

MANAGERS' PERCEPTIONS OF INDUSTRIAL DIGITALIZATION IN THE EARLY PHASES OF A PANDEMIC: A QUALITATIVE STUDY

Linnéa Carlsson¹, Masood Rangraz¹, Anna Karin Olsson¹

¹ University West, Gustava Melins Gata 2, Trollhättan, Sweden

Abstract

This paper explores how managers in the manufacturing industry simultaneously accommodated industrial digitalization and the impact of COVID-19. Managers' views and understanding of industrial digitalization during the early phases of the COVID-19 pandemic are narrated through the circumstances that came to their proxy during the spring of 2020. The study result is based on qualitative in-depth semi-structured interviews conducted with eight small- and medium-sized manufacturing managers. This study contributes by giving empirically informed implications on manufacturing managers' perception of industrial digitalization during the early phases of the COVID-19 pandemic. Findings show that industrial digitalization due to the COVID-19 pandemic is viewed differently from previous digitalization processes, causing new ways for managers to perceive how and why digital technologies may be implemented.

Keywords

Industrial digitalization, COVID-19, SME, manufacturing organizations, managers

1. Introduction

Industrial digitalization and the COVID-19 pandemic are viewed as complex phenomena with various effects on work, strategies, and working life within an organization [1]–[3]. Dealing with industrial digitalization is already challenging for many organizations and hence, an unavoidable research agenda for academia to promote and pursue.

The new wave of reliance on digital technologies, because of the COVID-19 pandemic, has a broader effect not limited to leveraging industrial digitalization but developmental purposes for survival amidst further uncertainties in the future [4]. It could be argued that industrial digitalization until the pandemic was a topic of choice that could be overlooked if wanted, and the COVID-19 pandemic pushed forth a forced adoption of various digital technologies. To this end, we believe that the emphasis on industrial digitalization due to the COVID-19 pandemic differs from the emphasis on industrial digitalization as a trigger for business improvement.

This study explores managers' perceptions of industrial digitalization during the early phases of the pandemic. The study is focused on manufacturing SMEs (Small- and Medium-sized enterprises) in Sweden operating under the restrictions imposed by the Swedish national strategy to deal with the pandemic and exploring how industrial digitalization is perceived. Unlike the rest of the world, Sweden has chosen a different pandemic strategy, committing to less restricted measures and avoiding a total lockdown. This strategy has meant sustaining production with limited to no knowledge of similar phenomena, intensifying existing production challenges, such as resource constraints and changes in work procedures. Given the above, the following research question is posed:

How do SME managers perceive the impact of industrial digitalization on manufacturing organizations in the early phases of the COVID-19 pandemic?

8th International Workshop on Socio-Technical Perspective in IS Development (STPIS 2022), August 19–21, 2022, Reykjavík, Iceland
EMAIL: linnea.carlsson@hv.se (A. 1); masood.rangraz@hv.se (A. 2); anna-karin.olsson@hv.se (A. 3)



© 2022 Copyright for this paper by its authors.
Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).
CEUR Workshop Proceedings (CEUR-WS.org)

This study explores the complex dynamism of SMEs engaging in industrial digitalization when responding to COVID-19 in its early phases. Qualitative data collection methods were applied given the complexities of industrial digitalization and the pandemic. The study result is based on qualitative in-depth semi-structured interviews conducted with eight manufacturing managers during the spring of 2020. Findings show that industrial digitalization due to the COVID-19 pandemic affects the workplace, agendas, strategies, and future work differently from the previous digitalization process. We report and reflect on the nature and the extent of this difference. The narration-based findings and analysis give insight into the pandemic's early phases and the manager's interpretation of its effect on industrial digitalization. We discuss the practical implications of the pandemic on industrial digitalization and vice versa as manufacturing industries endure the COVID-19 pandemic.

