; Yin, 2018). This study is not comparative; instead, the companies complement each other through the selection of managers and for generating various perceptions, actions, and possible strategy formulations of industrial digitalisation. Hence, the companies are not compared but rather considered as one analytical unit (Yin, 2018). Both industrial companies meet the criteria selection required as a relevant key sample and constitute the unit of analysis related to the aim of the study (Naderifar et al., 2017).

The partner companies in the case study are both global international industries, so-called original equipment manufacturers (OEMs) with production, business sales and services in a local and global chain of production plants. One company is in the aerospace engine sector and the other company manufactures gas turbines for industrial turbomachinery. They both produce and perform maintenance of cutting-edge components of high-quality product parts for aerospace engines and turbomachines. Both manufacture heavy and high-quality products, with advanced production processes, such as machining, including cutting, pressing, forming, and welding. The production at the two local Swedish sites particularly included in this study, is mainly arranged in functional production units with low degree of automation, long production cycles, and heavy reliance on manual operations.

3.1 Data collection

The data collection was ongoing during 2019–2020 with the perspective of active engagement and close collaboration built on an earlier research study (Lundh Snis and Hattinger, 2019). Hence, the company stakeholders influenced the design of the interview guide and choice of key informants (Maxwell, 2013). The qualitative data material consisted of ten in-depth interviews with managers with an engineering background and responsibilities for either technical development, IT architecture, production, quality, or logistics. They represented a mix of top and middle management levels equally distributed between the two companies, see Table 2.
Following the research question, the interest was to explore managers’ perceptions of industrial digitalisation related to organisational capabilities for strategy formulation. The interview guide included three themes: effectiveness and strategy formulation, examples of initiated or implemented digital initiatives in production, and strategic competence development. Related open-ended questions to themes were performed in a dialogue:

1. How do you as a manager perceive digitalisation in the organisation?
2. Is there a digital strategy in place? If so, describe the formulation and application
3. Can you describe any engagement in digitalisation or digital initiatives?

The open-ended questions focused on the informants’ reflections on their work practice concerning their function and responsibilities and the whole company context (Walsham, 1995). When clarification was needed supplementary questions were proposed. Interviews lasted between 45–90 minutes and were recorded and transcribed verbatim.

<table>
<thead>
<tr>
<th>Function</th>
<th>Numbers of informants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic manager, SM</td>
<td>4</td>
</tr>
<tr>
<td>Manager of engineering and development, MED</td>
<td>4</td>
</tr>
<tr>
<td>Production manager (second line), PM</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
</tr>
</tbody>
</table>

### 3.2 Data analysis

The data analysis of the transcribed text was conducted in four iterations. In the first iteration texts were coded through content analysis to interpret managers’ perceptions of industrial digitalisation and organisational strategies, hence an inductive approach (Kohlbacher, 2006). All authors read through this analysis multiple times to verify the accuracy of the interpretation of the data. The focus in round one was to become familiar with the data and identify relevant excerpts.

In the second iteration, the dynamic capability framework (Teece, 2007) was applied as a coding scheme to identify managers’ ideas and statements concerning company plans, applications, support, and other marks in the data that embarked on potential challenges of formulating a digital strategy. In this second round of analysis, managers’ perceptions were sorted through the core capabilities of the dynamic capability framework: sensing, seizing and transforming.

The third iteration in the analytical process was identifying capability actions within each sorted core capability, see Table 1. This was a stage of explanation building, trying to understand managers’ perceptions of industrial digitalisation related to prevailing organisational capabilities and the capability actions for strategy formulation. Hence, it was an analytical process of mapping the ‘how’ and ‘why’ (Yin, 2018), related to the empirical data and the dynamic capability framework.

This interpretative approach yielded a set of categories (core capabilities) and sub-categories (capability actions) inspired by the dynamic capability framework. Once all data were examined, a cross-group analysis followed, comparing the excerpts and the identified categories and sub-categories within each to determine whether they reflected a common analytical ground.
The cross-group analysis showed that the dynamic capability framework (Teece, 2007) was applicable for the data analysis. However, it revealed that the framework was insufficient in capturing managers’ perceptions of early phases of searching for meaning and potential opportunities arising with an increased industrial digitalisation. Thus, an additional core capability was discerned, i.e., ‘seeking’. This identified and added core capability came to be further analysed into three new sub-categories: articulating, appropriating, and involving.

4 Findings

Four categories were found to characterise the managers’ perceptions of industrial digitalisation related to prevailing organisational capabilities and the capability actions for strategy formulation:

1 New core capability: Seeking – articulating, appropriating, and involving.
2 Core capability: Sensing – scanning, learning, and calibrating.
3 Core capability: Seizing – selecting, designing, and committing.
4 Core capability: Transforming – leveraging, creating, assessing, and releasing.

The four categories that emerged from the data embody interpretations that reflect how capabilities for strategy formulation are searched for (seeking), how they are identified (sensing), how they are utilised (seizing), and how they ought to change (transforming) the manufacturing companies’ strategies. Seeking was identified throughout the data analysis as informants regularly spoke of a constant fumble for the meaning of industrial digitalisation. Many of the informants’ interpretations of industrial digitalisation exposed unsynchronised, or even lacking, actions that were reflected in their ability, for example, to communicate, engage, and identify opportunities. Many informants reported a mixed understanding and a scattered interpretation of company plans, applications, and support of industrial digitalisation.

4.1 Seeking

Managers described digitalisation as an abstract form of knowledge that only a few people in the organisation could take advantage of. They expressed a feeling of lacking direction and necessary competence for strategy formulation related to digitalisation. At the time, strategy formulations were described as not locally anchored or related to specific initiatives. As such, managers perceived that they lacked full control of issues regarding digitalisation. They believed a formal strategy or a document described how the company should adopt various I4.0 initiatives but not an overall vision.

“It [a strategy] exists within the organisation. There is one, but we don’t have an explicit one locally. However, we have more initiatives that should be linked to that strategy. (MED)”

By discussing industrial digitalisation, one of the managers acknowledged seeking basic understanding. He perceived himself as acting on articulated agendas simultaneously as he was trying to search for formal agendas on digitalisation. The majority of informants
identified themselves as having little or very little knowledge about digitalisation. Many of them sought operationalised examples of how digitalisation could be an opportunity for more profitable production. Informants emphasised the importance of an informative strategy that included human aspects and competence development. The importance of prioritising learning and competence related to digital maturity was also stated as key elements when managers discussed digitalisation. They perceived it as important that every employee understand the meaning of digitalisation, how it affects them, and how employees are expected to participate in organisational development. They spoke of digital maturity as a needed mechanism for enabling change. For example, maturity was described in terms of the need to involve practical training and general competence related to organisational change. Informants spoke in terms of ‘pitcher-of-a-leader’ (production manager, PM), ‘getting everyone on board’ (strategic manager, SM) and ‘if you are not in it with the basics, you do not know when to learn again’ (manager of engineering and development, MED). One of the managers expressed a need for such maturity as a prerequisite to generate organisational advantages for a larger group of employees. However, the same informant did not show any interest in digitalisation relative to his tasks. He perceived that digitalisation initiatives were for other employees, without specifying whom, or functions as illustrated in the following quote:

“Digitalisation is more than a fluffy image. It is smart and someone in the company will benefit – but not us. (SM)”

One manager elaborated on required strategies and their organisational readiness concerning strategy formulation, he stated that many of the employees regardless of function are often positive towards change related to digitalisation. However, the actual practical implications often remain absent since mechanisms were lacking:

“Everyone is positive, but then one does as one wants…and you wonder why the system does not work. That is the problem that exists. (PM)”

However, instead of speaking of what was understood, some managers pointed out they have just started to understand that they do not grasp the complexity of digitalisation. As a result of the mixed attitudes towards perceived maturity, some informants gave the impression of there being informal consent to how digitalisation should be faced. Contrary to perceptions of there being no local strategy towards digitalisation, one informant stated:

“In the past, the strategy included both business and digitalisation. But unfortunately, those who advocated this were referred to as backward-looking. (SM)”

Some managers made it abundantly clear that their organisations had a specific strategy and were able to discuss details of whether they perceived it as being holistic or not. Others described that they experienced a strategy for digitalisation at large (globally) but not at the local organisation. Notably, managers tended to connect with more local initiatives when discussing digital strategy formulation as these became concrete and manageable compared to an overall strategy related to digitalisation.

This newly found core capability and its capability actions are further elaborated in the discussion section.
4.2 Core capability: sensing opportunities

Regarding an organisation’s ability to identify and create business opportunities, several informants talked insightfully of sensing strategies for industrial digitalisation, e.g., the need for roadmaps, competencies existing or needed, level of expertise, etc. An important aspect is that such insight was based on an individual, but not company-specific, understanding of digitalisation. As such, many managers discussed the need to understand the terminology and concepts of digitalisation. They mentioned the idea of a centralised function that would foster such a coherent view. A manager likewise promoted the more holistic viewpoint of strategy formation, that digitalisation is an integrated part of all organisational work. However, managers perceived a lack of basic level of understanding for industrial digitalisation:

“Given the level of knowledge within the [management] group, I don’t think it’s easy to talk about digitalisation and think that it’s merely mobile phones. That’s at an extremely low level! (PM)”

One of the managers expressed that needed competence is not necessarily internal:

“I think you will have to bring in those who can. Those who know digitalisation. You can’t make anyone learn digitalisation in addition to his/her ordinary tasks. You have to bring in someone who has the skills needed. (SM)”

Findings related to the first capability action of scanning indicated that many referred to decisions of change regarding I4.0 technologies or methods of work having been made by an unidentified individual or function at a higher level. However, such comments did not always point to a low level of insight but were a way of directing the responsibility of understanding away from themselves. Yet, managers shared the idea that they (managers) needed to be involved in the process, arguing ‘if you’re not involved, you hardly know that you have to understand something new’ (SM). When asked to elaborate on their perception, a cultural change was described as a mechanism for change:

“It needs to change inside the company and find out how to avoid creating fear. (PM)”

In addition, managers spoke of the importance of a common terminology, which one can communicate for understanding and knowledge development, along with digital expertise and skills.

Evident in these perceptions is the view of interest, because employees described to have a large technology-driven interest, just not driven by digitalisation. Digitalisation was not seen as a subject that motivates changes at shop-floor level since it is too abstract. For example, the organisations usually work firmly project-based with specific resource constraints and gains, i.e., business case. As a result, managers found it easier to describe digitalisation in terms of innovations or specific technologies:

“We have a lot of digitisation generals who bring in lots of 3D and products in 3D, but we don’t really know what the customer wants. (SM)”

The managers in this study received little official information about industrial digitalisation, or what it could entail in their organisation. When managers were interviewed some tended to address digital administration and office work instead of digitalised production. Some managers viewed it as role models when discussing digitalised production. However, these informants also acknowledged that digital
production requires something, or someone who understands I4.0 technology linked to specific parts of production:

“I, as a manager, need to understand the terms and concepts of this field that I’m not very experienced in. …[you] need to surround yourself with competent employees. It’s difficult to succeed in doing everything with old knowledge. (SM)”

Regarding the second capability of action learning, managers perceived that digitalisation seemed to happen unpredictably and ad-hoc, not linked to the needs or even challenges met in production, e.g., quality, capacity, or lack of capacity. Managers pinpointed that the organisation can only be as digitalised as the lowest level of basic understanding.

The lack of formal terminology about digitalisation resulted in managers drawing knowledge from LEAN in conceptual implementation. Importantly, they did not compare digitalisation to LEAN management, but to the cultural wave and implementation it brought. For example, findings revealed that digitalisation was discussed at formal and informal forums yet in an exploratory rather than a clear-cut way:

“The basic foundations of digitalisation need to reach the company in some way. Why do we do that?... in the same way we talked about LEAN. (MED)”

Regarding commitment, one manager insisted it does not matter if the phenomenon is digitalisation or pure welding skill if relevant employees are not involved in the latest trends and talks. Hence managers stated that it does not matter how fancy a strategy may be, either way, it is the lowest level of involvement that is the cornerstone in change management.

“It does not help to write digitalisation means this, on any document or PowerPoint slide. One has to get the chance to ask and think. (PM)”

In terms of calibrating, almost all managers argued digitalisation may not be a way of leveraging production unless the basic principles of why are solved, since digitalisation per se will not solve anything. They pinpointed that one must understand underlying factors to why to committing. With respect to one’s illiteracy, one manager illustrated how he thought the organisation was unable to use collected data:

“The job is that we can get data…. I don’t know how much data we generate. But what is it good for? (SM)”

4.3 Core capability: Seizing opportunities

The majority of managers believe they have taken the opportunity to initiate digitalisation initiatives in their businesses, that is, mobilising to address opportunities and then utilising them. For example, they describe when the opportunity for sound digital initiatives arises, they will not miss it. However, they were also describing how difficult and risky seizing opportunities could be:

“We cannot digitalise everything. Now we are bubbling, all initiatives are good. But someone should receive everything and if nine of ten projects are not a good hit, there is a risk of it [digitalisation] becoming a buzzword. (SM)”

Some managers were anxious about how to keep the quality when initiatives are bubbling:
“It’s important that we as leaders gather and maybe, this was good, but we delete these four… So there we try to industrialize it. (SM)”

As such, some managers pinpoint the importance of industrialising initiatives – copying good initiatives to another area or part of production. However, some voices stressed that they struggled to select several possible initiatives. For example, some are unwilling to seize digitalisation initiatives if benefits and values are not specified in a business case or included in a business plan. In such cases, they were worried how to translate the business case into actual means:

"“What is the business case? You have to have an idea. (SM)"

“Many digitalisation or numbers are what management needs to present to top management. But it is not an ordinary person who translates into what I should do. (SM)”

The need for a formal business case is seen both as hindering for not cultivating small innovative initiatives, and as an opportunity to make the pilot initiative more well-known within the organisation. Managers want to know more about the business value behind pilot projects and what resources are being allocated. This is argued as being part of a transparent exploration process for the whole company. Notably, company practice was to standardise and industrialise as far as possible to save resources. This was operationalised using business cases. However, it was pointed out that standardisation is perceived as an obstacle to digitalisation when initiatives were forced to fit into different business cases. One manager anxiously described this as threading a fine line between shutting down creativity [initiatives] and keeping the standardised structure functional. It was seen as a clash between the traditional business structure and adapting to new needs.

From a management perspective the committed design of initiatives becomes essential:

“IT is starting to make themselves heard now. We must not end up where we have started to build 35 different I4.0 initiatives that do not talk to each other…(MED)”

4.4 Core capability: Transforming opportunities

Findings revealed stray examples of organisational capabilities complying with transforming. Managers showed stray examples of the organisation’s ability to be flexible, align new gained insight and activities, and hence internal change. Managers related transforming to I4.0 initiatives and wanted to talk about such matters. They stressed how the challenge is the phase of transformation, i.e., how an initiative is to be implemented. Informants spoke of mechanisms related to all three core capabilities that make it difficult to stimulate the wanted pace of change. Managers were more prone to describe their perceptions when discussing organisational involvement for industrial digitalisation. However, managers pointed out that much depends on the context and not just the overall maturity in the company:

“It [implementation] can take different lengths of time depending on the place and background. If you bring technology into a group that is looking for a solution, it is much easier than when you introduce new technology in a place that is already ticking. (PM)”

Managers described how hard it can be to continuously keep the digital maturity level up:
“It’s enough that we have high pressure. Not everyone is mature and interested in change. It takes a certain mentality to constantly bang your head against the wall and get ahead. (MED)”

Regarding creating, another mechanism that became clear when managers reflected was the feeling of exploring. Managers often ended or started their interview with the integration being complex without pinpointing where complexity arises or for what reason. Accessing, or even releasing, actions for digitalised production remained absent. Instead, they returned to their primary focus on seeking a conceptual understanding or from the perspective of a business case, highlighting how I4.0 initiatives need to fit with the rest of the organisation for an initiative to be considered to add value:

“When we come to I4.0 or digitalized and integrated environment, it becomes extremely complex when you must make them stick together. It becomes a neat job and if you then have a lot of jerry rigs that are not quality-assured and controlled. It will be hard to keep them alive… (MED)”

4.5 Summarised findings of managers’ perceptions

Managers could not point out functions or roles in the organisation when talking about strategy formulation tackling digitalisation. When highlighting managers’ perceptions, uncertainties or discrepancies of functions and structures in the organisation it became explicit that there is a lack of personal interest and directions of actions. Organisational structures were analysed as hindering or supporting I4.0 technologies enabling digital and efficient industrial production. However, both changes in structure and information flow is reported to be precarious to alter. Organisational structures were not seen as a tool for formulating a digital strategy among the informants, rather seen as a condition to consider when designing for progress of industrial digitalisation. Such structural mechanisms were not in place, nor had the right timing in the case.

Perceived increased complexity combined with low digital maturity challenge the work with formulating a digital strategy. Digital maturity is essential and is influenced by the changing environment. Hence, building digital maturity can help management question, support, and inform a digital strategy formulation. However, findings state managers struggle with allocating time and focus and are desperately seeking the meaning of industrial digitalisation.

5 Discussion

In this study we explored managers’ perceptions of industrial digitalisation related to organisational capabilities in the process of formulating a digital strategy, i.e., strategy formulation. We emphasise that the expanded dynamic capability framework was fruitful to explore managers’ perceptions of and approaches to strategy formulation.

Galliers (2011) and Chaniais et al. (2019) argue for a strategy formulation to be more holistic and transcend traditional functions. Dixon et al. (2014) share a similar approach by suggesting a dynamic capability lifecycle framework, in which managers play a key role leading digital innovations. In line with Teece (2007, 2012), scholars (Chaniais et al., 2019; Dixon et al., 2014) argue industrial digitalisation affects the organisation horizontally. However, such a view embarks on an organisational construction and reconstruction of the application of I4.0 technologies. While this is important it is not the
first issue affecting managers, but it is the first trembling steps initiating sensing, seizing, and transforming that is of great concern, e.g., seeking.

5.1 Dynamic capability loop for digital strategy formulation

By contributing to research on theories of dynamic capabilities (Teece, 2007, 2012; Warner and Wäger, 2019; Yeow et al., 2018), we propose a conceptual and enhanced framework that visualises the process of recurring work of digital strategy formulation, illustrated in Figure 1. Our proposed framework adds an additional core capability, *seeking*, with the following sub-categories (actions): *articulating, appropriating, and involving* opportunities that are discussed in the following sections.

Figure 1  Dynamic capability loop for digital strategy

5.1.1 Articulating – ability to create a common terminology

Managers seem less keen to prioritise creating a holistic understanding of digitalisation. As reported by previous research (Kane et al., 2017; Peter et al., 2020; Warner and Wäger, 2019), a common organisational culture with shared terminology is highly valued when pursuing industrial digitalisation. Our findings showed the need to articulate operationalised examples, which could help move digitalisation from the abstract to the concrete. Articulating a common terminology may translate to a digitalisation-oriented mind set and understanding (Singh and Hess, 2017). However, creating organisational structures that favour a common perception and experience of digitalisation could foster a homogeneous culture, suffocating the innovative pace often connected to digitalisation. Arguably, knowledge of utilising I4.0 technologies needs to not only be commonly communicated but recognised as potentially hindering, or supporting, mechanisms, i.e., ways of providing services, and perceived problems at both production and managerial levels. In the core dynamic capabilities (sensing, seizing, and transforming) matters were not about understanding the changing environment or potential changes but cross-functional articulations for translating the means of digitalisation (Warner and Wäger, 2019). While current staff may have a different, less digitalisation-savvy mind set and may lack the required capabilities to cope with upcoming changes, coherent procedures
could support companies by guiding appropriation of their existing technological capabilities to weigh current understanding. Matt et al. (2015) stress that early actions can be taken if expectations of digitalisation are not met, but then clear procedures on the reassessment of transformation actions are needed.

5.2 Appropriating – ability to diagnose organisational mechanisms

The ability to diagnose organisational mechanisms – appropriating aims – for planning, applying, and supporting organisational capabilities is in line with the ability to construct and reconstruct actions for change management (Teece, 2007; Warner and Wäger, 2019). Even in early phases of formulating digital strategy, managers stressed the importance of negotiating and renegotiating knowledge and resources. Sony and Naik (2019) argued that managers must be more agile towards getting an organisation ready for implementing I4.0 technologies. While a few informants showed no basic coherent conceptual understanding, most took advantage of I4.0 technologies in local initiatives. Compared to previous research, managers seem to neglect a holistic perspective complying with initiatives to only concern single functions (cf. Chaniais et al., 2019; cf. Kane et al., 2017). Appropriating organisational structures could entail the perceived contradictory action of articulating and creating a common mind set that sometimes misaligns with current ones (cf. Yeow et al., 2018). To exemplify such tensions, informants articulated significant focus on formulating a business case for I4.0 initiatives instantaneously as describing the misalignment of such a way of tackling seizing opportunities.

The action of appropriating is argued to be the ability to diagnose organisational mechanisms which support a responsive mind set (Rueckel et al., 2020). Since digital strategies affect the entire company, and their execution may result in resistance from different areas of the company, seizure of industrial digitalisation in strategy formulation should be a cue for more effective use of resources. This means taking time to reflect on supportive mechanisms that allow for the ability to diagnose, which is in line with the change management perspective (Teece, 2018).

5.3 Involving – ability to engage

One of the identified mechanisms hindering the organisation’s ability to reconcile capabilities was the collective understanding, which includes all employees, potentially identified as digital maturity manifested in verbal indifference (cf. Kane et al., 2017). Indeed, Hess et al. (2016) argued that the initial coherent mindset and organisational involvement are essential for industrial digitalisation. In the findings of Magalhães (2006), issues of formulating a strategy depend on the context in which it is to be implemented.

Regarding the collective understanding and progression of digitalisation initiatives, there was difficulty coping with marginal digital maturity (Warner and Wäger, 2019). It was manifested in the way managers recognise their inability. Some informants even showed fear of the low organisational digital maturity. Informants described an overall low involvement, stating that they had to bring in new employees who can handle changes related to digitalisation to fully become digitalised. This indicates a shift in perceptions of employees moving from appreciating long-term experience and skill, to instead viewing them as individuals who delay development. This also indicates a shift in responsibility as managers push the focus of industrial digitalisation away from strategy
formulation. The question arises whether informants should be addressing competence concerning single technologies or potential neglect of responsibility. Nonetheless, holistic strategy formulation could improve digital maturity (Karimi and Walter, 2015), based on cross-functional involvement. Multiple employees with different views, knowledge, and competence, may be involved.

5.4 Digital strategy formulation – dynamic capabilities continuously adjusted

A central contribution is based on managers’ perceptions of digitalisation trajectories, which we argue will have to be continuously adjusted. Thus, a more holistic discussion beyond the current framework of dynamic capability is required. Instead of viewing the dynamic work as process oriented (Warner and Wäger, 2019; Yeow et al., 2018), we argue it should be viewed as a loop. Findings showed that industrial digitalisation processes often include managers’ limited ability to understand what changes are needed and how to respond to identified needs. Organisational mechanisms for a manufacturing company’s ability to plan, apply and support digital capabilities were lacking. Actions of articulating digitalisation are recognised as important for creating initial means of appropriation to deal with and perform industrial digitalisation through involvement. Due to the complexity of re-structuring for digital strategy formulation, the dynamic capabilities should be based on recurrent and continual cross-functional work. The environment will continuously generate new opportunities and challenges over time; agendas and strategies will likely have to be continuously adjusted (see Figure 1). The suggested seeking capability becomes a way of contributing to a more continuous view of the dynamic capability framework (Dixon et al., 2014; Warner and Wäger, 2019; Yeow et al., 2018) to digital strategy formulation. Thus, it would be reasonable to assume that the context in which the digital strategy is to be formulated is of greater concern for managers. That formulation issues would depend upon such a context in which the looping takes place (cf. Magalhães, 2006), i.e., dynamic capability loop for digital strategy (see Figure 1).

6 Conclusions and implications for future research

This paper has contributed to a new approach by proposing an enhanced framework, dynamic capability loop for digital strategy (Figure 1), that visualises managerial and organisational digital strategy formulation as a continuous loop. Based on theoretical reasoning and empirical evidence, the dynamic capability loop is developed. The loop model is a theoretically bound conceptual framework that provides a systematic and holistic reference model for any digitalisation study that considers digital strategy formulation. It is a further development of the core capability framework but adds a process-oriented perspective such as a loop metaphor. It further includes a process that categorises digital strategy work into four, not just three, key activities, i.e., the seeking, the sensing, the seizing, and the transformation actions. Hence, it adds the first action ‘seeking’. The loop framework also provides a comprehensive conceptualisation to indicate the engagement and negotiation that managers continuously do to desperately seek for and strategise industrial digitalisation. The loop framework – dynamic capability loop for digital strategy – has the power for exploring, understanding, explaining and
further, suggesting potential future research directions. We conclude that managers show a seeking orientation towards industrial digitalisation and thus a focus needs to include the initial phases, as they need organisational support in their desperate seeking for digital strategy formulation.

As with all exploratory research, this study is not without limitations. One limitation is the potential transferability of the suggested framework to a wider research context and it is thus unclear if it applies to a broader industrial context in changing dynamic environments. Future studies are encouraged to include non-managerial employees. To move the suggested framework forward, further qualitative research in different contexts and with dissimilar informants may validate the new core capability seeking and the related added capability actions (articulating, appropriating, and involving).

Acknowledgements

This research was funded by the Swedish Knowledge Foundation (http://www.kks.se) and industrial work-integrated learning in the Primus research environment at University West. The study was carried out within the Industrial Digitalisation and Organisation (INDIGO) project, and the Artificial and Human Intelligence through Learning (AHIL) project. We gratefully acknowledge the two partner companies for sharing their knowledge and expertise.

References


Paper 2

Taking Responsibility for Industrial Digitalization: Navigating Organizational Challenges

Linnéa Carlsson, Kristina Eriksson, and Anna Karin Olsson

Published in ”Sustainability”

MDPI, 2022

Printed and published with permission
Taking Responsibility for Industrial Digitalization: Navigating Organizational Challenges

Linnéa Carlsson 1,* , Anna Karin Olsson 1 and Kristina Eriksson 2

1 School of Business, Economics and IT, University West, SE-461 86 Trollhättan, Sweden; anna-karin.olsson@hv.se
2 Department of Engineering Science, University West, SE-461 86 Trollhättan, Sweden; kristina.eriksson@hv.se
* Correspondence: linnea.carlsson@hv.se

Abstract: In this article, an employee perspective has been applied in aiming to explore how organizations face challenges and take responsibility for industrial digitalization, thus extending the research on the human-centric perspective in relation to Industry 4.0 technologies. To give emphasis to the human-centric perspective, the co-workership wheel was applied to identify and analyze data. The findings of an explorative longitudinal qualitative case study consisting of 35 in-depth interviews with informants from a manufacturing company were used. Additional data collection consisted of documents and project meetings. By applying a human-centric perspective, lessons learned from this case study show that taking responsibility for industrial digitalization is challenging and the importance of an adaptive organizational culture and a focus on learning and competence are crucial. We argue that the findings give useful implications for manufacturing organizations navigating the challenges of industrial digitalization to sense and seize the benefits of Industry 4.0 technologies.

Keywords: industrial digitalization; Industry 4.0 technologies; co-workership wheel; adaptive culture; learning; competence; manufacturing; human-centric

1. Introduction

Industrial digitalization is not driven mainly by technological development, but by digital strategies, often rooted in organizational culture [1], and no part of the organization is immune to its effects [2]. The growing interconnections between employees and Industry 4.0 (I4.0) technologies are modifying the conditions under which organizations must navigate, hence prompting organizational changes. I4.0 technologies include, for example, internet of things, robotics, big data analytics, and cloud manufacturing [3] often related to artificial intelligence solutions. Furthermore, manufacturing organizations also must respond to external demands of sustainable production [4]. In addition, manufacturing organizations’ existing organizational structures and cultures need to be tailored to the desired outcomes of organizational capabilities and external sustainability demands [4–6] since industrial digitalization is challenging organizational structures and employees’ actions [7]. Organizational structure herein refers to the allocation of tasks and responsibilities to employees and various degrees of centralization, hierarchy, and specialization within an organization [8]. Organizations need to be clear about why digitalization is important, when proper, and what initiatives are beneficial [9]. In turn, employees need to understand how to integrate and manage I4.0 technologies related to work and tasks, thus needing organizational approaches for learning and competence [3,10]. As such, it becomes essential to understand how organizations face challenges and are taking responsibility for industrial digitalization since it is an ongoing strategic issue for manufacturing organizations.

Recently, a more human-centric perspective has arisen as a response to the technocratic understanding of industrial digitalization; Industry 5.0 (I5.0) [11]. This perspective, with a strong focus on the organizational structure, culture, and employees’ engagement and responsibility as drivers of industrial digitalization, is a contrast to the technocratic
understanding and focus on key technologies. For instance, humans’ interaction, critical thinking, and interpretation are described as important when facing challenges of industrial digitalization and new technologies [12,13]. This human-centric perspective emphasizes the need to acknowledge employee resistance, striving towards trust and learning as a solution for reaching sought efficiency. In doing so, it is argued to be a way of pairing human and machine to better navigate the elusiveness of industrial digitalization [11]. On top of that, it is argued that industrial digitalization is not dependent on the level of innovations or type of business. Rather, the basic prerequisites ought to be human behaviors, norms, and working routines on which the organization is built [14].

Organizational culture has been recognized as an important condition for enabling industrial digitalization given that it is a prerequisite for adaptability to changes [15]. Culture is here viewed as the weave that binds schemes, norms, beliefs, and routines together in an organization [16]. The organizational culture evolves over time and may be subject to internal or external change efforts; in this study, changes related to industrial digitalization. The organizational culture constitutes an interpretation pattern that helps employees, regardless of level, to understand situations in similar ways, prioritize in a similar fashion, and ultimately handle similar situations in a similar manner [16]. Adaptability is consequently a cultural trait which guides behaviors and processes that support appropriate responses to external and internal conditions, i.e., industrial digitalization. Notably, how effectively an organization can navigate industrial digitalization will represent the level of cohesiveness of the organization [17]. Hence, a human-centric perspective is vital.

To give emphasis to the human perspective, a co-worker approach is herein applied. The essence of the concept of co-workership is taking responsibility; other aspects are higher degrees of employee engagement, participation, inclusion and openness, trust, and influence [18,19]. Earlier research also emphasizes that employees need basic understanding of 4.0 technologies combined with the ability to communicate and work as a team [3]. In this regard, an adaptive culture is viewed as a mean of fostering engagement and commitment to industrial digitalization, both regarding managerial actions associated with adoption of 4.0 technologies and the encouragement of initiatives among employees [20].

Digital innovations often stem from grassroots initiatives, which allow for creativity, trial and error, and shop-floor experiments, etc. [21]. As such, it is not the 4.0 technologies that are in the epicenter of the change but the human relations, i.e., employees. Allowance for creativity, trial and error, and advocating experimentalism, employee engagement, and responsibility are all features of an adaptive culture [22]. This study is closely related to the concept of co-workership [19]. Moreover, this comes close to the discussion of what sets of capabilities are necessary to navigate industrial digitalization.

Consequently, following this reasoning, and the importance of understanding humans (employees) in relation to 4.0 technology applications, we argue the need to further explore human-centric perspectives in the era of 4.0. By applying an employee perspective, this study aimed to explore how organizations face challenges and take responsibility for industrial digitalization. The term employee is herein applied in a general sense to describe all co-workers of the organization. Given the above, the following research questions are addressed:

(i) How can challenges of industrial digitalization be understood through the perspectives of employees?

(ii) What are the implications of employees’ perspectives when organizations are navigating the depicted challenges of industrial digitalization?

The article is structured as follows. In the first section, the theoretical framework is presented. Here, the organizational culture and change in the era of industrial digitalization are outlined. This section is followed by a presentation of the co-workership wheel, a means of understanding organizational change based on employees’ initiatives and interpretations. After that, a longitudinal explorative case study is presented, including a description of the empirical case, method, and analysis. Lastly, the findings are presented and sorted following the theoretical framework of co-workership. To conclude, this paper discusses
taking responsibility for industrial digitalization through an employee perspective and the implications for organizations to navigate industrial digitalization.

2. Theoretical Framework

2.1. Organizational Culture and Change

Earlier research often views “digitalization as a bundle of social, economic, and cultural changes” triggered by the increasing use and advance of I4.0 technologies [7]. I4.0 technologies are herein the collected term covering, e.g., automation, the internet of things, machine learning, and other advanced technologies increasingly practiced in contemporary manufacturing organizations [23]. As such, I4.0 technologies are the applied advanced technologies within the era of industrial digitalization, which manufacturing organizations must strategize. From a more business-oriented perspective, industrial digitalization is often viewed as a source of disruptions triggering strategic responses [24] and organizational changes [20]. In brief, academic literature is dominantly focused on specific aspects such as key technologies, and challenges and drivers of industrial digitalization. The largest gains of the introduction of I4.0 technologies are argued to be neutralized as large resistance towards the implementation among employees may follow [11]. It is argued that resistance stems from a lack of a human-centric perspective, e.g., the changes of social and cultural aspects. As such, some scholars suggest providing a holistic agenda [25] as it is essential to encompass the entire picture to achieve an overall view of digitalization [2]. It has also been highlighted that the aspects of gaining management support and understanding of the adoption of novel technologies are important for successful implementation [26], and how the organizational culture affects adaptability [17]. A holistic view is emphasized as vital when building strategic resilience and leading to organizational sustainability [27]. Thus, it is argued that the process of digitalization needs to manage structural changes and organizational barriers to progress [24].

It is important to understand the barriers to industrial digitalization. Thus, participatory actions should be aimed for among employees as well as offering opportunities for learning [18]. This entails that the organizational abilities to foster responsibility are a shared endeavor. However, employee participation and learning, including gaining or holding skills in how to face industrial digitalization, is not something that just happens through management declaration, but through organizational culture. Culture is the capability of an organization that preserves the know-how of adaption that has been arranged into a tacit knowledge “pattern of recipes for handing situations” [28]. The development of organizational capabilities helps an organization to modify or create new operational routines as organizations need to change [20].

Culture as a capability [29] is viewed as a stock of knowledge and serves as a scheme “that constraints what people do and a scheme of interpretations of how the doing is evaluated” [28] (p. 378). For example, recent research has discussed the connections between an organization’s need to understand the relation between the culture and employees [30] to be able to navigate industrial digitalization. An open and engaging attitude towards technology-driven change has been argued to be crucial, as well as challenging [17].

Within an organization, the integration of human and technology perspectives, i.e., digital, and non-digital assets, must be bridged in innovative and sustainable ways, including a substantial redefinition of structural boundaries [17].

2.2. The Concept of Co-Workership

The employee is here viewed as an autonomous actor of the collective structure. Hence, the employee is understood as being an actor within the organization and not dependent; to be following someone’s directions formally or informally or bound by hierarchical structures of the organization [31]. Thus, herein co-worker refers to all employees.

The concept of co-workership is also a way of depicting that management questions reside around structures and employees’ attitudes towards the organization and its vision-
based work. In this sense, co-workership is a concept of understanding organizational change based on employees’ initiatives and prospects [32].

The co-workership wheel is a theoretical framework that characterizes co-workership through four thematic conceptual pairs (see Figure 1):

![Co-workership Wheel](image)

**Figure 1.** The co-workership wheel (see [16]).

2.2.1. Trust and Openness

Co-workership is in its essence about relationships, including work relationships. Trust is within all functional relationships a core ability. The ability is mainly manifested through open dialogues among constellations such as managers and workers, workers and workers, or workers and employers in general [16].

2.2.2. Community Spirit and Cooperation

Effective cooperation should transcend organizational borders, regardless of organizational structures or hierarchy professional roles, functions, or other barriers [16]. A part of the community spirit is the encouragement of learning with colleagues and by colleagues. However, it has been emphasized that organizations are struggling to address the missing digital competence [33]. This aspect of joint learning and knowledge exchange is highlighted as an important factor among employees when engaging in competence development initiatives [26,33].

2.2.3. Engagement and Meaningfulness

Beyond the commitment to the work itself, constructive co-workership requires a commitment to the organization. Such commitment is influencing the meaningfulness of the work [16]. The more an employee is engaged, the more one may mature in the task assigned, but also in the collective one belongs in. As such, responsibility becomes a question of allowance for commitment and constructiveness.

2.2.4. Responsibility and Initiative

Responsibility and action are closely linked, since those who feel responsible in a situation tend to be active and take initiative. One who feels responsibility also requires formal structure and routines to go through with initiatives. Responsibility strengthens initiative actions within an organization and may engage employees in organizational visions [16]. In addition, the ability to engage in initiatives and take responsibility is also a question of one having the competence needed to see and understand initiatives.

2.3. Motivation for Theoretical Framework

Given the above the co-workership wheel describes the conditions necessary for constructive co-workership. When these conditions exist, they feed back a development process, e.g., during organizational change. The conditions thus become both conditions
and outcomes of a constructive co-workership [16,19]. Increased openness and dialogue may strengthen the sense of community, which may promote cooperation and engagement in the organization, which in turn may strengthen the employees’ sense of responsibility and willingness to take the initiative. If such exemplified approaches are shared within an organization, co-workership may be viewed as a part of the organizational culture. The culture, in turn, may help employees create a homogeneous understanding, prioritize similarly, and ultimately similarly handle challenges.