2. Introducing Industrial digitalization

Industrial digitalization encompasses a plurality of core technologies, methodologies, and trends that increase process efficiency, value creation, and competitiveness. Often industrial digitalization is viewed as a disruptive force affecting SMEs' internal and external processes related to organizational work, strategies and working life. We take on the following conceptualization when exploring industrial digitalization: "*Digitalization [is] a sociotechnical process of applying digitizing techniques to broader social and institutional contexts that render digital technologies infrastructural*" [5, p. 749]. Hence, we recognize that industrial digitalization consists of both the social and the technical [6]. Industrial digitalization would be adopting and using digital technology in a broader organizational context [7]. Given this, it is argued that industrial digitalization affects current business models, and organizations moving towards a more digitalized business must undergo a socio-technical change to remain competitive [8].

In the past decade, industrial digitalization emerged as an essential phenomenon encompassing the profound changes in manufacturing industries through digital technologies. Digital technologies include the internet of things, robotics, big data analytics, and cloud manufacturing, often related to artificial intelligence (AI) solutions enabling vertical integration of manufacturing organizations' systems, horizontal integration in collaborative networks, and end-to-end solutions across the value chain [9]. However, the breadth and depth of strategies for implementing and enabling digital technologies vary substantially with the various technologies [10].

Lately, a more human-centric perspective has arisen to respond to the challenges of leveraging digital technologies [11]. For instance, the effect on the workplace, work, and working life is essential when facing challenges related to industrial digitalization [12]. The human-centric perspective emphasizes the need to acknowledge the human strengths and competencies for reaching sought efficiency of industrial digitalization.

In the industrial sector, the influence of industrial digitalization has increased in recent years. Today, leveraging digital technologies is a needed step forward when wanting to enable, improve, and transform operations functions, models, processes, or activities within an organization [13]. The competitiveness-driven changes in environmental dynamism are seen as changes in operational and strategic models caused by, for instance, COVID-19 [14]. Few SMEs dismiss the importance of industrial digitalization, yet few have developed digital strategies and practical guidelines for seizing the potential value of industrial digitalization [15], [16]. However, since implementing digital technologies may require re-defining work and work processes, it is understandable why industrial digitalization is argued to be complex and easy to overlook if not forced. As SMEs often have fewer resources and the next generation of technology is hard to predict, let alone adopt, it is not conventional to formulate a sensible implementation of digital technologies [14].

2.1. Industrial digitalization and COVID-19

Even in the pandemic's early phases, an accelerated trend in remote work and automation has occurred. Suggesting that the future of work, strategies, and working life within an organization can be altered faster by digital technologies than before the pandemic [4], [17]. There are also suggestions that

employees' use of technologies might change as the pandemic progresses, potentially altering the view of autonomy and professionalism [18].

Although, the common feature of many initiatives aided towards increased use of digital technologies within a manufacturing organization is the proximity to a more prosperous production. Many organizations have already deployed automation and digital technologies in warehouses and production plants to reduce workplace density and cope with surges in demand. In information systems research, the challenge of COVID-19 is to understand the ripple effects on the larger economic fabric [19], for example, the industrial sector. This study explores these effects by focusing on managers' perception of industrial digitalization during the early phases of COVID-19. The COVID-19 pandemic has presented several challenging paradoxes for managers related to industrial digitalization.

On the one hand, managers' perceptions of digitalization have helped little as the crisis has disrupted everyday organizational structures. Engaging in digital technologies has been postponed due to closer threats. On the other hand, digitalization has become more critical than ever during COVID-19 [2]. It has become clear that the everyday life of an organization depends much on digital tools. However, the overall belief was that organizations had years to plan, build, and implement such tools to become resilient in times like these [20]. Strategic organizational responses towards industrial digitalization were not to be immediately present but an emergent phenomenon. Therefore, many organizations were forced to rapidly implement working arrangements online, including arranging for employees to work from home [21], creating a conventional enough need for digital technology to force a major impact on strategic work [3], [21]