While some of these terms (initiative, engagement, and participation) have been used relative to industrial digitalization [9] and the strategic imperative [34], their usage here reflects the interest of how employees’ perspectives may affect organizations navigating industrial digitalization. Earlier studies of Swedish manufacturing industry showed that as the number of I4.0 technologies increases within an industry, cooperation and social factors become more crucial, leading to a change in management being more distributed [35,36], and hence, becoming more inclusive and human-centric in organizational change.

3. Methodology

This research was designed as an explorative longitudinal case study, focusing on employees’ interpretations of industrial digitalization. In order to embrace the elusiveness of industrial digitalization, a case study methodology was applied to study a phenomenon in its real context with its specific features [37,38]. This approach was favored as it gives allowance for in-depth study of employees’ understandings and perspectives. Further, it helps explain how employees’ perspectives may affect the organization’s capability to navigate industrial digitalization successfully. The term employee is herein applied in a general sense to describe all co-workers of the organization. Hence, the chosen qualitative methodology is appropriate to grasp the human-centric perspective focusing on the four conceptual pairs within the co-workership wheel. To embrace the elusiveness of industrial digitalization a case study methodology was applied to study a phenomenon in its real context with its specific features [37,38].

Early research shows that interpretations of technology are particularly influential because interpretations are established rapidly and are assimilated into work practices, organizational routines, and work habits, e.g., culture [13].

3.1. Case Description and Data Collection

The empirical setting of this case study was one large manufacturing organization in the Swedish energy sector, herein referred to as Alfa (a pseudonym), with seven production units. All seven units produce and sell original equipment in a local and global chain of production plants. Furthermore, Alfa is part of a larger global company with multiple manufacturing sites. Herein, if not stated otherwise, when referring to Alfa all seven production units are of concern.

The explorative case study began by creating a general understanding of Alfa’s organization and production system arrangement. This was done through an initial case study to obtain a background understanding. We collected and analyzed production data to identify the data requirements for application of I4.0 technologies for production decision-making. The result from this initial case study gave an overall understanding of the added complexity of implementing novel technologies in an existing manufacturing facility with disparate production processes, complex production flow, older machinery, and much manual work. This in turn emphasized the human knowledge and involvement necessary to fully move into the era of I4.0 [12]. Further, the outcome indicated that there may be synergies between the effectiveness of the production system on the shop-floor level in relation to organization, management, and company culture. This became essential for designing the next part of the explorative longitudinal case study—emphasizing the importance of studying the holistic perspective of an organization to understand challenges through employees’ perspectives of industrial digitalization. Hence, a strength of this initial case study was the combination
of understanding the production flow, system, and processes in relation to management and organizational culture.

Moving forward, to obtain a holistic understanding of the case study, 35 interviews were conducted combined with two pilot interviews, nine partner meetings, and collection and reading of firm documents such as annual reports and strategic digitalization documents (see Table 1). Interviews were conducted by authors of this paper, except for six of the interviews that were performed together with one other researcher. This holistic approach served as a means for continuous validation and dissemination of findings during 2019–2021 to enhance the university-society research collaboration (see [39]).

Table 1. Overview of empirical data.

<table>
<thead>
<tr>
<th>Material</th>
<th>Amount of Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviews</td>
<td>35 informants</td>
</tr>
<tr>
<td>5 March 2019–24 June 2021</td>
<td></td>
</tr>
<tr>
<td>Pilot interviews</td>
<td>2 informants</td>
</tr>
<tr>
<td>CEO</td>
<td></td>
</tr>
<tr>
<td>Head of digitalization process</td>
<td></td>
</tr>
<tr>
<td>Partner meetings; date</td>
<td>9 meetings</td>
</tr>
<tr>
<td>16 October 2020</td>
<td></td>
</tr>
<tr>
<td>23 January 2020</td>
<td></td>
</tr>
<tr>
<td>12 February 2020</td>
<td></td>
</tr>
<tr>
<td>6 November 2020</td>
<td></td>
</tr>
<tr>
<td>4 December 2020</td>
<td></td>
</tr>
<tr>
<td>15 January 2021</td>
<td></td>
</tr>
<tr>
<td>8 June 2021</td>
<td></td>
</tr>
<tr>
<td>22 October 2021</td>
<td></td>
</tr>
<tr>
<td>23 November 2021</td>
<td></td>
</tr>
<tr>
<td>Documents</td>
<td>7 documents</td>
</tr>
<tr>
<td>Vision and policy documents</td>
<td></td>
</tr>
</tbody>
</table>

To gain insight about the organization’s size, business, and structure, two pilot interviews were held with one chief executive officer (CEO) and the head of the internal digitalization process. They were asked to foretell the business structure and hierarchy of functions. In addition, eight partner meetings were held to feed back information to Alfa as well as validate findings and results. In these meetings, employees at Alfa were encouraged to reflect and give responses on the empirical work in order to check for accuracy [40].

Access was granted to six internal documents to obtain formal information of the organization’s size, business, structure, and strategic work with industrial digitalization. These documents emphasize Alfa’s vision and core values: responsibility, excellence, and innovation. The three core values were designed and communicated to influence the overall strategic and operational work to provide guidance to employees.

As is often the case with manufacturing industries, Alfa has a hierarchical organizational structure, operating at a centralized office level supported by the business functions. Underneath, each workshop operates as a closed system, working with others if the internal system of supply chain demands so. Alfa consists of seven individual production units. Five of the production units produce and perform maintenance of cutting-edge components of high-quality product parts for the energy sector. Further, these five units manufacture heavy and high-quality products with advanced production processes, and low automation grade with a high amount of manual work such as welding. These five units are also primarily arranged in-job shop layouts with comparatively long production times and crossing production flows. Standard production processes are machining, including milling and turning, and other processes such as cutting, pressing, forming, welding, etc. The additional two production units produce spare parts and new parts on demand through the production process of additive manufacturing. To summarize, all seven units produce advanced, physically large-sized products for a global energy market. However,
the industrial digitalization of the case-study company may be viewed as scattered since some units of the organization are well advanced while a larger part of the organization is still in the early phases of the industrial digitalization journey.

From a historical perspective, Alfa manufacturing has undergone a change process from being a prototype workshop to moving into series production. Over the years, Alfa has initiated and distributed multiple projects internally labeled as digitalization initiatives, by employees described as attempts to “leverage the possibilities and opportunities of digitalization”. The overall aim declared in the visionary documents explicitly states that everything Alfa develops and produces in the long term shall aim towards zero emissions for sustainability.

Furthermore, Alfa has business functions such as IT, digitalization, and human resources (HR) situated globally. These functions define corporate standards and support the overall infrastructure of the company. These functions are at Alfa referred to as “global”.

The corporate service group of employees at Alfa consists of a compilation of managers and corporate service employees from the following functions: technical managers, quality managers, and production, logistics, and business. Furthermore, HR business partners, business administration, business development, and IT and planning are covered in the corporate services. This section of employees has in most cases a higher educational degree and many of them have been working for Alfa for more than 20 years; some of them even longer, starting off as trainees.

Detailed data generation was conducted through 35 semi-structured interviews between the 5 March 2019 and 24 June 2021. All interviews followed an interview guide including themes of questions, such as: “What is the significance and ambition of Industry 4.0 technologies in production (the organization’s)?”; “The organization employs what concept(s) to describe digitalization?”; “Does the organization have a meaningful cohesiveness of employed concept(s)?”

Given the explorative approach, the selection of informants was based on a snowball sample [41] to capture different employees within the corporate service section. Towards the end of an interview session, informants were asked to suggest additional informants. Snowball sampling is a valuable method to reach and locate a target group or hidden groups within a case study, giving access to formal and informal social circles, and encouraging involvement in the study since it is often based on trust [42]. However, all informants went through the same criteria of inclusion, i.e., to represent a cross section of employees working with various assignments related to strategic work in corporate services.

Snowball sampling is based on referral sampling where one informant recommends the second who refers to the third and so on, hence the analogy of a snowball [39]. The snowball sampling is a dynamic social process conveyed over time [39]. Given the above, informants spanned multiple functions and included managers, in-house consultants, and technologists, as illustrated in Table 2. Alfa and its informants have been described as transparently as possible without breaking our confidentiality agreement. In total, 35 interviews, each about an hour in length, were conducted either digitally or face-to-face and recorded with confirmed consent (Table 2).

The data collection was an iterative process in which some of the informants participated in several interviews. Likewise, nine meetings with Alfa were set up to report back and confirm information retrieved in the interviews. Due to the iterative process, the data collection process became longitudinal and spanned between March 2019 and November 2021.
3.2. Data Analysis

The qualitative approach yielded an analysis of different informants’ interpretation of the sensed responsibility and actors’ actions around it. To do so, the analytical process followed a thematic analytical approach; “a method for systematically identifying, organizing, and offering insight into patterns of meaning (themes) across a dataset” [43] (p. 57). All collected data were jointly analyzed in several rounds by all authors (see Figure 2) and we thus took an iterative approach following a method of a thematic analysis.

The data were initially revised to identify excerpts reflecting employee perspectives of industrial digitalization challenges. This familiarizing process with the collected data (31 h of recorded material) resulted in a total of 256 selected excerpts. To narrow the number of excerpts, interview transcripts and field notes were examined to identify statements or actions that reflected employees’ perspectives of industrial digitalization. In this step, data were read and sorted into categories based on the data rather than imposed theoretical assumptions [44]. Once all data were examined, 224 excerpts remained.

Then, a second round of analysis followed, identifying challenges related to each of the four conceptual pairs through a coding scheme based on the co-workership wheel: trust and openness, community spirit and cooperation, engagement and meaningfulness, and responsibility and initiative (see Figure 1). This step was to reflect upon whether the determined identification displayed common analytical patterns within each conceptual pair [45]. This round resulted in a total of 57 excerpts scattered across the four conceptual pairs of the co-workership wheel.

The third round in the analytical process was searching for analytical patterns within each conceptual pair. This iterative examination yielded a set of analytical patterns concerning each conceptual pair (see Table 3). When these analytical patterns were identified, the dataset was re-examined and re-coded in a fourth round, using the proposed analytical patterns. This was done to ensure the analytical patterns covered as much data as possible. Once all data were examined, a cross-group analysis followed, comparing the excerpts and the analytical patterns within each conceptual pair to determine whether they reflected common analytical ground [45].
Table 3. Overview: analytical patterns within each conceptual pair.

<table>
<thead>
<tr>
<th>Conceptual Pairs</th>
<th>Analytical Patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trust and openness</td>
<td>Trust in the system and structure</td>
</tr>
<tr>
<td></td>
<td>Competence</td>
</tr>
<tr>
<td></td>
<td>Adaptability</td>
</tr>
<tr>
<td>Community spirit and cooperation</td>
<td>Cultural change</td>
</tr>
<tr>
<td></td>
<td>Learning</td>
</tr>
<tr>
<td></td>
<td>Competence</td>
</tr>
<tr>
<td></td>
<td>Cohesive</td>
</tr>
<tr>
<td>Engagement and meaningfulness</td>
<td>Engagement in digitalization</td>
</tr>
<tr>
<td></td>
<td>Shortage of time</td>
</tr>
<tr>
<td></td>
<td>Meaningful digitalization</td>
</tr>
<tr>
<td>Responsibility and initiative</td>
<td>Competence</td>
</tr>
<tr>
<td></td>
<td>Resource</td>
</tr>
<tr>
<td></td>
<td>Cohesive</td>
</tr>
</tbody>
</table>

In this fifth and final iteration, a mutual agreement among the three authors resulted in three overarching analytical themes for navigating industrial digitalization—adaptive culture, learning, and competence (see Table 4).

Table 4. Overview: analytical themes.

<table>
<thead>
<tr>
<th>Analytical Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptive culture</td>
</tr>
<tr>
<td>Learning</td>
</tr>
<tr>
<td>Competence</td>
</tr>
</tbody>
</table>

In the following section, the findings are presented in accordance with the analytical patterns (see Table 3) and the analytical themes (see Table 4).

4. Research Findings

A larger set of analytical patterns (13) were found to characterize employees’ interpretations of industrial digitalization and its role in Alfa and the challenges postulated (see Table 3). These analytical patterns embodied how employees understood the challenge of industrial digitalization, and how they came to challenge various aspects of their work. The analytical patterns interacted and overlapped within and between the conceptual pairs. The analytical patterns are not believed to be independent. However, for the purpose of discussion, they are distinguished since such a distinction highlights the relevant differences in potential navigation of them. Below, the findings are presented with selected excerpts for each of the four conceptual pairs (see Tables 5–8).

The selected excerpts related to the first conceptual pair, trust and openness, resulted in four analytical patterns: trust in the system and structure, competence, and adaptability (see Table 5). Analysis of trust in the system and structure demonstrated a culture among employees in which it was hard to build and retain trust towards digital systems. Informants stressed that even if pilots of initiatives were made, the human factors were seldom accounted for in the pilot or finished product, which created a suspicion towards the organizational structure. The second analytical pattern, competence, reflected a need for increased competence in what a digital system affords. Informants described how data output can be inconvenient, thus disbelieved. Furthermore, informants emphasized not having the same level of competence and thus having a hard time trusting each other or the initiatives. The third analytical pattern was adaptability. Informants had a clear and somewhat broad idea of what challenges Alfa faced when adapting to industrial digitalization. Essentially, informants stressed that an overarching vision was needed to reach an openness towards digitalization initiatives. What such a vision would mean for the leadership, structure, and culture of Alfa, or how it would be enacted, was not specifically articulated.
Table 5. Trust and openness.

<table>
<thead>
<tr>
<th>Analytical Patterns</th>
<th>ID</th>
<th>Excerpts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trust in the system and the structure</td>
<td>I3</td>
<td>“It’s also this, that when you have tried to introduce something new here, you do not dare to trust it [the system] and then it will be undermined in the end.”</td>
</tr>
<tr>
<td></td>
<td>I1</td>
<td>“We will never make the system work if we do not follow it: shit in, shit out. I’m sitting on my hands here.”</td>
</tr>
<tr>
<td></td>
<td>I27</td>
<td>“It has to be correct in our systems, which is not the case right now.”</td>
</tr>
<tr>
<td></td>
<td>I4</td>
<td>“The way we work now, we e-mail what to override the production scheduling software with, because it [the system] doesn’t have time to update—so we deprioritize ourselves.”</td>
</tr>
<tr>
<td></td>
<td>I4</td>
<td>“Sometimes the production card disappears and then you go looking for it. You don’t go into the computer and search for the information. You go around looking for the piece of paper.”</td>
</tr>
<tr>
<td></td>
<td>I29</td>
<td>“Imagine if we had it all digitalized how good it would have been, but at the same time, no, it might not have been really that good; look at the problems that are being created.”</td>
</tr>
<tr>
<td></td>
<td>I4</td>
<td>“One piloted [IoT software] on a too small a scale, I think ... I think it was piloted too little. That’s my spontaneous feeling. The system had not really been understood.”</td>
</tr>
<tr>
<td></td>
<td>I21</td>
<td>“You spend more time convincing managers upwards than you spend on the digital initiative itself.”</td>
</tr>
<tr>
<td></td>
<td>I17</td>
<td>“You can push as much top down as you want, but if you don’t have any confidence from the bottom up, it won’t work.”</td>
</tr>
<tr>
<td></td>
<td>I29</td>
<td>“It’s always uncomfortable when a system reflects reality and the reality looks this bad. That kind of acceptance is not always a company ready to embrace.”</td>
</tr>
<tr>
<td></td>
<td>I11</td>
<td>“It is also a journey of maturity. There is no big abyss between us, but you have slightly different understandings. We’re looking a little bit more long term while the first line is looking a little more operationally.”</td>
</tr>
<tr>
<td>Competence</td>
<td>I5</td>
<td>“It’s fun to have some tablets in the production. ... [However] I haven’t seen any underlying ideas. It is more [important] that one can show that you have it [tablets].”</td>
</tr>
<tr>
<td></td>
<td>I12</td>
<td>“We are too vague in our communication with our employees and especially when it comes to digitalization.”</td>
</tr>
<tr>
<td>Adaptability</td>
<td>I35</td>
<td>“It’s about getting employees to understand the big picture: where are we going and understanding its [digitalization’s] role in the production flow ... one must visualize the production flow to understand its role in this.”</td>
</tr>
<tr>
<td></td>
<td>I10</td>
<td>“I need to see the whole picture in order to see the benefits, but I don’t need to understand the details.”</td>
</tr>
<tr>
<td></td>
<td>I26</td>
<td>“I think it [leadership] needs to be very clear and that everyone is working in the same direction ... production is best served by the fact that we are going in the same direction and that it is very open. ... we want to know what’s going on and feel as a part of it.”</td>
</tr>
</tbody>
</table>

The selected excerpts related to the second conceptual pair, community spirit and cooperation, resulted in four analytical patterns: cultural change, learning, competence, cohesiveness (see Table 6).

*Cultural change.* An important aspect of understanding the challenges of industrial digitalization is understanding how to appropriate and deploy its effects effectively. Such knowledge was interpreted by the informants as a challenge in the collective structure. Lack of interest, communication, and competence were identified as hindering factors embedded in the collective structure. The informants in this case study interpreted that they received little or no official resources for learning how to adapt or get acquainted with industrial
digitalization. Some informants described the learning process as a lonely journey and thus some informants had limited knowledge of initiatives. Other informants had ideas about initiatives, but these were either misinterpreted in what competence was needed, or the initiatives were merely focused on the need for tablets or computers with an incomplete vision of the applicability. The final analytical pattern, cohesiveness, demonstrated the lack of formal and informal connection between functions. In addition, coordination of strategic work was interpreted as missing; that is, because an incremental change process was missing, many initiatives were left to be dealt with by a few of the informants.

Table 6. Community spirit and cooperation.