In relation, manufacturing industries may get a triple hit by COVID-19, (i) affecting production such as direct supply disruptions, (ii) supply chain contagion effects, and (iii) demand disruptions such as wait-and-see purchase delays and other investment delays [22], [23]. Organizational uncertainty, significant disruptions in global supply chains, lack of buffer stocks, and factory closures may delay or stop investments [23]. Similarly, lockdowns have generated supply and demand shocks, and gradual reopening will cause supply-demand imbalances within industries (Goodhart & Pradhan, 2020; Miles & Scott, 2020). The pandemic forces a change from globalization to regionalization due to efforts to locate more stock closer to customers and factories to mitigate imbalances [4]. These disruptive changes in the digitally dynamic context create unpredictable challenges for SMEs. Digital technologies may mitigate COVID-19 effects on manufacturing industries (e.g., smart factories, automated material and transportation systems, automated design, predictive tools, and predictive maintenance) [24]. However, such mitigation is argued to depend on the previous implementation degree in the organization [25].

3. Methodology

This study explores managers' perception of industrial digitalization during the early phases of the pandemic by applying a narration-based understanding of organizational challenges and opportunities. SMEs are in focus as they are widely impacted by the COVID-19 outbreak and lack strategic responses [25]. Furthermore, SMEs often have limited resources and digital maturity [26], [27]. Therefore, this paper focuses on SMEs in Sweden operating under the restrictions imposed by COVID-19 and the Swedish national strategy for dealing with the pandemic. It is essential to mention that Sweden has chosen a different pandemic strategy than the rest of the world, avoiding a total lockdown [28]. This study applies an exploratory qualitative approach to capture managers' perspectives on industrial digitalization. As an initial step, 20 manufacturing companies in western Sweden were invited by e-mail in the spring of 2020 to participate in an online-based interview. Eight production manufacturing companies participated, including companies from the aerospace, offshore, naval, detail, and component manufacturing industries, see table 1.

Most companies operate on a global market except for one industry, an exclusive national firm. In addition, all the companies were SMEs, i.e., fewer than 500 employees [29]. However, some industries are part of larger groups but remain SMEs locally in Sweden. Two of the industries were also family companies with fewer than 20 employees. Additionally, all manufacturing companies have been active for at least 15 years and have had industrial digitalization initiatives or shifting strategies.

3.1. Data collection

During the spring of 2020, detailed data collection was conducted using semi-structured interviews. Eight interviews were performed with upper management, as illustrated in Tabel 1.

Table 1.
Overview of Informants

ID	Roles	Sectors
I1	CEO	Offshore and naval
I2	Head of product development	Detail- and component
I3	CEO	Oil, mist filtration
I4	Managing director	Aerospace
I5	Head of Research	Aerospace, Gas turbines and Parts.
I6	Head of quality, safety, and HR	Packaging solutions
I7	CEO	Medical Technology
I8	CEO	Hydraulics

The online-based interviews were chosen due to the regulation set by the Swedish government regarding COVID-19 on social distancing. The informants were asked to share their views, reactions, and actions regarding the following: the influence of the pandemic on the workplace; the impact of the pandemic on strategic initiatives towards digitalization; and their perception of how the future would change. These questions were discussed relative to managers' perception of industrial digitalization as they were asked to describe their organization's current engagement regarding industrial digitalization. As such, the interviews gave a preunderstanding of the potential influence COVID-19 may or may not have on industrial digitalization strategies in manufacturing industries. Assessing a maturity framework was neither the focus nor aim of this study.

To guide the discussions, informants were invited to speak freely about their views and thoughts on the current situation in their organization. However, the focus remained on disruption and the pandemic's impact on digitalization. All the interviews were held using Microsoft Teams, each lasting approximately 40 minutes. Interviews were recorded directly via the platform's recording service and uploaded to the Microsoft stream server. The data remained safely stored from unauthorized people and were downloaded to be stored on a local server after permission from each informant. The recorded material was treated as an audio recording and fully transcribed accordingly. All participants provided informed consent to both audio and video recordings.