<table>
<thead>
<tr>
<th>Analytical Patterns</th>
<th>ID</th>
<th>Excerpts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural Change</td>
<td>I2</td>
<td>“Historically, we haven’t been that interested. We think we’ve done pretty well on our own. But with things like this [digitalization] we don’t. We don’t have the resources.”</td>
</tr>
<tr>
<td></td>
<td>I6</td>
<td>“Regarding competence and communication: after all, you should be able to get support from any group by sitting by the neighbouring desk or door to door next by.”</td>
</tr>
<tr>
<td>Learning</td>
<td>I7</td>
<td>“Sometimes I think you kind of need to try it out. Sometimes it gets a bit wrong. Then you must back off. Maybe we have slightly different views there.”</td>
</tr>
<tr>
<td></td>
<td>I17</td>
<td>“Maybe the problem is that one has done oneself a disservice and called it digitalization. If you had just presented it as this is another business development project, you might have had other references and other possibilities.”</td>
</tr>
<tr>
<td></td>
<td>I8</td>
<td>“Try and translate the goals into what it means for us to meet the requirements. You take a little step every day. You can’t take a big step... There are risks involved.”</td>
</tr>
<tr>
<td>Competence</td>
<td>I8</td>
<td>“Optimally, it would fit like a glove, but there are different digitalization strategies coming from above. But as I said, it has to be put into practice at an understandable level by the employees.”</td>
</tr>
<tr>
<td></td>
<td>I8</td>
<td>“Digitalization probably has different meanings for different people. But when you come up with these overall plans, it comes to such an abstract level that it does not become gripping for the employees.”</td>
</tr>
<tr>
<td></td>
<td>I23</td>
<td>“Within manufacturing in general, it may be difficult to separate digitalization from digitization or just like IT in general.”</td>
</tr>
<tr>
<td></td>
<td>I10</td>
<td>“Most operators don’t have their own computers, tablets or anything like that. So, we still have a bit of a walk to take there... We’re still kind of printing the order statements on paper. I think it’s really weird in 2020.”</td>
</tr>
<tr>
<td></td>
<td>I10</td>
<td>“Our boss is trying to keep us together so we’re able to work together. But otherwise, there has been a lot of spread between different functions how digitalized you are. I haven’t seen a holistic approach to the whole site.”</td>
</tr>
<tr>
<td></td>
<td>I11</td>
<td>“I couldn’t keep all the roadmaps up to date. They became out of date after a while because we didn’t look at them.”</td>
</tr>
<tr>
<td>Cohesive</td>
<td>I13</td>
<td>“Where do we store different types of data? We haven’t quite sorted that out yet. I think that should be done more overall.”</td>
</tr>
<tr>
<td></td>
<td>I13</td>
<td>“But there will be a bit more of islands where we create automation and robot solutions and not fully integrated solutions.”</td>
</tr>
<tr>
<td></td>
<td>I17</td>
<td>“One wants to do a lot on short-time small projects that give pay-off at once and it doesn’t always rhyme with what digitalization actually is.”</td>
</tr>
<tr>
<td></td>
<td>I6</td>
<td>“It’s a project that’s on John’s [fictive name] desk and it lives a little in the shadows to the day-to-day operations.”</td>
</tr>
<tr>
<td></td>
<td>I8</td>
<td>“Everything is business driven and you almost have to convince [the management/the organization/who?] that this [digital initiative] is good.”</td>
</tr>
</tbody>
</table>

Selected excerpts related to the third conceptual pair, engagement and meaningfulness, are categorized in three analytical patterns: engagement for industrial digitalization, time shortage, and meaningful industrial digitalization (see Table 7).
Table 7. Engagement and meaningfulness.

<table>
<thead>
<tr>
<th>Analytical Patterns</th>
<th>ID</th>
<th>Excerpts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engagement for industrial digitalization</td>
<td>I4</td>
<td>“First and foremost, I think you have to get the employees interested in digitalization.”</td>
</tr>
<tr>
<td></td>
<td>I22</td>
<td>“It is no longer possible just to talk about it, you really have to hold on and rave over digitalization—otherwise it will not happen!”</td>
</tr>
<tr>
<td></td>
<td>I24</td>
<td>“It is not a hobby and it is not a playhouse . . . it is serious now!”</td>
</tr>
<tr>
<td></td>
<td>I18</td>
<td>“We are in a production situation that we cannot plan ourselves out of.”</td>
</tr>
<tr>
<td></td>
<td>I31</td>
<td>“We see great opportunities to collect data in a short time and spend time doing analyses instead of spending time collecting data from very different systems, as we have it today.”</td>
</tr>
<tr>
<td></td>
<td>I2</td>
<td>“. . . and then the production managers are the next team to be persuaded believers who understand that this [digitalization] is what we are going to do. If that step is not completed, it will be extremely difficult to get anything to happen.”</td>
</tr>
<tr>
<td></td>
<td>I6</td>
<td>“. . . and then the production managers are the next team to be persuaded believers who understand that this [digitalization] is what we are going to do. If that step is not completed, it will be extremely difficult to get anything to happen.”</td>
</tr>
<tr>
<td></td>
<td>I15</td>
<td>“We dig where we stand! We have to look up and ahead!”[They are stuck in one place and need to increase the view (holistically) to move forward.]</td>
</tr>
<tr>
<td></td>
<td>I7</td>
<td>“Sometimes it feels like this: ‘At least we have published many PowerPoints’. But when you are in the middle of it, you wonder—is this progress?”</td>
</tr>
<tr>
<td></td>
<td>I19</td>
<td>“If you really want to get into Industry 4.0, then we need to look into machines and such with instant feedback. We have a lathe from 1952. There is a challenge also there.”</td>
</tr>
</tbody>
</table>

Analysis of the engagement in industrial digitalization demonstrated the importance of generating interest among employees, to be able to identify opportunities, and the potential impacts of industrial digitalization, while at the same time realizing that now was the time to face industrial digitalization. Informants stressed that all levels of the organization needed to be included and to engage ‘believers’ to make things happen.

The excerpts about the second pattern—time shortage—point out informants’ views of perceived shortcomings regarding lack of time and focus on industrial digitalization. The challenge is to keep regular production going while at the same time understand and plan for ongoing or future industrial digitalization.

The last analytical pattern, meaningful industrial digitalization, includes excerpts in which informants do not understand or worry about what digitalization may mean for the organization, what kind of digital devices are needed for individuals in the production, what are the benefits of a digitalized production, and how industrial digitalization may be compatible with an older traditional machine park with much manual work.

Selected excerpts related to the fourth conceptual pair, responsibility and initiative, are categorized in four analytical patterns: competence, resources, and cohesiveness (see Table 8).
Table 8. Responsibility and initiative.

<table>
<thead>
<tr>
<th>Analytical Pattern</th>
<th>ID</th>
<th>Excerpts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competence</td>
<td>I10</td>
<td>“Now it is so that I tag along those who are interested [in industrial digitalization].”</td>
</tr>
<tr>
<td></td>
<td>I15</td>
<td>“I always ask what problem we solve now and after the third time I ask, I usually don’t get to be involved any more.”</td>
</tr>
<tr>
<td></td>
<td>I11</td>
<td>“Some people are interested in this topic, they are interested in digitalization both privately and at work. They pick up much faster. Somewhere you have to find what the minimum level is. What skills and knowledge do we need among our employees? At the same time, we must not hinder those who are passionate about it.”</td>
</tr>
<tr>
<td>Resources</td>
<td>I15</td>
<td>“It’s a small challenge that John [fictive name] is quitting. He’s passionate about digitalization and things like that. Now that he’s disappearing we’ve got to try to continue on his parole there.”</td>
</tr>
<tr>
<td></td>
<td>I16</td>
<td>“We can’t rely on charity.”</td>
</tr>
<tr>
<td></td>
<td>I17</td>
<td>“I don’t think it’s an optimal set-up at the moment because it’s enthusiasts who lead the initiatives here and there, and thus it will not be a whole.”</td>
</tr>
<tr>
<td></td>
<td>I15</td>
<td>“I have been given the role of working with digitalization, but there is no budget and no framework.”</td>
</tr>
<tr>
<td>Cohesiveness</td>
<td>I13</td>
<td>“Whether an initiative comes from above or below doesn’t matter. It goes into a process where we produce a business case and check the budget [and present] it in a forum where all managers at my level and above take a stand.”</td>
</tr>
<tr>
<td></td>
<td>I17</td>
<td>“Even though I didn’t know all the lines of argument [in the business case], I found out how they [initiatives] would be pushed to get a decision. Then there were further decision-making paths afterwards. That was frustrating.”</td>
</tr>
<tr>
<td></td>
<td>I19</td>
<td>“Then there is a lack of knowledge about how to fill out the template [for business cases]. That’s why you need the help of a business developer.”</td>
</tr>
<tr>
<td></td>
<td>I11</td>
<td>“I have no designated digitalization manager in my management team, it is a shared responsibility.”</td>
</tr>
</tbody>
</table>

The excerpts in the analytical pattern sorted as competence demonstrated the need for a common level of understanding of I4.0 technologies to take initiative and be willing to seize responsibility. Moreover, not having a mutual lowest level of competence was interpreted by some informants as creating a need to question and dispute initiatives.

The third analytical pattern—resources—demonstrated informants’ hardship and ambiguity when communicating applying for resources for an initiative. Informants interpreted both soft resources (employees and skills, etc.) and hard resources (money, time, etc.) as important to distribute so the responsibility of industrial digitalization was allocated to the collective rather than risking it being outsourced to a single individual.

The third and final pattern—cohesiveness—includes excerpts in which informants express that the lack of harmonization in the organizational structure has removed the employees’ allowance for taking responsibility for industrial digitalization initiatives. Informants emphasized the vulnerability of lacking cohesiveness when building responsibility and initiatives regarding I4.0 technologies.

Given the above, three analytical themes for navigating industrial digitalization—adaptive culture, learning, and competence—were found to overarch all analytical patterns (see Table 4).

Adaptive culture refers to the challenge of organizing and continuously supporting industrial digitalization initiatives in a flexible style while understanding organizational capabilities and collective structures. Informants regularly spoke of an indistinct culture within the organization which allowed for formulating and reformulating the capabilities that would facilitate industrial digitalization. At the time, such a capability did not exist within Alfa, either in the organization as a whole or at the local production units. Many of the informants’ interpretations around industrial digitalization exposed unsynchronized actions that were reflected in distrust in the system and structure, adaptability, engagement,
and believed meaningfulness. That is, informants were caught up with the advanced capabilities of I4.0 technologies rather than focused on its role to some specific organizational end. This was illustrated by Informant 3 stressing that an adaptive culture is of high importance:

“If you ask me, it’s the culture. If you ask them why one does not follow the production planning system... Somewhere it is a lack in courage, and you dare not trust the system. I feel like I have to make the system so incredibly transparent and good for people, so there’s no doubt about how to get it up and running. So, you have to go berserk and bend yourself around to get through. And there’s something curious here. It is an aspect of not daring to let it [the old way] go. And if I suggest it then I’ll be assassinated.” (I3)

Learning refers to informants’ views of how their organization acquired and implemented initiatives of industrial digitalization. Learning includes their understanding of the motivation or vision behind organizing and continuously supporting decisions and the likeliness of benefiting the organization. When employees were asked how they experienced implementing I4.0 technology, they tended to focus on the technical aspects in the form of a business case. The potential revenue and success were stressed; however, social aspects were left out. In other words, informants lacked the time and focus for trial and error. All informants generally described this assumption as:

“It’s a problem when everything is going too fast, and you don’t have time to learn.” (I33)

Other informants had similar reactions but observed the space of growth more directly:

“It also needs to be coaching to allow the individuals to grow.” (I34)

Competence refers to informants’ interpretation of what understanding is required for the individual and what knowledge is required at the collective’s lowest level. The informants in this study argued that they had little or no required competence for navigating the challenges of industrial digitalization. When they were interviewed, many reported a mixed understanding of how I4.0 technologies could be applied and how such applications could be dealt with, and by whom. Furthermore, many of the informants did not know who had the formal responsibility for industrial digitalization or related initiatives in the organization. In the absence of competence, informants stressed that it was important to build a common ground:

“My idea is that if you are going to have speed on digitalization it is probably the most effective to do many small [initiatives], a little try it out, so employees get to try it out and learn what can be done. One of the challenges I have seen in digitalization is that we as business managers must have a certain type of competence when we want to realize the digitalization projects.” (I11)

5. Discussion

This study approached the challenges of industrial digitalization through an employee perspective by applying the co-workership wheel [16]. Findings indicate that to face industrial digitalization, contemporary manufacturing industries need to focus on the human-centric perspective to sense and seize the prospects of I4.0 technologies. This understanding is in line with recent reports by the European Union [4,6] and recent research stressing the importance of the human factor in digitalizing production [5,11,27].

The human-centric perspective is also shown in the capabilities—adaptive culture, learning, and competence—identified to be needed by contemporary organizations when navigating the challenges industrial digitalization poses [12]. The findings herein state that contemporary manufacturing industry has a technocentric perspective of industrial digitalization in which I4.0 technologies are not fully synchronized with the overall production. Organizations continuously adjust to how I4.0 technologies extend the function of work routines. However, the cognition of how I4.0 technologies affect the overall organization are not considered or accounted for and related to social aspects of an organization [9]. Corresponding to earlier research, this case study also identified the importance of applying
a holistic view focusing on human, social, and cultural aspects when organizations are moving towards industrial digitalization [1,7,11,25]. This is seen as crucial for transforming existing production while maintaining daily operational capacity. As shown at Alfa, when an organization changes the cognition of diverse perspectives it is institutionalized and manifested through culture. However, once the understanding is institutionalized it tends to produce organizational inertia—a state of organizational stagnation [9]. This may also prevent an organization from negotiating a changing environment, i.e., industrial digitalization, potentially leading to an unwanted regression of change towards industrial digitalization. Again, this illustrates the need to emphasize human, social, and cultural aspects when navigating the challenges of industrial digitalization.

We argue that for organizations to face challenges and take responsibility for industrial digitalization with a human-centric perspective, the following themes must be accounted for in organizing and continuously supporting concerns: an adaptive culture, learning, and competence (see Figure 3).

![Figure 3. Illustration of a human-centric industrial digitalization.](image)

**Organizing and continuously supporting an adaptive culture.** Employees sometimes pass on responsibility to others, make excuses to avoid engagement, or lack confidence in the digitalization process since it is unclear where the responsibility for digitalization lies. Hence, it could be argued that there is a lack of guiding norms, beliefs, and routines for facing industrial digitalization [7,16,17]. As such, this affects community spirit and trust within the organization [16] since one of the challenges of organizing and continuously supporting concerns of industrial digitalization in a flexible style and, in addition, formulating an adaptive culture that deals with potential negative cognitions such as fear, low self-esteem, and scapegoating. If not, understanding an organization’s capabilities may become unsynchronized with employees’ abilities. As presented in the findings, cognition plays an important part in anchoring Industry 4.0 technologies to existing production systems. Several examples show how Alfa tested different Industry 4.0 technologies for production planning and control of production, although they did not always follow it all the way through and sometimes returned to manual planning, applying, e.g., Excel. Characteristically those digital initiatives depended on an individual enthusiast with a sole drive. The organizational capability of navigating industrial digitalization hence risk becoming reliant of the ability of enthusiasts.

Because of this inability to follow through, intense uncertainty arises. To this, Alfa has responded by encouraging the organization to create initiatives that easily could be copied to other parts of the organization—the innovation and progress of Industry 4.0 technologies...
were forced into an initialized frame. However, though this response is not necessarily inherently negative, the cognition of how I4.0 technologies affect the norms, beliefs, and routines was neither being negotiated nor accounted for.

**Organizing and continuously supporting learning.** This domain allows us to explain that although an adaptive culture is essential, it is not all. For example, a certain amount of backlash in change towards industrial digitalization must be allowed for and thus learning should be prioritized [9]. Contradictory outcomes, due to different interpretations of I4.0 technologies, are not only due to technological misfits, but are also affected by organizational norms, beliefs, and routines [26]. Suggesting that a certain amount of organizational backlash in change towards industrial digitalization must be allowed for and thus learning should be prioritized [9]. Hence, the appropriation of interpretations needs to be openly communicated, likewise the acceptance of misfits [16]. Alfa’s employees, in contrast, formulated a fear of making faulty decisions. As such, employees rather did nothing than risked doing wrong. In addition, backlashes were neither accounted for nor anticipated. When backlashes did occur, the change process was turned down since there was no time for learning what went wrong. The day-to-day operational work overrides the long-term vision. The “fear of doing wrong” thus forms a powerful jargon that is not stimulating learning for industrial digitalization.

**Organizing and continuously supporting competence.** Alfa employees repeatedly stated that there was no time, place, or strategy for competence development, contrasting earlier research on the importance of continuing competence development addressing industrial digitalization [26,33]. Most of Alfa’s employees had been employed for a long time or were considered to be of high age, and thus competence development was not seen as relevant. According to employees, the older workforce was more costly to focus on than recruiting a younger workforce to address industrial digitalization. Hence, the younger generation of employees was considered responsible for sensing and seizing I4.0 technologies. Alfa has not prioritized organizing and continuously supporting digital competence throughout the organization, which has resulted in lack of interest among the employees and passing responsibility to enthusiasts with a sole drive for digital initiatives.

5.1. Research Contribution

This study contributes to the research on organizing and continuously supporting industrial digitalization by exploring the perspectives of manufacturing organizations’ employees and their impact on navigating the challenges of industrial digitalization. The challenges were identified to be three overarching analytical themes related to the human-centric perspective on organizing and continuously supporting industrial digitalization: an adaptive culture, learning, and competence.

5.2. Implications for Practice

We argue that the identified analytical themes have useful implications for manufacturing organizations’ strategic imperative. For example, a great technocentric focus results in outcomes that may deviate from the anticipated vision. The three analytical themes offer a human-centric approach to face and navigate industrial digitalization in a sustainable and inclusive manner.

5.3. Implications for Further Research

While the three analytical themes are individually understood, they are also intertwined. We emphasize that the three identified analytical themes extend earlier work focusing on the human-centric perspective. In particular, the analytical themes are useful when trying to understand how organizations face and navigate challenges and how responsibility is accounted for. For example, while a technocentric approach may explain
the adaptive issues of navigating industrial digitalization, the identified analytical themes have implications for organizations’ strategic imperative.

Further research is encouraged to focus on the three identified analytical themes from the perspective of operators to further explore the issue of responsibility related to industrial digitalization.

6. Conclusions

By applying an employee perspective, this study contributes to exploring how organizations face challenges and take responsibility for industrial digitalization. The study provides an in-depth case study analysis of employees’ perspectives using the co-workership wheel to identify challenges related to industrial digitalization. Lessons learned from this longitudinal explorative case study indicate the importance of an adaptive culture and a focus on learning and competence while navigating industrial digitalization. Thus, the following analytical themes were identified as vital to organize and continuously support manufacturing organizations navigating the challenges of industrial digitalization:

(i) Adaptive culture
(ii) Learning
(iii) Competence

Applying a human-centric perspective that considers the prerequisites of an adaptive culture, learning, and competence of employees is herein argued to be crucial for navigating industrial digitalization. As the challenges of industrial digitalization are not typically discussed or articulated, they may, as we saw in the case of Alfa, result in unwanted misaligned actions.

The conceptualization of adaptive culture, learning, and competence also provides a means for influencing the organizational development and implementation process as industrial digitalization proceeds. It may also provide insight into the potential source of incongruence among employees; different incongruences may provide different characteristics of challenges or opportunities and hence the nature of navigation may shift over time. That is, distinguishing between incongruences due to structural, cultural, or social (human) factors may give more information to organize and continuously support an organization. For example, realizing the need for a more human-centric approach navigating industrial digitalization could reframe industrial digitalization to an incremental change rather than radical and threatening as anticipated by employees in the given case.

Limitations and Future Work

There may be limitations due to the single case study approach; however, the intention was to bring forth an in-depth case study analysis contributing to the human-centric perspective and the emerging I5.0 research. To further develop the findings, the existing case study is planned to be enriched by comparative analysis including of a structured sample selection of further staff functions such as shop-floor level and manufacturing engineers. Furthermore, future studies are encouraged to cover multiple cases or even different business sectors to examine what actions respective analytical themes include and how such actions can be managed to transform an organization navigating industrial digitalization. The analytical themes herein presented may be particularly important in the case of dealing with industrial digitalization and transforming an organization accordingly. Understanding adaptive culture, learning, and competence also have implications for the practice of strategic work itself: in professionals’ way of making sense of and employees’ ability to partake in industrial digitalization initiatives.

administration, A.K.O.; funding acquisition, K.E. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was supported by the Swedish Knowledge Foundation Grant no. 202 000 350* and University West Sweden.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** Not applicable.

**Acknowledgments:** The study was carried out within the AHIL-project, Artificial and Human Intelligence through Learning (2020–2022), funded by the Swedish Knowledge Foundation and University West Sweden. We appreciate the assistance provided in six interviews by Monika Hattinger, University West Sweden.

**Conflicts of Interest:** The authors declare no conflict of interest.

**References**


23. Osterrieder, P.; Budde, L.; Friedli, T. The Smart Factory as a Key Construct of Industry 4.0: A Systematic Literature Review. *Int. J. Prod. Econ.* 2020, 221, 107476. [CrossRef]


To digitalize or not? Navigating and merging human and technology perspectives in production planning and control

Kristina Eriksson, Linnéa Carlsson, and Anna Karin Olsson

Published in "The International Journal of Advanced Manufacturing Technology"
Springer, 2022
Printed and published with permission
Paper 3

To digitalize or not? Navigating and merging human and technology perspectives in production planning and control

Kristina Eriksson, Linnéa Carlsson, and Anna Karin Olsson

Published in "The International Journal of Advanced Manufacturing Technology"

Springer, 2022

Printed and published with permission
To digitalize or not? Navigating and merging human- and technology perspectives in production planning and control

Kristina M. Eriksson1 · Linnéa Carlsson2 · Anna Karin Olsson2

Received: 9 July 2022 / Accepted: 28 July 2022 © The Author(s) 2022

Abstract
Contemporary manufacturing companies are navigating industrial digitalization anticipating increased production efficiency and competitiveness in a volatile environment. This study focuses on the implementation processes of digital tools for production planning and control (PPC), i.e., advanced planning and scheduling (APS) software, in relation to the application of analog planning with physical flow boards. Digital tools can support understanding the consequences of production changes and variations, hence facilitating adaptable and resilient manufacturing. However, technological changes can be daunting, and effective implementations require dynamic capabilities to remain competitive in elusive environments. The aim is to study the implementation processes of an APS software to understand the requirements of fruitfully moving from analog planning to next-generation digital tools for decision support in PPC. The paper presents an explorative case study, at a manufacturing company within the energy sector. The interview study took place over 9 months during 2020–2021, investigating current and retrospective aspects of the case across 2019–2021. The case study comprises 17 in-depth interviews with a range of company employees, e.g., logistics managers and functions responsible for digitalization development. The results highlight the challenges of implementing and especially trusting digital tools for PPC. To realize the value of digital tools for PPC, it is argued that it is imperative to simultaneously apply a human-centric perspective in decision making to ensure trustworthy, sustainable, and resilient human-data-technology nexus implementations towards smart manufacturing.

Keywords Industrial digitalization · Smart manufacturing · Production planning control · Dynamic capabilities · Human-centric perspective

1 Introduction
Manufacturing companies are attempting to navigate through industrial digitalization and adopting new digital tools anticipating improvement of their production efficiency and competitiveness in an evolving global economy. One area potentially benefitting from support of the application of digital technology within the era of Industry 4.0 (I4.0) is production planning and control (PPC) [1]. Nevertheless, manufacturing companies may struggle to strategically achieve long-term digital transformation due to difficulties understanding data generated from digital technologies and lack of competences [2]. Recently, Industry 5.0 (I5.0) has arisen, emphasizing the creativity and intelligence of humans in co-operation with intelligent machines to obtain user-favored manufacturing solutions [3, 4], thus, accentuating the human-centric perspective and the need to acknowledge employee involvement, striving towards trust, and new competence to achieve sustainable industrial digitalization when moving from manual to digital production planning and control.

PPC aims to deliver products on-time, in the correct amount, and in the right place to a suitable cost, and becoming PPC results in, e.g., high inventory, long waiting times, obsolescence products, and delays in deliveries [5]. PPC can be complex and stochastic when affected by disturbances [6]. Automated and digital tools for PPC, such...
as advanced planning and scheduling (APS) software, are designed to handle scheduling and rescheduling in dynamic shop floor environments to cope with breakdowns and material shortage [7]. Despite the long-time existence of digital PPC systems [8] and recent developments in I4.0, e.g., Internet of Things (IoT) and big data analysis, manually updated spreadsheets are still used to a large extent [9]. Over the past decades, lean production, a strategy of flow efficiency, has gained industrial interest [10]. More recently, some would argue that lean production cannot continue to be efficient without I4.0 technologies [11]. It is highlighted that I4.0 technologies, such as IoT and big data, are expected to be integrated with lean production, also stressing the human perspective as important for companies to succeed [12]. The evolution of PPC from Industry 3.0 through Industry 4.0 predicts the move towards adaptive, self-organized, big-data driven, collaborative, and digital twins-based scheduling [13]. Such planning requires a high digitalization level of manufacturing, e.g., real-time data collection and big data analysis. However, many manufacturers are still to move fully into the era of I4.0, as they have semi-automated production, older machinery, and a large amount of manual work [14, 15].

Further, certain production characteristics can make the use of I4.0 technologies complex, e.g., implementing fitting scheduling in high-mix low-volume manufacturing remains a challenge, as the properties of both parts and processes are dynamically changing [16]. Among criteria for real-time decision-support system for scheduling are IoT, inventory levels in real time, sensors, and actuators [16]. Big data analytics still have a low implementation level in manufacturing, emphasizing companies’ uncertainties for technical requirements and anticipated benefits of I4.0 [17]. Many traditional manufacturing companies have not reached a high digitalization level yet, turning to analog planning tools or manually handled spreadsheets. Thus, the matter of how manufacturing industry with low digitalization level can take advantage of novel technologies remains. In addition, it shall be realized that in the paradigm shift towards smart manufacturing, all are not able to move at the same pace, and the mindset of employees going through change needs to be considered [3, 15, 18]. Recent research put forth that manufacturing companies have disparate levels of digital maturity and other unique characteristics, e.g., different types and sizes of companies affecting the transformation and performance [19]. Thus, it is stressed that further interdisciplinary research is needed to study the phenomenon of industrial digitalization [19]. Therefore, it is relevant to understand how manufacturing companies can decide how to embrace digital technologies, or choose not to, yet stay competitive, while at the same time the aspects of the human-data-technology nexus are understood.

This study focuses on the implementation and application of an APS software in a manufacturing environment with predominantly manual work and a low level of digitalization and automation. The aim is to study the implementation processes of an APS software to understand the requirements of fruitfully moving from analog planning to next-generation digital tools for decision support in PPC. To understand the complexity of effective technology implementation, the study investigates the requirements through the lens of the Dynamic Capability Framework. The research question posed is: How can the dynamic capability framework be applied to understand the transformative requirements for implementation of digital tools in production planning?

Next, the framework for dynamic capabilities is outlined, followed by method and case description, data collection, analysis, results, discussion, and conclusion.

2 Dynamic capabilities for digital transformation

The framework of dynamic capabilities (DC) was initially designed to explain how organizations achieve and sustain competitive advantages [20]. More specifically, the framework focuses on the actions taken by an organization to adjust current resources and to continuously adapt to and build advantage in elusive environments [20], here referring to industrial digitalization. DCs stem from a resource-based understanding of financial, technological, human, or supplier chain assets and the organizational capacity to modify resources [21]. Thus, the DC framework designed by [20] is adopted in this study and applied to highlight how an organization may fruitfully utilize its resources [22]. Moving from analog planning to next-generation digital tools for decision support in PPC implies changes to, e.g., company processes. Thus, it can be argued that understanding DCs is essential to implement novel technologies successfully [23].

DC comprises three core capabilities: sensing opportunities and threats, seizing opportunities, and transforming by organizing resources to companies’ envisioned utilization [24]. Sensing opportunities and threats involve activities such as scanning, creating, learning, and interpreting [24]. To carry out meaningful sensing activities, there is a need for the organizational routines to be related to identified underlying activities [23]. However, it may be significantly more challenging for established companies to predict and take advantage of novel technologies [25]. As envisioned, digital tools may challenge established standards, and changes in company processes may require structural changes to be captured [2]. Seizing opportunities relates to sensing capabilities as sensed opportunities need to be addressed through new products, processes, services, or a combination [24], hence, the capacity to capture the sensed value [23]. However,
organizations frequently sense opportunities and threats but fail to seize value due to many reasons, such as lack of commitment, risk management, or financial concerns [24]. Transforming capabilities is the means of reconfigure organizational processes [26]. Transforming capabilities play an essential role in transforming existing resources to align with new strategies, building new resources, and supplementing current gaps in an organization’s resource base [26].

These comprehensive groups of core capabilities are widely used in the literature [20, 22–24, 26] and are applied in this study to analyze transformative requirements of implementing digital tools in production planning.

3 Method

This section includes the case description, presentation of data collection, and an overview of informants, jointly with a description of the data analysis.

3.1 Case description

One large Swedish manufacturing company in the energy sector was selected as the case, herein referred to as the Case Company (CC). CC produces and performs maintenance of cutting-edge, large-sized, heavy, high-quality components in a local and global chain of manufacturing units being part of a large global company. CC has a hierarchical organizational structure, operating at a centralized office level supported by the business functions. The industrial digitalization of the global company is scattered with advanced units as well as units in the early phases of digital transformation. CC has a low level of digitalization and automation with a high degree of manual work, e.g., welding operations. The factory layout is a job shop where similar processes are grouped. The large number of product variants share resources, are routed differently throughout the shop floor, and rework is often routed back to the shop floor, breaking up the production flow further. Those characteristics result in crossing flows and complex planning, which is difficult for employees to overview. In addition, job prioritization is affected by manually overriding production plans due to individuals’ experiences or pressing deadlines.

The case is framed around a production unit at CC, which is in its early phases of digitalization. The study focuses on implementing a digital PPC initiative, an APS software, which is set in relation to analog planning approaches. Characteristically for APS software is applying mathematics to calculate and analyze production schedules considering multiple constraints and performance measures. The intention is to demonstrate improved visibility for on-time delivery and inventory reduction.

3.2 Data collection and analysis

This study was conducted as an explorative qualitative case study, focusing on the implementation processes to understand the transformative requirements of moving from analog planning to next-generation digital tools for PPC. A case study methodology was applied to capture the elusiveness of industrial digitalization by approaching it through semi-structured in-depth interviews with employees and observations in its real context [27, 28]. The term employee is herein applied in a general sense to describe all co-workers at the company. The qualitative approach allowed the informants to give voice to their understanding and interpretation of the complexity when moving from analog to digital PPC.

To sample informants responsible for digitalization of production planning and control purposeful sampling was applied. This choice of sampling was strategically made to capture informants’ perceptions and understanding of the phenomenon studied related to the research question [29]. Further, to identify informants, snowball sampling [29] was applied, meaning that one informant recommends the second who refers to the third and so on as a dynamic social process conveyed over time [30]. The phenomenon investigated is elusive and difficult to grasp and thus requires a sampling technique which allows to find hidden, hard-to-reach, and conflicting groups of informants [31].

The study took place over a period of 9 months (October 2020 – June 2021), investigating the case currently and in retrospective between the years 2019 and 2021. The case study comprises 17 in-depth interviews with technical, quality, production, and logistics functions, functions responsible for digitalization development, and corporate service functions such as HR, IT, and business administration, to get an encompassing understanding from different functions, see Table 1. In one of the interviews, two informants took part (13a, 13b); hence, a total of 18 informants are included. All interviews were digitally conducted due to restrictions of the Covid-19 pandemic and were recorded with informed consent.

The qualitative approach yielded an analysis of different informants’ interpretation of production planning, either only planning or in relation to organization and digitalization. As illustrated in Fig. 1, the analysis followed a thematic analytical approach in which all collected data were verbatim transcribed. Then, the multidisciplinary group of authors familiarized themselves with the transcripts. Thereafter, the data was jointly analyzed in several rounds, by all authors, in an iterative approach following a thematic analysis [32].

Initially, 141 excerpts were selected in the collected data material of 14.3 h of recorded material. In the second sorting, excerpts directly related to the implementation of the APS software were picked out, resulting in 59 excerpts that were analyzed through the lens of the Dynamic Capabilities

 Springer
Framework core capabilities as: sensing opportunities and threats (31 excerpts), seizing opportunities (24 excerpts), and transforming (4 excerpts).

To reach a deeper insight into dynamic capabilities concerning the implementation of digital production planning tools, the authors were inspired by a narrative approach when collecting and analyzing the interview data and thus presenting the result as a narration revealing employees’ views and experiences [33]. The narrative approach to structure the results has been specifically chosen as this format gives emphasis to an interpretative and more descriptive understanding of the digitalization initiatives in the production planning and control, thus, unboxing the employees’ elucidations of the human-data-technology nexus implementations. After a mutual agreement of analysis, a total of 16 excerpts were selected as key to the narrative.

4 Result and discussion

This section outlines the results narratively as a story told over time. The narration is followed by a discussion of what occurred during the narrative discussing how and why the story enrolled as it did.

4.1 DC framework to understand the transformative requirements for implementation of a digital tools in production planning: a narrative

The results are narratively presented to explain and illustrate how CC moves back and forth through the phases of the DC framework as they strive towards improving PPC. Throughout the narrative, excerpts are included marked with the informants’ IDs and the phases of the DC framework that the excerpts refer to. The narrative covers the development of the PPC over a period of approximately 3 years, 2019 – 2021. As the data collection through the interviews began in 2020, informants reflect both on the current state and back in time. Also, organizational changes and restructuring of the management group took place during this period. CC has a traditional job shop layout, large product flora, a high rate of rework, and increasing order intake. CC has applied an Enterprise Resource Planning (ERP) system coupled with Excel spreadsheets over several years, and in parallel CC keeps those when introducing new specific planning approaches for PPC. Further, no approaches related to lean production, such as flow boards, 5S, or Value Stream Mapping, have previously been applied at CC.

Figure 2 outlines how CC moves stepwise and between the DC phases, showing the different initiatives of PPC over time. After an initial short trial with flow boards, CC implements an APS software and, in this case, partly reaches the phase of transforming but keeps returning to the seizing phase, which is shown as a loop between those phases, the dotted arrows in Fig. 2. Then, a decision is made to withdraw the APS software entirely. Thus, this digital tool is not implemented to its full use, and instead, CC decided to attempt anew to implement analog flow boards, see the right side of Fig. 2.

To begin the narrative, CC employees seemed aware of the move towards increased digitalization illustrated in the two following excerpts:

“For me, digitalization is a paradigm shift... Today we are very document-based” (8, Sensing).

“Still [use] paper and pencil on the production floor” (1, Sensing).

Further, the employees realized the planning complexity, and there seemed to be a consensus among employees...
at CC that PPC needed to be more efficient, illustrated in the following excerpts:

“I think we are limited by our factory layout” (4, Sensing).
“We have about a thousand orders in progress, and we are four planners who will keep track of 250 orders each. No! It’s not possible! It’s inhuman” (6, Sensing).
“We have not acted on the (increase in) volumes we have seen” (5, Sensing).

The above excerpts demonstrate the need for understanding improved PPC and CCs’ considerations to different approaches to improving PPC. Analog boards to visualize production flows and operations (flow boards) was the first approach to be tried, though this proved hard to implement, illustrated by the excerpts:

“There was so much resistance to order, visualize and introduce the flow boards” (2, Sensing).
“The planning department said we cannot have the flow boards because they will mess up the APS software” (2, Seizing).

Before the initiative with the flow boards developed into the DC framework’s transformation phase, this initiative was overridden by upper management’s decision to implement an APS software. The initiation of the APS software meant that CC retracted its steps to the sensing and seizing phases, as illustrated here:

“In the beginning it [the APS] was not fully developed, so it also had a very large instability” (4, Sensing).
“The APS was updated once a day, but in one day quite a few changes in production can happen, it was not that flexible” (15, Seizing).

Going into the phase of seizing, CC are struggling to adjust and follow the plan by the APS software; the excerpts below show movement between the phases of seizing and transforming:

“One challenge is that everyone should believe in the plan, so that you actually do what is planned. The next challenge is that those who are in a hurry and do not want to follow [the plan] stand last in the queue” (6, Seizing).
“The APS software was very, very good, I think. The downside to it was that it was not updated live.” (4, Transforming).
“It is always inconvenient when a system says that it actually looks this bad. And that acceptance is a company not always is ready to take” (11, Transforming).

In relation to this, a point recurs in the interviews of the difficulty of finding time to work with improvements—a point that increases the risk of getting stuck in the sensing phase, illustrated by:

“We do not have time to work with what might be very value-creating for the customers” (8, Sensing).

The implementation of the APS software proved difficult due to the disinclination to trust the APS software, and thus orders were prioritized outside the APS software plan. Though some believe the APS software could have worked if there was a consensus to follow it, but as it turned out the planning made by this software was constantly overridden. This lack of trust may indicate why CC gets stuck in between the DC phases seizing and transforming. Eventually, this led to the removal of the APS software and thus transported CC’s attempts of improving PPC back to the sensing phase, and instead a second try with analog flow boards was embarked upon. When we leave the narrative, CC has reached the seizing phase with analog flow boards as PPC method, illustrated by the following excerpts:

“We have gone back in development to moving operations on a flow board manually. It became easier and clearer...because it gave a sense of safety” (7, Seizing).
“It’s about getting employees to understand the big picture. Where are we going? And understand your role in the production flow...you must visualize the production flow to understand your role in this” (15, Seizing).

“We do not master our processes, but if we learn our processes, we will constantly get better” (14, Sensing).

When we leave the narrative CC is moving towards the transforming phase with the flow boards approach.
5 Discussion

Throughout the interview study, there seemed to be a consensus among employees that CC needs to improve their production planning and control, especially as it is highlighted that production variations are significant, and the order intake is increasing. However, there are different ideas of how and what approaches to improve PPC that should be chosen. CC seems to lack a coherent view of how to approach the planning and what strategies to work towards as they move between analog and digital approaches. To sense activities towards improving PPC, there is a need for embedded organizational routines related to underlying activities [23, 24]. The employees emphasize that aspects such as crossing production flows and disparate products variants make planning difficult, and they request a better understanding of how to manage such production characteristics.