3.2. Data analysis

To reach a deeper insight into how SME managers perceived industrial digitalization during the early phases of the pandemic, we were inspired by a narrative approach when collecting and reporting the interview data and thus presenting the result as a narration revealing managers' views and experiences, i.e., perceptions [30]. This reflexive approach aligned with the thematic analysis process used to make sense of the collected data.

The analytical process followed a reflexive approach applying thematic analysis as a method to work with and make sense of data [31], [32]. In particular, the data analysis focused on formalizing a particular interpretative understanding of the managers' perception considering industrial digitalization during the early phases of the COVID-19 pandemic and then explaining patterns of meanings. When exploring the potential impact of the COVID-19 pandemic on industrial digitalization, the thematic analysis helped go beyond the surface of the data, creating a sense of scope and diversity in themes that reveal contradictions in statements [31].

As a first step, the authors familiarized themselves with the data by reading and re-reading the material to understand the whole and uncover the managers' perspectives. First, the transcripts were read individually to assess scope and sense, and the focus was to generate initial codes. Then, the codes were compared and discussed in the research group. This stage formalized initial categories in which

statements could be included and excluded depending on the fit to said category [33]. The three themes identified during the analytical process, i) Impact on workplaces, ii) impact on agendas and strategies, and iii) Impact on future work, are formalized in the narration and carried out in the following section.

4. Findings and analysis

This section outlines the findings narratively, presenting a story occurring within SMEs during the early phase of the COVID-19 pandemic in spring 2020. The narration includes a continuous discussion of what occurred during the early phases of the pandemic. The narration follows the three identified themes i) Impact on workplaces; ii) impact on agendas and strategies; and iii) Impact on future work, and the narrative discusses how and why the early phases may have enrolled as they did.

4.1. Impact on workplaces

Industrial digitalization could be a complex challenge, but its nature and consequences differ significantly from the COVID-19 pandemic. During the pandemic's early phases, organizations become mindful of industrial digitalization and digital technologies [2]. Leveraging industrial digitalization is argued to be efficient in their processes, produce quality products, and remain profitable in their business. In this regard, the pandemic is yet another disruption of industrial digitalization. However, the pandemic has forced SMEs to respond more rapidly, creating an even more challenging and complex workplace as the pandemic moves industrial digitalization to become a forced action. For example, the managers illustrate how it was no longer a choice to use digital technologies but a necessity in everyday work. The daily work activities depended on a fast implementation of digital tools to keep the workplace going [21]. Even if managers described themselves as not critical of implementing digital technologies or tools, they still found themselves surprised by the ease. Managers argue that using digital tools in the workplace is critical despite its previous non-critical value to everyday work. Industrial digitalization was not perceived as game-changing before the pandemic but has since shown its value as a tool that can maintain the organization's competitiveness during the pandemic [20]. When managers were asked to describe how COVID-19 had impacted their workplace, some used an incremental description of the process:

“It moves in different stages. First came the first challenge of not being able to welcome visitors. Then that was big. Then when we adjourned working from home, that became big. So we get used to it step by step.” (I6)

Several managers emphasized that the pandemic had been a unifying force within the organizations, contributing to a stronger sense of internal collaboration and understanding of chosen actions: “Everybody just wants to reach the same solution. Previously one has just looked after their own business” (I3). Managers often began with the bright side of the pandemic, explaining their flexibility and how they try to live by the new reality:

“We are taking this [pandemic] as an opportunity. Okay, so with the less production we run, we are now running out [finishing up] projects instead. For example, we are installing conveyors. So, we moved our first machine to set that up to be prepared for the conveyor. [. . .] We will do it out of a business perspective, not from a COVID-19 perspective. COVID-19 just gives us the opportunity and time.” (I3)