Consequently, the scattered understanding of the production traits may make it more challenging to succeed with the implementation of novel approaches and digital tools if the holistic aspects of the production characteristics are not fully grasped. In other words, the routines related to underlying activities are not clearly defined. For traditional manufacturing companies, sensing capabilities to predict, take advantage of, and implement new approaches and novel digital tools could be even more challenging due to organizational historicity [25], as shown in CC. This underlines the importance of communication for a shared understanding and joint identified strategies of the planning needs before embarking on new approaches and novel digital tools. If one does not grasp the production traits, one cannot seize to implement and apply a new planning system. Further, the consequences of overriding the plan by manual re-prioritization need to be realized, as such undertakings may result in production backlog, overwork, and rework.

After applying the digital planning solution of an APS software, CC retraces its steps and begins anew with an analog approach of physical flow boards in production. Reconfiguring means is argued to be imperative for transforming existing resources and activities [19, 23]. Indeed, CC retraction the steps may be a reaction to recognizing the importance of understanding the production characteristics before embarking digitalization. However, manufacturing companies fail to seize the value for many reasons, such as lack of commitment, aversion to risk, or financial reasons [21, 24]. If the manufacturing setting has a low automation level and mainly manual work, is it necessary to begin with an analog planning approach to move forward? It can be argued that this is not the case; somewhat digital technologies can make lean production more effective and reduce its limitations, such as poor customization [12], and improve flexibility and productivity [13]. In the case described here, CC returned to an analog lean approach. An advantage may be that it enhances employee involvement and thus supports an improved understanding of the production. If this is the case, then the nexus between humans and technology is missing, arguing that understanding the production characteristics should be facilitated from a human-centric perspective [2]. This since traditional manufacturing companies may find it much more challenging to adapt to standardized technological solutions [4]. CC failed to implement analog flow boards the first time around, running into much resistance and the incentive did not seem strategically anchored. Thus, the company culture of resisting change, scattered trust in the PPC system, and overriding planning decisions have impacted analog and digital approaches, e.g., manifesting challenging historicity within CC [25]. Rather than working scattered across the production job shop and risking sub-optimization, it is vital with coherent and holistic strategies, thus, mutually working towards continuously keeping fruitful communication between employees to build and sustain an adaptive community [15].

In this case, reversing to analog planning can indicate a higher level of comprehension of their production characteristics. CC may have realized the need to find solid ground before reconfiguring their search for and navigation through the winding roads of industrial digitalization. To illustrate this, Fig. 3 displays the DC phases from bottom to top in a triangle shape with an arrow in the Y axis pointing upward to visualize and highlight the increasing understanding of the production characteristics. The triangle in Fig. 3 is divided in three areas where the DC phases that CC has gone through to address their PPC are shown from bottom to top and indicating the time frame in years in each area and thus emphasizing that the understanding is higher in relation to historicity. The three areas of the triangle are increasing in size in the upward direction, symbolizing the increased understanding of the production characteristics throughout the different attempts of addressing PPC and moving through the DC phases. To emphasize the upward pointing arrow shows the higher and broader, i.e., more holistic, understanding of the PPC needs for CC’s production characteristics, hence, accentuating a cumulative knowledge building of identifying production characteristics in relation to introduction of new techniques for production planning and control in the organization.

To summarize, this study has outlined a case of finding suitable solutions to PPC, studying the implementation of an APS software in relation to an analog approach with flow boards. The data collection from the interview study was analyzed through the Dynamic Capability Framework indicating the phases of sensing, seizing, and transforming to understand the processes of change in the era of digital transformation. As a response to the technocratic understanding of
industrial digitalization, a more human-centric perspective, Industry 5.0 (I5.0), has arisen [4], thus, reasoning that industrial digitalization requires human-centricity and incremental steps of change when implementing new incentives [15]. This is illustrated by the results herein; when aiming towards successful, sustainable, and resilient production planning and control it is essential to apply clear and common strategies in which the human-centric perspectives are in focus. The use of digital tools for PPC shall not be discarded, especially as the study demonstrates implications of what is required to succeed in the next iteration of industrial digitalization.

### 6 Conclusion

The DC framework has been applied to study transformative requirements for implementing digital tools for PPC. The study contributes a deeper insight into how traditional manufacturing companies navigate industrial digitalization, struggling to merge human and technology perspectives while moving from manual to digital production planning and control. Enriching for the study has been the multidisciplinary research group setting of authors with expertise and perspectives from production systems and logistics, information systems, and organizational sciences, contributing to a multifaceted understanding of the studied phenomenon.

This study concludes that, to link human and human, and human and technology in manufacturing corresponding to the emerging Industry 5.0, it is vital that employees understand the production and its characteristics before embracing new technologies. If the production characteristics are unclear to company employees, the company can neither sense or seize how to use new technology, nor be capable of trustworthy decision-making to transform production planning and control in a sustainable and resilient manner. Furthermore, employees have limited understanding of the overall consequences of not following the plan, e.g., the effect of overwork, delays, quality issues, rework, and manually re-prioritizing orders. Thus, there seems to be a prerequisite ability to grasp and comprehend the holistic view and

---

**Fig. 3** Overview and analysis of the DC phases that CC has gone through to address their PPC illustrating the increased understanding of CC’s production characteristics.
understanding of the production. Potentially, this can be overcome by avoiding employees working in scattered clusters. Arguable, the importance of communication between employees on all levels to jointly understand the production characteristic and the company’s needs is essential. Moreover, it is recognized that industrial digitalization needs incremental steps when implementing digital production planning and control. Simply digitalizing industrial processes does not necessarily generate a system that will automatically give a prosperous production. This study clearly shows that employees need to understand the holistic production system before digitalization. This aspect is essential to grasp, by all employees, as part of the development towards increased collaboration of human intelligence and intelligent machines that is the focus of Industry 5.0. The added aspect of human-centricity is especially vital in traditional, low-level digitalized manufacturing, thus, concluding that the nexus between human and technology cannot be dismissed when deciding whether to digitalize or not.

There may be limitations because of the single case study and the sampling technique applied; thus, it is encouraged in future studies to cover more functions and/or multiple cases. The intent of this study was to identify employees and functions relevant for the posed research question and to put forth the in-depth understanding through a narrative approach highlighting the human-technology nexus contributing to the emerging I5.0 research. Future work in this field is encouraged to take a human-centric perspective when studying and understanding how the manufacturing industry and, production planning and control, can become sustainable and resilient.

Author contribution All authors contributed jointly to the multidisciplinary approach of the study conception and design. Material preparation, data collection, and analysis were performed by KME, LC, and AKO. The first draft of the manuscript was written by KME, and then all authors commented and revised the manuscript. All authors read and approved the final manuscript.

Funding Open access funding provided by University West. The study was carried out within the AHIL-project, Artificial and Human Intelligence through Learning, funded by the Swedish Knowledge Foundation, Grant number 20200035*, and University West.

Declarations

Competing interests The authors declare no competing interests.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

10. Modig N, Ahlström P (2016) This is lean resolving the efficiency paradox. Rheologica Publishing, Halmstad, Sweden

Publisher’s Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.
Paper 4

Strategizing organizational capabilities for industrial digitalization – exploring managers’ technological frames

Linnéa Carlsson

Published in "Journal of Manufacturing Technology Management"

Emerald Publishing Limited, 2023

Printed and published with permission
Strategizing organizational capabilities for industrial digitalization – exploring managers’ technological frames

Linnéa Carlsson
University West School of Business Economics and IT, Trollhättan, Sweden

Abstract
Purpose – This study draws on technological frames to provide an understanding of organizational processes of strategizing by exploring how strategizing organizational capabilities for industrial digitalization could be understood through managers’ perceptions of digital technology applications. This study complements earlier research focused on industry outcomes by addressing technological frames to understand how strategizing organizational capabilities within industrial digitalization may provide insight into socio-cognitive aspects which may affect technology-induced organizational change.

Design/methodology/approach – The single case study uses 14 in-depth interviews collected over two years (October 2020 to February 2022). The study follows an interpretative research design exploring managers’ perceptions of industrial digitalization through a digitalization project.

Findings – The case study contributes to research by emphasizing socio-cognitive aspects through technological frames exploring how and why managers’ perceptions of industrial digitalization affect strategizing organizational capabilities. The study contributes to practice by bringing attention to the disparate views of industrial digitalization. By illustrating how socio-cognitive aspects shape organizational capabilities, this study offers managers valuable insight into the relationship between an organization’s capabilities, the individual and the shared structures affecting a digitalization project.

Research limitations/implications – The case study is limited to Swedish manufacturing industries and is not aiming to be transferred or generalized to other industrial contexts or countries.

Originality/value – This study recognizes that strategizing organizational capabilities depends on managers’ ability to illuminate the socio-cognitive aspects. Hence, the study contributes to practice by bringing attention to the disparate views among managers on the enhancement efforts made using digital technologies.

Keywords Industrial digitalization, Strategizing, Organizational capabilities, Socio-cognitive aspects

Paper type Article

1. Introduction
Digital technologies used in the manufacturing industry, such as artificial intelligence, cloud computing and the Internet of Things, are part of the larger dynamic environment referred to as industrial digitalization (Colli et al., 2022; Savastano et al., 2022). Industrial digitalization as context reflects the enhancement efforts made using digital technologies within manufacturing organizations towards production (Carlsson et al., 2022). Digital technologies often affect all functions of an organization and even cross firm boundaries impacting, i.e. products and business processes (Matt et al., 2015) - challenging existing ways of doing business. In this context, it has been argued that it is not a specific set of dynamic capabilities required, but the organizations capabilities to enhance digital technologies (Henderson and Venkatraman, 1999). Or the capability of an manufacturing organization to

© Linnéa Carlsson. Published by Emerald Publishing Limited. This article is published under the Creative Commons Attribution (CC BY 4.0) licence. Anyone may reproduce, distribute, translate and create derivative works of this article (for both commercial and non-commercial purposes), subject to full attribution to the original publication and authors. The full terms of this licence may be seen at http://creativecommons.org/licences/by/4.0/legalcode

The current issue and full text archive of this journal is available on Emerald Insight at:
https://www.emerald.com/insight/1741-038X.htm
continuously explore the basis of digital technologies. Given this, organizations may act depending on their ability to strategize organizational capabilities within industrial digitalization (Spieth et al., 2021; Volberda et al., 2021).

Strategizing is a dynamic organizational process of acknowledging potential tension between exploiting existing plans, ideas, resources, while exploring new and emerging means to achieve organizational objectives through activities (Marabelli and Galliers, 2017), such as enhancement efforts made using digital technologies. Given this, strategizing is a social process in which challenges associated with digital technologies are discussed and worked through by individuals and the collective (Volberda et al., 2021).

A challenging part of strategizing is argued to be balancing exploiting existing organizational capabilities while building new ones (Warner and Wager, 2019) since managers rely on socio-cognitive structures to untangle the complexity, referred to as “technological frames”. Technological frames (TF) describe the assumptions, expectations and knowledge individuals use to understand a technology’s application and consequences in a specific context (Orlikowski and Gash, 1994), for instance, the use of digital technologies within manufacturing production. In addition, a manufacturing organization comprises multiple individuals with diverse specialties, competencies and incentives, all of which are argued to require coordination for significant digital technology advancement (Carlsson et al., 2022; Eriksson et al., 2022; Orlikowski and Gash, 1994). This implies that to untangle the complexity of technology-induced organizational change, managers must interpret, assess and select appropriate digital technologies (Spieth et al., 2021). As such, organizational capabilities complement managers’ TF related to technological advancement (Mishra and Agarwal, 2010), emphasizing the importance of understanding how socio-cognitive aspects may shape strategizing organizational capabilities.

The overarching concept of organizational capabilities embraces a collection of capabilities that depend on the organization’s dynamics (Teece, 2012; Teece et al., 1997). Organizational capabilities are defined by an organization’s abilities, skills and accumulated knowledge that enable an organization to continuously create value (Li et al., 2017; Mishra and Agarwal, 2010). Furthermore, they are characterized by an organization’s ability and reliability to be at least minimally satisfactory in an identified process given the environment (Demeter et al., 2021; Li et al., 2017).

Industrial digitalization does not simply start and end on the shop floor or in management at managerial levels. Instead, it can be contextualized to every part and aspect of the manufacturing organization, its formal and informal organizational structures, and its various individuals and functions (Björkdahl, 2020). This complexity of industrial digitalization makes interpreting and assessing digital technologies challenging (Azad and Zablith, 2021; Becker and Schmid, 2020). Previous research reports how managers might struggle to sense and seize digital technologies (Demeter et al., 2021). For instance, against what criteria digital technologies should be validated and how they might affect the organization (Vial, 2019). Research on managerial perception has shown that managers’ interpretation of the environment affects an organization’s response to environmental-driven change (Grewatsch and Kleindienst, 2018). How a manager’s assumptions, knowledge and expectations affect organizational abilities, skills and accumulated knowledge is an understanding or interpretation of what meaning or use managers have entitled them to (Eggers and Kaplan, 2013; Mishra and Agarwal, 2010). It is also suggested that organizational capabilities influence a manager’s perceptual ability to recognize ways to improve competencies and identify opportunities to apply them (Teece et al., 1997). In this sense, organizational capabilities exist as managers interpret them, and in turn, the interpretation of organizational capabilities’ purpose depends on being seen as useful or meaningful (Grewatsch and Kleindienst, 2018). Thus, understanding organizational capabilities should be guided by socio-cognitive aspects, given that a particular context...
shapes managers’ frames and thus affects how managers assemble and develop organizational capabilities (Demeter et al., 2021; Grewatsch and Kleindienst, 2018).

This study aims to explore how strategizing organizational capabilities for industrial digitalization could be understood through managers’ perceptions towards digital technology applications—drawing on the TF framework to provide understanding into organizational processes of strategizing. As such, the following research question is posed:

How may strategizing organizational capabilities for industrial digitalization be understood through managers’ perceptions of digital technology applications?

2. Theoretical background
2.1 Technological frames
A large amount of research on IT in organizations has found that individuals form perceptions of technologies during the practice of work (Orlikowski and Gash, 1994). TF was first introduced by Orlikowski and Gash (1994), referring to frames as social constructs that include “assumptions, knowledge and expectations expressed symbolically through language, visual images, metaphors and stories” (p. 175). For example, how industrial digitalization is spoken about or how consensus on means in digital technologies is reached.

By examining sensemaking related to information technology in organizations, Orlikowski and Gash were able to identify frame content in a new context for socio-cognitive perspectives covering three domains: (1) the nature of technology, which refers to the individuals’ interpretation of technology and their understanding of its usefulness and meaningfulness; (2) technology strategy, which refers to the user’s view of why the organization needs to implement the technology; and (3) technology in use, which refers to individuals understanding of how the technology can be used in the everyday practice and the possible consequences related to this (Orlikowski and Gash, 1994). These domains indicate context dependency and facilitate interpretative analysis of an individual’s understanding, perceptions and use of technology at various organizational levels and throughout an organization, e.g. managers, engineers, designers and so forth. Thus, TF is applied to address individuals’ experience and interpretation of digital technology to illuminate how frames may shape strategizing organizational capabilities.

In an organizational context, it has been argued that the dynamics and potential challenges of configuration and re-configurations of frames are essential for technology-induced change (Klos and Spieth, 2021). A manager who interacts with new digital technology evaluates its usefulness concerning the presumed work task (Mishra and Agarwal, 2010). When confronted with new technology, TF is often seen as a socio-cognitive sensemaking structure applied by individuals and groups (Klos and Spieth, 2021). As such, managers draw on assumptions, expectations and interpretations to make sense of and process new information individually and collectively, forming socio-cognitive aspects that may guide a manager to understand consistent problems and constrain reactions to new information (Davidson, 2006; Raffaelli et al., 2019), i.e. the application of digital technology. Thus, the sensemaking activity is carried out through managers’ socio-cognitive structures of knowledge that relate to a potential technology-induced change.

TF exhibit a diagnostic dimension, i.e. sensing the problem and a prognostic dimension, which includes seizing a solution for the identified problem (Mishra and Agarwal, 2010). In addition, it is suggested that TF are flexible in structure and content and may shift over time (Högberg and Olsson, 2019). This understanding implies that the formed understanding of digital technology is fluent. Arguing that TF act as a socio-cognitive filter, directing managers’ attention but also filters contextual information inconsistent with existing frames (Davidson, 2002). As such, individual frames may be incongruent with others’
understanding of the usefulness and meaningfulness of digital technology (Orlikowski and Gash, 1994).

Herein, TF is understood as a collectively constructed set of assumptions, expectations and knowledge concerning technology and its uses and applications in an organization, based on the socio-cognitive processes by individuals and the collective, see Figure 1.

The concept of TF is adopted to explore the mutual shaping of frames by managers and the collective during strategizing organizational capabilities, given that frames act as interpretive filters favoring cues consistent with an existing frame (Davidson, 2002). Both managers’ frames and their effects on the collective and organizational belief system are thus given attention.

2.2 Socio-cognitive aspects of organizational capabilities

Organizational capabilities are a complex bundle of abilities, skills and accumulated knowledge that allows an organization to perform activities generating value (Mishra and Agarwal, 2010). Organizational capabilities are not fixed but may evolve and change over time (Li et al., 2017) and are influenced and responsive to the dynamic environment (Teece, 2012), such as industrial digitalization. Organizational capabilities responding to the dynamic environment consist of activities clustered into three core dynamic capabilities: sensing, seizing and transforming (Teece, 2007). These core capabilities are structured by abilities, skills and accumulated knowledge that enable an organization to create value continuously (Li et al., 2017; Mishra and Agarwal, 2010). In addition, it has been argued that carefully developed knowledge-related assets, as mentioned, give greater flexibility in a dynamic environment (Kyläheiko and Sandström, 2007).

Technology-induced change in an organization is argued to involve the ability to sense and seize potential challenges and opportunities of digital technologies. The transformation of an organization is often related to change and, therefore, also closely related to an interpretative process of making sense (Colli et al., 2022; Demeter et al., 2021).

As manufacturing organizations may “evaluate their ability to sense opportunities in digital technology, strengthen their organization ability to seize large market opportunities, and propose the competitive capability of transforming their business” (Lin et al., 2020, p. 409). Depending on the context and the associated individuals, sensing and seizing may result in inconsistent information triggering socio-cognitive inertia in managers, which risks spreading in an organization through interaction (Young et al., 2016). For example, a manager working within a job shop may evaluate the usefulness and meaningfulness of a
particular digital technology differently than a colleague in another job shop – despite being bound by the same organization. In this sequence of events, organizational actions depend on how management allocates attention to information and how such information is interpreted (Ocasio, 1997; Raffaelli et al., 2019).

When a manager tries to handle the endless stream of competing and conflicting information and actions, understanding organizational capabilities can support managers in building a competitive advantage (Carlsson et al., 2021). Volberda et al. (2021), for instance, argue that digital technologies not only affect how an individual makes use of and responds to information but also that the role of different individuals impact strategizing. An individual acts upon her interpretation of industrial digitalization, and her understanding must change if their actions are to change. In strategizing organizational capabilities, it becomes essential to understand how managers make sense of digital technology in relation to industrial digitalization. As such, the socio-cognitive aspects represent a dominant collective understanding of the prevailing organization’s actions and objectives and the opportunities the organization may pursue to reach a more prosperous production.

3. Research study
The study explored how a local digitalization project was understood and acted on by managerial functions responsible for untangling the identified core areas and managers steering the project. Given that the aim never was to draw generalized assumptions but through exploration understand what potential socio-cognitive aspects of managers’ perceptions that affect the technology-induced change while configuring and re-configuring for technological adjustment.

3.1 Case description
With two sites in Sweden, Alfa (a pseudonym) employs around 2,500 employees. Like many other Swedish manufacturing organizations, Alfa has a hierarchical structure operating through local production units at the centralized office level. The central level coordinates through policies set by headquarters, operating both from Sweden and global offices. One of the most influential policies is the strict “business case” structure that controls digital initiatives’ identification and project building, such as a digitalization project. Alfa has a separate digitalization office that sets corporate standards and supports manufacturing functions.

One production unit specializes in additive manufacturing (AM) with powder solution producing new equipment, spare parts on-demand and repair work. In 2015, the AM production unit began a digitalization journey referred to as the “Digitalization project” (pseudonym), aiming toward the envisioned use of 3D printing. Alfa identified the need for a documented process and an increased machine learning capacity to leverage the production process. To do so, Alfa worked until 2018 to identify core areas lacking competence, skill, or technological advancement to achieve a more prosperous production. Between 2020 and 2022 Alfa focused on analyzing identified core areas for the next phase of the Digitalization project. The next and final phase of the Digitalization project is the aim of the AM job shop to be a closed-loop and self-healing process where spare parts and other necessities are ordered by themselves. This envisioned autonomous workshop is projected to be reached by 2025.

3.2 Data collection
The interpretative single case study follows Alfa in its Digitalization project over two years (2020–2022), surrounding the AM workshop as they set off to identify critical characteristics for taking the next step in their established industrial Digitalization project, e.g. reaching for a
more prosperous production. It must again be emphasized that despite the potential difficulty or undesirability in summarizing a case study, the case-study method contributes to the cumulative knowledge (Flyvbjerg, 2006), as per the focus in this study.

Following Yin (2018), the data collection was iterative and included information and data for formulating pre-understanding as well as for data analysis. The interpretative approach facilitated exploring the dynamic environment (industrial digitalization) and the TF affecting the project. This approach allowed for actively reflecting and iterating between data and theory (Walsham, 2006) to illuminate managers’ assumptions, expectations, choices and actions throughout the research process.

Notes from six Digitalization project meetings during 2022 formulated a pre-understanding of the Digitalization project and the prospected technology-induced change within Alfa. Access to nine documents formulated the preunderstanding of the case-study context: visionary documents; policy documents of Alfa’s culture; digitalization project white papers.

In-depth interviews (see Table 1) were used for the data analysis. Interviews were conducted in three rounds throughout the two years of the case study (2020; 2021; 2022). Informants spanned several managerial functions related to the Digitalization project at the AM workshop. Since the data collection was iterative, two informants (I1 and I9) participated in two interviews. In total, 12 informants were interviewed.

The interviews followed an open-ended procedure, asking how each identified informant interprets the usage and assessing what autonomous workshop entails, i.e. their interpretations, assumptions and expectations of industrial digitalization. All interviews began with questions concerning the informants’ work tasks and functions, their involvement in the Digitalization project, and their understanding of industrial digitalization. In addition, they were asked about relationships and collaboration across work groups, e.g. “Can you describe what [core area] in relation to industrial digitalization mean for you?”, “How is industrial digitalization spoken about in your workgroup?”, “Is there a consensus on value and means relative to industrial digitalization”. The informants were also asked to reflect on why and how their interpretation of digitalization could affect their strategic work, which was relevant when analyzing individual and collective frames of reaching a more prosperous production.

3.3 Data analysis

The analysis facilitated an examination of various informants’ perceptions of the Digitalization Project and their knowledge, assumptions and expectations towards and

<table>
<thead>
<tr>
<th>ID</th>
<th>Date of interview</th>
<th>Managerial function</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1A</td>
<td>Oct 2020; Sep 2021</td>
<td>Chief executive officer</td>
</tr>
<tr>
<td>I2</td>
<td>Nov 2020</td>
<td>Group manager business development</td>
</tr>
<tr>
<td>I3</td>
<td>Dec 2020</td>
<td>Program manager: model-based definition</td>
</tr>
<tr>
<td>I4</td>
<td>Jan 2021</td>
<td>Product developer</td>
</tr>
<tr>
<td>I5</td>
<td>Jan 2021</td>
<td>Business developer</td>
</tr>
<tr>
<td>I6</td>
<td>Jan 2021</td>
<td>Business developer</td>
</tr>
<tr>
<td>I7</td>
<td>Mar 2021</td>
<td>Production manager: AM</td>
</tr>
<tr>
<td>I8</td>
<td>Apr 2021</td>
<td>Head of digital PLM</td>
</tr>
<tr>
<td>I9A</td>
<td>Apr 2021; Aug 2021</td>
<td>Group manager: digitalization of AM</td>
</tr>
<tr>
<td>I10</td>
<td>Jan 2022</td>
<td>Project manager: AI</td>
</tr>
<tr>
<td>I11</td>
<td>Jan 2022</td>
<td>Head of cyber security</td>
</tr>
<tr>
<td>I12</td>
<td>Mar 2022</td>
<td>Group manager: VR and AR</td>
</tr>
</tbody>
</table>

Table 1. Overview informants

Source(s): Authors work
within it. The analytical process followed a reflexive approach through abductive engagement with the data and theoretical reasoning (Alvesson and Sköldberg, 2017). The process aided in interchangeably developing, testing, verifying and understanding events seen in the data. This approach emphasizes the interplay between empirical data realized through real-world problems that are inductively obtained in combination with influences from theory that are deductively inferred by viewing data from a theoretical viewpoint or perspective. This tandem nature of the analytical process was conducted to formalize an interpretative understanding of the informants’ perceptions regarding the digitalization project in the light of TF to explore patterns of meaning. An interpretation of individual frames was developed by focusing on the informants’ stories, metaphors and expressions (Davidson and Pai, 2004). Hence, applying a socio-cognitive perspective on informants’ perceptions to understand theory and, in time, empirically formed themes parallel through conceptualization.

The analysis came to recognize the situated aspects across the case while striving for patterns of meaning developed through coding. The coding of the material was reflexively thematic and influenced by the framework of TF. The analytical process included six steps (see Figure 2).

The first step was the act of reading and understanding the content in all data sources, particularly the recorded material (11 h). Systematically, data segments were carefully read through, potentially critical data points were highlighted, and excerpts extracted. This step resulted in 97 initial excerpts in the data set.

The second step was initial data interpretation. This immersion with the data gained deep insight into the content and the need to ask critical questions since being deeply engaged in the dataset—continuously asking why and how generated an initial label to each excerpt (See Table 2).

The third step was to link each initial label to the technological frames (Orlikowski and Gash, 1994). The analytical attention shifted from smaller meaning units to larger patterns

<table>
<thead>
<tr>
<th>ID</th>
<th>Excerpt</th>
<th>Initial label</th>
<th>TF</th>
<th>Initial theme</th>
<th>Theme refining</th>
</tr>
</thead>
<tbody>
<tr>
<td>I4</td>
<td>“There is probably a lot for free. We do not have to reinvent the wheel; enlist the help of other projects around the business within Alfa [pseudonym]. It is a huge company; if you can use everything around here, it is almost a digitization project to capture what already exists”</td>
<td>Resources throughout the organization; communicate throughout the management team</td>
<td>The nature of technology</td>
<td>Communicating. An experience of misalignment in both communication and competence concerning the individual understanding; willingness to learn with the employees or change structural circumstances</td>
<td>Affective collectivism</td>
</tr>
</tbody>
</table>

Source(s): Authors work
of meaning. The initial themes were formulated as comments on the relationship between the initial label and the relation to TF. Contradictions in, or dichotomization, formed the basis of the initial themes as individuals’ frames, along with the collectives, are argued to affect the belief system, i.e. frames.

Given the reflexive nature of the analytical process, the fifth step of theme refining and defining was to reflect upon whether the determined identification displayed common analytical patterns within each TF domain, making up identified socio-cognitive aspects. This step was a process of continuous adjustment, and the refining took several rounds until the three final themes were identified: Affective collectivism, affective individualism and structural framing.

4. Findings
First, the digitalization project is introduced, followed by the identified three socio-cognitive aspects (themes) - Affective collectivism, Affective individualism and Structural framing– regarding individuals and the collective knowledge, assumptions and expectations of the digitalization project and the digital technology application within. The findings reflect managers’ anticipation of industrial digitalization and their efforts in reaching the next step projected within the Digitalization Project.

4.1 The introduction of the digitalization project
The studied digitalization project of Alfa was introduced as a research and development project in 2015 as the AM workshop pursued its Autonomous AM vision. By the end of 2025, the stipulated goal by Alfa is that the AM workshop will have moved from a traditional workshop to an autonomous one.

Managers had interpreted the perceived fitness of the AM workshop as easy to use and assumed that their employees had the knowledge and know-how. The AM workshop and the 3D printing had been perceived as an opportunity to “produce wherever or whenever”, leveraging the value chain with machine learning. However, sensing the opportunity of 3D printing had taken much longer than managers expected, and challenges hindering the AM workshop from capturing the value were seen as necessary to identify. The perceived fitness of the AM process was formulated in eight core challenges: material knowledge, design culture, stand-alone software, training, machine performance, quality issues, health and safety concerns and development speed. The latter was pushed as the most essential as the autonomous workshop would be reached by 2025. An important note is that there is a perceived easy-coming, easy-go mentality toward implementing Digital technologies relative to industrial digitalization. The project manager for AI describes this as employees not having a mutual language or point of reference for digitalization initiatives:

We see the friction: as in where they [colleagues] are currently at and that they [colleagues] need to understand where we are at (I10)

In the citation above, the language in terms of being able to communicate is described as a potential barrier to any further digitalization initiative. Informants explain the communication barrier to differences in competence leading to variety in word usage, definitions of industrial digitalization and misaligned project prospects, e.g. timeframe. Indicating a strong affective process. The Group Manager for Digitalization and Industrialization of AM acknowledged the complexity of the eight identified core challenges:

… We faced opposition from employees saying: no, oh lord, you do not understand anything about the material we receive or how we construct; our software systems are rubbish… no one receives any further education, and we have no engineers trained by any education worthy the name. (I9B)
The quote from the manager illustrates the opposition met when introducing 3D printing from a management perspective. In internal documents, management presented the challenge of capturing the value of 3D printing as: “it is not just 3D printing! It is much more complex . . .” and in one of the Digitalization project white papers, the AM journey came to be presented as both a hype and a “valley of tears”.

The Group Manager for Digitalization and Industrialization of AM elaborated on the complexity:

It was probably not a deliberate misdirection but a lack of knowledge. Management had not realized how hard it is to go through with something, not just the first time – but every time. . . . We faced opposition from employees . . . (I9B)

Among the informants, a rather disparate diagnostic dimension was shown. The sequence of events layered out throughout the years illustrates a challenge in sensing the problem and having a hard time seizing a solution for the identified problem. Nonetheless, individual frames concerning the technology strategy and technology-in-use were strong, albeit inconsistent throughout the two years. As such, it could be argued that the issue might not be the ability to change the mind but the effort of commencing dominant frames from the management’s side. One of the informants’ points this out by saying:

I think we have . . . Partly I think we have different perceptions in the organizations. Where some feel that this [technology-induced change] is more important and others feel that they do not want to be a part of this (I11)

The citation above illustrates how strong individuals’ frames concerning industrial digitalization were during these two years and the contradictions within the organization.

4.2 Affective individualism

In response to the disparate collectivism in the previous theme, affective individualism is characterized by separate units of shared understandings among managers and the solid emotional belief that the manufacturing unit is unique compared to the rest of the organization. The manufacturing management bringing forth the Digitalization Project did not succeed in providing a dominant frame concerning the usefulness and meaningfulness of leveraging 3D printing. An early quote from Alfa’s Chief executive officer shows how not only does the organization lack a collective understanding of industrial digitalization but also that individuals perceive it differently:

I do not think the organization has a definition of what it [industrial digitalization] is. I think there are different perceptions among different decision-makers. (I1A)

Among the informants, a strong affective individualism was illustrated: not having trust in the organization regarding industrial digitalization. Some informants displayed that the experienced individualism may stem from the work, and working life, being tightly connected to the organizational structure organized in silos or closed workshop areas. However, transitioning towards a shared collective understanding and ways of working is a tedious process. The quote below illustrates the efforts to organize employees collectively. Interestingly, managers experience efforts to enhance the organizational structure to create a maze of managers:

If you want to keep industrial digitization together within the group, try it out and explore in one place at a time, and then spread good examples; that sounds very nice in theory. However, we have managed—historically anyway—to make it a bureaucratic fever. That seventy-two decision-makers at very high levels should be involved in things that you may not have full insight into, and they are rather much inhibited as well. (I6)
It is arguably a result of too much dominance on the management level. Despite this, informants showed a strong emotional belief that their respective manufacturing unit is unique to the rest of the organization. Another notion of perceived affective individualism was the need to individually argue for digital initiatives. Currently, managers would need to pass through an incensement of an initiative by formulating a business case. Some promoted this process by saying that Alfa should not be a “playhouse” but instead focus on well-drafted business cases. Others argued that creativity and shared thinking were being suppressed when one had to pursue a business case. The head of digital product life cycle management explains that many employees experience their workshop unique to the rest of the organization, needing tailored solutions to industrial digitalization:

Every single time they [employees] say we are special and we are unique — I start digging into it, and every single time I note that, no, it is not like that at all. … Alpha, I would say, has been a little bit unique since we are doing extremely well … (I8)

The manager’s frame concerning technology strategy is practically the same as his colleagues, whom he stomped upon for saying their unit is unique. This situated frame is one example of managers having different frames for the identified problem. Some of them were aware that this existed yet failed to recognize their dimension to it. This could illustrate the difficulty of diagnosing and prognose problems of organizational capabilities related to industrial digitalization. In turn, managers’ affective individualism could affect the ability to recognize shared organizational action.

Individual managers could share an understanding of why the organization needs to implement digital technologies in smaller coalitions. However, the value of sharing experience was disparate both among individuals and within smaller groups of employees. This disparate sharing of experience can also be interpreted as poor strategy formulation for the Digitalization project. It could be interpreted that the dividing lines between the individual’s understanding of digital technologies and the organizations’ application show an incongruent technology strategy frame. In general, the managers’ frames of technology in use were very much influenced by the visibility of digital technology. The group manager of digital AM expresses this:

I think leveraging industrial digitization and solutions becomes clearer when you remember a time when you have not had it; when you expect digitization to be omnipresent, you might easily become blasé. (B9A)

As the above illustrates, managers say that they have found their way of interpreting and following guidelines from the organization, reflecting the lack of sensemaking among the collective. Although managers might be blasé, they have neither succeeded in communicating how they interpret industrial digitalization nor their everyday use. Given that managers at the various functions did not agree or had the same interpretation of strategy and guidelines, the actual use (technology in use) was affected, and a disparate view of the Digitalization Project grew.

Given that separate units of understanding formalized the “bureaucratic fever”, as previously stated, it could respond to the manifested affective individualism within the workshops and throughout the organization. It could be interpreted as the different individuals having access to different parts of the organization and thus having a different repertoire of frames. Over the two years, informants describe difficulties passing on the meaning of industrial digitalization to colleagues resulting in sheltered resources and competencies. As a result, many of the informants do not share the same understanding of industrial digitalization, while some even have a profound emotionally driven individual understanding compared to the organization at large. These clusters indicate a difference in frames concerning technology in use.
4.3 Affective collectivism
Affective collectivism is characterized by the informant’s firm belief that ideas and solutions to leverage the production process already exist in the organization. Insinuating that informants experience a sense of togetherness. This view was interpreted as shared by the manufacturing unit at large, and the perception of technology implementation and technology use took place at the management level. However, in terms of production managers communicating how to reach the desired value, there is a perception of misalignment in communication and competence among production managers.

Regarding competence, one function might not have enough knowledge or resources to convey the contemporary understanding of the company, working group, or function. All the informants had a background in the manufacturing industry, and most had worked entire careers. In discussions with the informants, this fact was highlighted as a double-edged sword. On the one hand, the great knowledge many of the employees had generated formulated affective collectivism from years of shared experience. On the other hand, it also formulated a systematic perception between managers as well as among them.

The informant’s group perception of leveraging 3D printing in the AM workshop indicated that the perceived usefulness of leveraging digital technologies is highly connected to the overall organizational structure. The chief executive officer at Alfa explains his interpretation of perceived usefulness:

...if you digitize, then one work between flows. You connect purchases with spare parts, with invoicing, and you do it seamlessly—Then you have digitized. (I1A)

Regarding communication, data demonstrated that managers perceived ideas and solutions to achieving industrial digitalization already exist in the organization but are not communicated throughout the organizational structure. The product developer illustrates this frustration by saying:

I think you would need to have the opportunity to capture more things from each other and learn from each other. A group that captures good things but also bad things too—if you work across the organization ... (I4)

The empirical data illustrates that affective collectivism does not allow for abilities, skills and accumulated knowledge to be shared outside groups. Instead, many managers hold on to their beliefs or struggle to share them with those close. This holding of belief is a contradictory behavior, as some of the informants stated that the sharing of accumulated knowledge is an important task:

There is probably a lot for free. We do not have to reinvent the wheel; enlist the help of other projects around the business within Alfa [pseudonym]. It is a huge company; if you can use everything around here, it is almost a digitization project to capture what already exists. (I4)

The quote above illustrates the hardship of paying attention to different organizational and technological frames. While a sense of togetherness through shared collectivism is taking place, attention is not given to how different configurations and accompanying behaviors may be triggered and the consequences of these understandings—arguing that a better approach could be to understand the spectra of technological frames occurring within the various functions and address the affective collectivism of the entire organization.

The manager’s group perception of the Digitalization Project in the organization indicated that they have difficulty formalizing shared meaning. For example, managers expressed that industrial digitalization as a phenomenon still generates many questions on what should be done or not, implicating that the existing frames are not always congruent. In fact, contradictory outcomes are not only due to technological misfits but are also affected by organizational norms, beliefs and routines. The program manager for model-based definition
illustrates the understanding of usefulness (technology strategy and technology in use) as: “For many individuals, industrial digitalization is merely a large cloud”. However, it is also pointed out that industrial digitalization is a worn-out word that merely holds a political status quo:

Industrial digitization as a word will have a value for another 3–4 years if we take the political dimension—precisely the power of digitalization. However, I think we will work with the actual doings of digitization for a long time. I believe it will be like a tool among other tools. No one is saying that you work with automation anymore, but in practice, we do. Nevertheless, the word lost validity as a status marker in the early 90s but we are still working with it. (I1A)

The intent to create congruent technological frames cannot only occur in silos. In Alfa, managers describe the organization’s guidelines (technology strategy) as aspirational, e.g. having visionary behaviors towards industrial digitalization. However, the coherent view of what type of tone and words should be used in the Digitalization Project was not shared. This indicates that the manager’s understanding of industrial digitalization will have an important impact on achieving leverage 3D printing in the AM workshop, but it might not have momentum throughout the organization.

As argued above, shared understanding is essential for sensemaking. Individual managers could share an understanding of why the organization needs to implement digital technologies in smaller coalitions. However, the value of sharing experience was disparate among managers and smaller groups of employees. This disparate sharing of experience can also be interpreted as poor strategy formulation for the Industrial Digitalization project. It could be interpreted that the dividing lines between the individual’s understanding of digital technologies and the organizations’ application show an incongruent technology strategy frame. In general, the managers’ frames of technology in use were very much influenced by the visibility of digital technology. The group manager of digital AM expresses this:

I think leveraging industrial digitization and solutions becomes clearer when you remember a time when you have not had it; when you expect digitization to be omnipresent, you might easily become blasé. (I9A)

As the above illustrates, managers say that they have found their way of interpreting and following guidelines from the organization, reflecting the lack of sensemaking among the collective. Although managers might be blasé, they have neither succeeded in communicating how they interpret industrial digitalization nor their everyday use. Given that managers at the various functions did not agree or had the same interpretation of strategy and guidelines, the actual use (technology in use) was affected, and a disparate view of the Digitalization Project grew. For example, managers expressed that industrial digitalization as a phenomenon still generates many questions about what should be done or not—implicating that the existing technological frames are not always congruent. In fact, contradictory outcomes are not only due to technological misfits but are also affected by organizational norms, beliefs and routines. The program manager for model-based definition illustrates the understanding of usefulness (technology strategy and technology in use) as: “For many individuals, industrial digitalization is merely a large cloud”. However, it is also pointed out that industrial digitalization is a worn-out word that merely holds a political status quo:

Industrial digitization as a word will have a value for another 3–4 years if we take the political dimension—precisely the power of digitalization. However, I think we will work with the actual doings of digitization for a long time. I believe it will be like a tool among other tools. No one is saying that you work with automation anymore, but in practice, we do. Nevertheless, the word lost validity as a status marker in the early 90s but we are still working with it. (I1A)
The intent to create congruent technological frames cannot only occur in silos. In Alfa, managers describe the organization’s guidelines (technology strategy) as aspirational, e.g. having visionary behaviors towards industrial digitalization. However, the collective view of what type of tone and words should be used in the Digitalization Project did not exist. This indicates that the manager’s understanding of industrial digitalization will have an important impact on achieving leverage 3D printing in the AM workshop, but it might not have momentum throughout the organization.

The empirical data illustrates that informants do not strive towards mutual sensemaking or make room for accumulated knowledge and variance in interpretations of industrial digitalization. Instead, managers seem to hold on to frames created individually rather than shared collective understandings. The missing act of re-framing the collective understanding was vital for the digitalization project. This line of citations suggests that formulating collective assumptions, knowledge and accumulated knowledge is critical, mainly since socio-cognitive aspects are indicated to shape how managers sense and seize organizational capabilities.

4.4 Structural framing

Two types of boundaries showed: The structural boundary and the emotional boundary, which interchangeably affect one another. Regarding the structural boundary, individuals are experiencing a structural boundary due to a high focus on the technological aspects of implementing digital technologies. The perceived structural boundary within Alfa influenced the technology implementation and technology use. The local managers had the mandate to choose what type of digital technology to engage with or proceed with but often struggled to formulate a business case. Managers formulated the business case process to ease the process of bringing forth digital initiatives. For those going through this process, it was interpreted as a high level of belief in the ability to account for the return on investment and a high level of belief in the trial-and-error process. Both in which money is the driving force creating creativity and inertia. Managers’ perception of the Digitalization Project indicated that they first saw the usefulness and meaningfulness of leveraging 3D printing. However, they also pointed out that digitalization processes differ from other business development processes. Emphasizing the perceived rigid structural framing:

I think you have this hierarchical order for a reason. One needs to get through every single manager upward. A project you want to run must be approved at every stage; it must be explained and budgeted. In the end, it becomes too big, and it turns out that you spend more time convincing the managers than you spend on the project itself. The hierarchy is too sluggish. It takes too long (I4)

Regarding the emotional boundary, individuals struggle to affect the meaningfulness of the organization due to too tight or heavy organizational structures. With a high focus on the technical aspects of leveraging 3D printing, managers argued that the actual use (technology in use) was overlooked. One such incongruence could arguably be the perceived meaningfulness and its fit to the structural framing. The chief executive officer describes that the risk of letting the technical aspects rule the structural framing is that you lose the human in it by saying:

I think we fall into the trap if we let the engineer control too much. You lose the human being. I am kind of an engineer myself. (I1A)

The statement above illustrates that managers struggle to look at problems or structures from a new perspective despite being aware of the complexity. In other words, they do not act as if the socio-cognitive aspects can be merged or even considered in the routines and processes of formulating a Digitalization Project. Alfa’s strategy and guidelines did not manage to influence or affect the technological frames of managers. Instead, the collective
frames were influenced by the affections dominant within the organization, which greatly influenced the activity of not wanting to engage in change on various levels. The spectra are reaching from verbally making a standpoint of being against change, and hence not feeling committed, to feeling a bit committed and having made sense of the change. As a result, the emotional boundary depends on individuals’ perception of the usefulness of digital technologies. The head of the digital production lifecycle management explained how the individuals struggle to perceive the meaningfulness of the organization due to too tight or heavy structures:

If they were to step into the change and help with the blockade instead, we would have the opportunity also to take care of the local needs. It often happens that the local managers are not contributing, so people get up and sit in the stands and scold the referee instead. I mean, why don’t you try to influence it? So it is clear to me that it goes sideways. (I8)

Alfa was more prone to work in silos rather than sharing experience over function and working group. Individuals described an experience of misalignment in communication and competence concerning the individual understanding and the Digitalization Project. Managers described the Digitalization Project provided by the management group as focused on individual use cases:

We start to have solid use cases that are deployed all over different organizations. We are not only a digitalization department; We have many other functions in Alfa. There are some nice, interesting people with great ideas. Moreover, I see they are also working on their projects, and we are collaborating, exchanging information, and trying to help each other. (I12)

In their respective function, many managers perceive that activities leveraging production are not given more time. Similarly, some managers also express that they do not prioritize such activities, which makes the silo structure more emphasized. Especially topics such as development speed were perceived to require not only competence and upskilling, but a mental shift was interpreted as structurally bound. An important note was the insight that almost every function would answer that resources and competence are lacking. However, not all are prone to formulate a more precise topic. This distress makes an essential base for strategizing organizational capabilities: e.g. Digitalization project.

5. Discussion

This case study aimed to explore how strategizing organizational capabilities for industrial digitalization could be understood through managers’ perceptions of digital technology applications. Findings show that despite strategies and efforts aiming for an autonomous AM workshop, Alfa failed when overlooking the socio-cognitive aspects. This concurs with previous research that argues that much focus is on industry-level outcomes, while socio-cognitive and intermediate outcomes of strategizing organizational capabilities have been foreseen (Carlsson et al., 2022; Raffaelli et al., 2019). It is argued that the configuration and re-configuration of organizational capabilities are context-dependent and emotionally affected by the setting in which capabilities are formalized and developed, see Figure 3.

As such, strategizing organizational capabilities is recognized to depend on managers’ ability to illuminate frames situated in the given context, i.e. the socio-cognitive aspects. The socio-cognitive aspects influencing production managers’ frames are herein identified through three themes: Affective individualism, Affective collectivism and structural framing.

5.1 Affective individualism

Managers indicated a solid emotional belief that the AM unit and Alfa are unique compared to the rest of the organization or other manufacturing organizations. Managers sensed their part
of the organization was unique and acted upon this subjective perception (Demeter et al., 2021). Arguably, the manufacturing management bringing forth the Digitalization Project failed to provide a dominant frame (Orlikowski and Gash, 1994) concerning the usefulness and meaningfulness of leveraging 3D printing. It can be argued that the different managers have access to different parts of the organization and thus have different repertoires of frames (Grover et al., 2022). One explanation is that managers struggled to perceive the meaningfulness of industrial digitalization for the organization due to too tight or heavy organizational structures. Similar results were found in earlier research (Björkdahl, 2020; Colli et al., 2022; Raffaelli et al., 2019). Managers individually formulated responses based on their subjective perceptions rooted in affectiveness towards the ability to build, integrate and reconfigure organizational resources. I.e. the perception of how technology can be used in everyday practice and the possible consequences related to this (technology in use) (Eggers and Kaplan, 2013). In turn, managers’ affective individualism could affect the ability to recognize shared organizational action (Ocasio, 1997). This could explain the difficulty of diagnosing and prognose problems of organizational capabilities related to industrial digitalization (Mishra and Agarwal, 2010) since emotionally bound individualism formulated separate units (islands) of shared understanding among managers.

Shared understanding in smaller coalitions of managers formulated the means of why and how the organization needed to implement digital technologies. In turn, the smaller coalitions led to a certain use of phrasing to enhance the timeliness and the need for internal funding in business cases. These coalitions led to different understandings of why the organization needs to implement the technology (technology strategy), particularly regarding why a technology-induced change was needed. Interviews showed a disparate view of the meaningfulness of digital technologies, such as 3D printing, which again points to the nature of the technology frame domain (cf. Orlikowski and Gash, 1994). As argued in previous research, an organization’s response to environmental-driven change, such as industrial digitalization, is affected by managers’ subjective perception of the environment, which implies that the existing TF is not always congruent (Orlikowski and Gash, 1994).

5.2 Affective collectivism
Findings recognize that managers strongly believe that ideas and solutions to the Digitalization Project already exist in the organization, along with the potential of information sharing and supporting each other. Most managers recognized the importance
of the collective and emphasized the risk of skepticism and frustration if no affective collectivism were in place. Many of the managers’ great knowledge formulated affective collectivism from years of shared experience. It also formulated a systematic perception, concurring with previous research arguing that employees’ responses to industrial digitalization depend on their ability to display competency (Solberg et al., 2020). Organizational actions depend on how management allocates attention to information and how such information is interpreted (Ocasio, 1997). Given that action is the last step in the information processing sequence, understanding shared (collective) cognition is needed to tackle industrial digitalization. This understanding, however, did not reach beyond the close working group in Alfa, affecting the managers’ interpretation of technology and their understanding of its usefulness and meaningfulness (The nature of technology). 

As shown in previous research, the organization must put much effort into sensemaking toward industrial digitalization as a collective (Volberda et al., 2021). This indicates that the manager’s understanding of industrial digitalization will have an important impact on strategizing organizational capabilities (cf. Ocasio, 1997), but it might not have momentum throughout the organization. Arguably, the dividing lines between the managers’ understanding of digital technologies and the organizations’ application show an incongruent technology strategy frame (Orlikowski and Gash, 1994). Although managers might struggle to formulate a collective understanding, they have neither succeeded in communicating how they interpret industrial digitalization nor their everyday use (Young et al., 2016). As organizational action is directly dependent on managers’ communication patterns and interpretation of information (Ocasio, 1997), the collective affectedness is perceived to need a stronger shared understanding. This view was interpreted as shared by the company at large, and the perception of technology implementation and technology use (Orlikowski and Gash, 1994) took place at the management level. However, in terms of communicating how to reach the desired value, there is an experience of misalignment in communication and competence.

Given that managers at the various functions did not agree or had the same interpretation of strategy and guidelines, the actual use (technology in use) was affected, and a disparate view of the Digitalization Project grew, which generated emotion-based collectiveness instead. Hence, strategizing organizational capabilities could be understanding the socio-cognitive aspect of shared experiences that ultimately affect the ability to strategize organizational capabilities.

5.3 Structural framing
Managers reported experiencing a structural boundary due to much focus on the technological aspects of implementation and an emotional boundary where individuals struggle to alter the meaningfulness of the organization due to too tight or heavy organizational structures. The perceived structural boundary within Alfa influenced the technology implementation and technology use (Orlikowski and Gash, 1994). Meanwhile, assumptions, knowledge and expectations were much related to emotional bonds, situated in an understanding or interpretation of what meaning or use organizational capabilities have entitled and how they were perceived to be configured or re-configured in relation to the structural framing.

The managers’ abilities, skills and accumulated knowledge were captured by the individual or potentially in an employee group. However, neither the individual nor the employee group “reframed” (Orlikowski and Gash, 1994) or seized to re-configure, and as a result, the organization was unable to adjust with the employees or change structural circumstances.

The business case illustrated the managers’ perceptions that the organizational structure is too hard to navigate. The technology implementation and technology use (Orlikowski and Gash, 1994) are channeled through a business case, and each individual is responsible for
writing up and conveying their business case. Yet, when the organizational structure became too “sluggish”, it became a hemming aspect – making managers question the usefulness and meaningfulness of digital technologies.

With a high focus on the technical aspects of leveraging 3D printing, the actual use (technology in use) was argued to be overlooked as the human aspects were not seen (Orlikowski and Gash, 1994). As argued in previous research, incongruences among managers may provide different characteristics of challenges or opportunities; hence, the nature of navigation may shift over time (Carlsson et al., 2022).

6. Conclusion
This single case study drew on the TF framework (Orlikowski and Gash, 1994) to further understand the organizational processes of strategizing. The study aimed to explore how strategizing organizational capabilities for industrial digitalization could be understood through managers’ perceptions towards digital technology applications.

6.1 Implication for research
The study has identified three aspects that affect strategizing organizational capabilities: Affective collectivism, Affective individualism and Structural framing. The three aspects show how cognitive aspects may shape the organizational frame and thus affect how managers assemble and recognize strategizing organizational capabilities. More importantly, the emphasis on affective indicates that all employees must be able to identify themselves as a vessel for the cognitive frame. The usefulness and meaningfulness must be understood by the individual and recognized through structural and emotional bonds within an organization. It is suggested that the individual not only needs to form an affective bond with digital technologies, but the collective needs shared assumptions, expectations and knowledge of the perceived technology-induced change. Nevertheless, shared understanding should also be promoted from a management perspective, where structural boundaries must be in tune with the shared frame.

6.2 Managerial implications
The study contributes to practice by bringing attention to the disparate view on strategizing organizational capabilities, i.e. capabilities, abilities, and accumulated knowledge. The results could be helpful for practitioners when initiating a digitalization project or initiative. Arguably, early articulation of means, reflection, discussion and daring to re-configure structural constructions may reduce the likelihood of unintended misconceptions or perceptions of organizational capabilities. The ability to strategize organizational capabilities heavily depends on the shared understanding of why the organization needs to implement digital technologies and the structures that allow sharing such means. By illustrating how socio-cognitive aspects shape strategizing organizational capabilities, this study could offer managers valuable insight into the relationship between an organization’s capabilities, the individual and the shared cognitive structures affecting technology-induced organizational processes.

6.3 Future research and limitations
The intention was to contribute by illuminating socio-cognitive aspects of managers’ perception of reaching for a more prosperous production by interpreting how perceptions of industrial digitalization affect strategizing organizational capabilities. It is recognized that other manufacturing organizations may have a different organizational culture affecting TF. This study only examined the digitalization project related to the AM workshop in Alfa.
There might be limitations due to the single case study approach. However, the intention was to bring forth an in-depth case study analysis contributing to how production managers strategize organizational capabilities for industrial digitalization and not to generalize. Future studies are encouraged to cover multiple cases or even different business sectors to examine socio-cognitive aspects of managers’ perceptions further. Distinguishing further structural or emotionally bound aspects may give more information on how a socio-cognitive aspect influences strategizing organizational capabilities within industrial digitalization.

References


**Corresponding author**

Linnéa Carlsson can be contacted at: linnea.carlsson@hv.se
Tidigare avhandlingar – Arbetsintegrerat lärande

THOMAS WINMAN Transforming information into practical actions A study of professional knowledge in the use of electronic patient records, 2012:1.

ANNIKA ANDERSSON In case of emergency Collaboration exercises at the boundaries between emergency service organizations, 2016:8.

MARIE WESTERLINDIND Knowing at work A study of professional knowledge in integration work directed to newly arrived immigrants, 2016:9.


LARS-OLOF JOHANSSON Engaged in digital service innovation, 2018:15.


CAMILLA SEITL Informellt lärande i en formell organisation. Om meningsskapande, kunskapsdomän och kompetens i arbete med kommunala mål, 2018:19.

KARIN HÖGBERG Persistent Digital Service Encounters Challenges of organizational use of social media in a hotel chain, 2018:22.


JENNIE RYDING Mellan evidens och reflektion. om professionellt lärande i Socialtjänstens familjebehandlande arbete, 2020:36.

VILLE BJÖRK Learning 'theory' at university and 'practice' in the workplace. A problematisation of the theory-practice terminology that the dualistic design of Work-integrated Learning institutionalizes, 2020:38.


ANDERS SANDBLAD Yrkeskunnande Maskiner Människor, 2021:47.

SANNA HEDRÉN Fritidshemmets (mellan)mål och mening. Positioneringar i kollegialt samtalande mellan fritidshemspersonal, 2022:50.

MARTIN SCHÜLER Säkerhetsklimat i en militär organisation, 2022:51.


SARA EKSTRÖM Teaching with social robots, 2023:55.
DANIEL OLOF WIEDEL Att skapa mål och mening i vakuumland – Om socialt arbete i en kommunal arbetsmarknadsinsats för unga, 2023:57.

ANNA ROUMBANIS VIBERG Lärarutbildarens professionella agency i en digital tid, 2023:58.
Social Aspects of Strategizing Industrial Digitalization

Industrial digitalization is elusive, and many contemporary Swedish manufacturing organizations struggle to strategize it as influences on and within the organization shifts over time. As such, this thesis explores how social aspects of strategizing industrial digitalization in contemporary Swedish manufacturing organizations can be understood and texturized. The results derive from a longitudinal case study of interviews and focus groups generated between early 2019 and spring 2023. This thesis presents three social aspects that give shape to industrial digitalization. The social aspects elaborated on and presented in this thesis are: to look beyond digital technologies, to formalize a shared understanding, and to transcend organizational structures. Together, these social aspects bring insights into how managers can guide the organizational capabilities to ensure synergy between an organization’s actions and objectives when strategizing industrial digitalization.

Linnéa Carlsson
School of Business, Economics and IT
Department of Informatics
SE-46186 Trollhättan
Sweden