The new reality of the workplace is something that managers seemed surprised about. However, managers did not seem surprised about “the new workplace” taking place, but how easy it would be to adopt digital solutions. As such, the phenomena of industrial digitalization seemed to lose the status quo. Many managers compared their actions with other local organizations when discussing the impact and responses to the COVID-19 pandemic. When doing so, the practical implications of the workplace were highlighted more than other issues:

“Yes, other industries here in our community moved forward much more aggressively. That has completely locked down. They started immediately practicing on working from if it would come to that.” (I1)

“[. . .] but I do not think we are alone in this; there are many [industries] in the same boat. The most important is that we try to look ahead.” (I7)

Some managers described their state using responses from other manufacturing industries as a potential measurement. The managers regarded digital tools as “rather useful in the crisis to have this collaborative platform” (3). Even if the managers had different views regarding the impact of COVID-19 on their workplace, they remained united when discussing its effects on work routines. The shared experience revealed that COVID-19 had pushed the boundaries for working with digital tools—i.e., working in Microsoft Teams sites and their perceived increased general knowledge:

“Thanks to COVID-19, we have learned to work with these media types [Microsoft Teams] we are in now. One understands that going on sale trips or supply chain visits necessary does not have to be physical. So, our digital maturity has increased a lot thanks to the situation we are in.” (I6)

“One has not have had the time to get into it [digital tools]. Instead, one has e-mailed back and forth in long lanes. So parallel with Corona, we have gone more towards using Office365. Before, we saw the good sides, but now we are forced into using it and virtual forums.” (I3)

Some managers noted that pushing boundaries for assessing digital tools at the workplace mainly concerned white-collar workers: “But in the white-collar side, it has increased” (I3). This manager noted that the organization’s white-collar work routines had shifted, not their work for the blue-collar workers. When the manager was asked about the potential of industrial digitalization to ease the workload, he stated that it had not had such a positive impact on the blue-collar workers compared with the white-collar workers: “I do not believe that increased automatization or digitalization would have made a difference actually” (I7). On the other hand, a minority of the managers described that this was because ordinary production already had a safe process concerning the given COVID-19 restrictions: “We do not have so much production work that is close to each other; instead, one can stay close to their machine, and so we wipe them off in between usage” (I6). Therefore, digitalization was not considered to ease the workload for blue-collar workers.

4.2. Impact on agenda and strategies

In conversations with the managers, it became clear that COVID-19 requires new agendas for short-time strategic changes rather than a known examined change associated with crisis [4]. Managers perceived that the mental models of such work were not sufficient. To illustrate the relevance of this issue, managers identified managerial reactions such as crisis benchmarking to be accommodated by managers to determine their preferred action regarding market orientation and their choice of action forced by COVID-19. As the managers create awareness and understanding of the crisis, they simultaneously adopt solutions [20]. Some of the solutions are digital and make the crucial role of crisis management non-comprehensive but rather determined by their proximity to SMEs. In other words, managers contending with the need for crisis management resulted in benchmarking local implementation of quick, simple solutions [4]. SMEs instead acted quickly rather than ending up doing nothing. While many managers described in the early phases of the pandemic that COVID-19 had not affected them too much, it seems that they had daunting challenges in their strategic work. SMEs often have more resource constraints, although they may be more flexible and less bureaucratic than larger companies [17], [24], [34]. One aspect that became clear was that managers had planned to leverage industrial digitalization long-term, i.e., for more than five years. However, managers’ perceptions of the impact of digitalization on their work varied: “We have not, erm, transformed so speak. Nor

prepared” (I6) and “we are formulating a digitalization and IT strategy for our organization at the moment” (I7). Furthermore, some of the managers described such strategies as aspirational but are not actively employed or are unnecessary:

“It does exist [digitalization]. Nevertheless, it is a matter of making it available for all employees. They have computers and hardware, making it possible in their working environment. We are an industry, so there is also a point with using paper – it is not as fragile.” (I1)

“We have no digitalization. What is that? ... I see no clear distinction.” (I8)

Several managers identified digitalization as automatization, but the strategic work remained hard to formulate or was put on hold:

“We have some automation. We have islands of everything, but it is not connected. We have no general picture. We create and work a lot at the side of the digital platforms.” (I5)

However, making inquiries about the current state of their business in numbers portrayed a different picture. It seems rather apparent that long-term arrangements are now on hold. The focus is on the present: “If a large industry has ordered a new production line from their subcontractor, we are the tenth subcontractors down” (I2). The strategic planning regarding industrial digitalization was heavily affected for no apparent reason. Some said it was because of the dynamic environment, others of the multifaceted customer chain: “Yes, because then you will not get as affected if one sector goes down” (I3). In line with previous research [15], organizations are arranging their operations on a day-to-day basis and planning on the go since the market estimates seem unpredictable and unreliable:

“We have had a significant loss of turnover; I would say that 10 percent of the turnover is lost. Moreover, a 10 percent turnover loss has already occurred. There is a significant impact also on the profit [. . .] we see that the volumes are not recovering as fast as expected, which means that we will have to take actions to reduce the loss even further. We think that the market demand drops somewhere from 25 to 40 percent [. . .] on the commercial side, and we did lack some incoming material to run our production. So, when there was a, I would not say dispute, but at least we discussed whether they had the legal possibilities to deny delivery or not.” (I4)

Putting long-term plans and strategies on hold is a recurring theme and is also stated to affect the planned leverage of industrial digitalization. Something that potentially could uphold the developmental speed in the industrial sector. The managers make their points known by making dramatic contrasts between what was intended before and what will become post-pandemic. Many responses indicate that operational thinking trumped strategic thinking:

“I mean, before the year started, we developed new products and planned some things that would happen this year and the next. But since then, a lot has changed, so you have changed the focus. Then there is no point in presenting new timetables until you know when you can get started. Previously, it was a diffuse plan three years ahead. Now it is more that it has been put on pause. Then there are some other activities that we run instead. However, it is more internal projects that are important for our well-being. So those plans extend throughout the year but are not the ones we intended to work with from the beginning.” (I3)

Managers stated that removing the long-term plans and focusing on what seems insight during a pandemic is the only way forward. As such, it seemed like the organizations were paralyzed by uncertainty regarding the effect of the pandemic on the workplace:

“Because we cannot reach many goals and we cannot test drive anything, we are changing. Maybe we work more with our staff and in the shorter terms. Then there is the transition or transformation in fewer at work, which also affects the business. [. . .] This will also remove the long-term plans; they are being shifted.”
(16)

4.3. Impact on future work

Managers admitted that they now view digitalization anew, and such, it had a significant impact on their future work. Managers view industrial digitalization through an operational mindset to survive daily to keep functioning, contrary to long-term strategic planning. This is partly because the business demands new ways of conducting office work, such as travel restrictions that force seller-buyer relationships into a digital environment. It is partly related to the crisis benchmarking explained earlier. They see the only way to have a competitive advantage is by fast implementing digital tools such as MS Teams, SharePoint, and Zoom, mainly related to internal and external communication.

Nevertheless, managers thought such digital tools would have little or no effect on the continuous production during COVID-19. Their new appreciation of digitalization had consequences on what they see now as necessary digital competence to endure the consequences of the pandemic on their business [4], [20]. However, their focus and actions remained solely on white collars skills and knowledge relative to digitalization:

“We have been traveling a lot. I have several [employees] in the office who maybe were in both three and four countries a week [. . .] sometimes not even be in the same continent [. . .]. Now you see how you can probably solve it differently to reduce physical travel. Regarding these online meetings: it is as good to meet our strategists online, but we have used to meet them physically. Now that we have run Teams or Skype meetings, we go through the same agenda, but it becomes a little more effective. [. . .] We also want to be able to position ourselves as a sustainable organization, and then maybe it is worth reviewing this [traveling].” (13)

The future of the organizations is depicted in various ways, ranging from “a return till how it was before” (I1) to “I think the entire community will change permanently and the companies as well” (I2). The experienced benefits of effective online communication and meetings replacing business travel and in-person meetings are pointed out as something that probably will be established in the post-COVID-19 organizations:

“We had never tried Teams before all this...We prefer to travel and visit our customers, but I can see benefits in using it. But we did not consider it before this”
(18)

The managers emphasize uncertainty, no possibilities to predict the future, and financial worries. :

“What happens in the future is a little hard to say. Such a rapid slowdown becomes both a huge uncertainty and concern. [. . .] Before we have known what we were going to do in two or three maybe four-five years ahead. Now we do not know what to do this fall. We do not know what we will do in 2021! [. . .] it all depends on the organization’s financial muscles.” (15)

Most managers have optimistic views of getting more robust by undergoing COVID-19. Leadership and crisis/risk management are stated as important future organizational issues:

“I think leadership is much more agile. I hope we should not have to have reports from seven years back without being more confident in ourselves and decision-making. Make a decision, try and adjust. I also think we will get stronger from this. Both at the employee level and the managerial level.” (I6)

I believe that we are better prepared for risks. We must change how we look at supply chains and have greater readiness for supply chains and logistics. We have noticed that companies will probably go more locally now and source their products locally than in China and Asia. I will consider that. Then we have a positive attitude in the organization now. Because we have realized that we are not to blame for this, we can become much more robust in the end. (I7)

Managers also stated that the pandemic generates time for quality refinements and hopefully increased business. Furthermore, some managers stated that investments should not be postponed several years:

It is a great opportunity to refine the business, expand our business segment, and develop faster processes. [...] If we come out of this and have succeeded, we may have expanded and improved our supply chain. (I3)

“Since we are dropping volume on our existing business, we need to gain new business faster.” (I4)

“I do not think we should postpone [investments] so far ahead in time. It is now we have the opportunity to make a little difference [. . .]. And then it is important to take the situation now when everyone else is a little passive, so we plan to be offensive.” (I7)

Corresponding to earlier research, leadership and optimism are highlighted in times of crisis [25], combined with risk preparedness and skills in crisis management [17]. One aspect of this is the managers' desire to change supply chains towards more local or regional controls of logistics and stocks of products [23]. However, the pandemic was also perceived as generating opportunities for proactive quality refinements on products and manufacturing processes and supply chains that may generate competitive benefits and new market positions [2], [17], [35]. Finally, managers perceived industrial digitalization in the early phases of COVID-19 as something that the small- and medium-sized manufacturing companies would survive, and they would potentially practice what they had learned from the crisis, ultimately strengthening their competitive position.

5. Conclusion and future research

In contrast to earlier research on COVID-19, which is mainly conceptual, this study provides empirical evidence from SME companies through the managers' perceptions of industrial digitalization during the early phases of COVID-19. This is particularly important since the insights from managers' views are captured during the pandemic and not as a retrospective reflection on their actions. Hence this paper addresses current topics that challenge today's managers, e.g., industrial digitalization and its socio-technical complexity of posing change to manufacturing organizations in an elusive environment. Findings show that industrial digitalization due to the COVID-19 pandemic affects the workplace, agendas, strategies, and future work differently from the previous digitalization process. Manufacturing organizations practice mixed crisis management strategies to survive and may become more robust on the other side of the crisis. Potentially causing a new way of viewing how digital technologies can be implemented and integrated into an organization. This study shows that organizational actions and processes that were radically changed and imposed new routines and business plans may be maintained during a phase of re-activation of new business practices towards adapting to “the next normal”. The radical changes that the pandemic brought might not have been fully implemented in all companies, supply chains, and customers before COVID-19, yet now these are seen

as possible ways to work. The radical shift to apply digital technologies or tools, online communication, digital meetings, and employees working from home has proven effective and sustainable, reducing travel and visits for office workers. However, it should be noted that this is in the early phases and could indicate learning in an organization during times of crisis.

This study gives empirically informed implications on manufacturing managers' perception of industrial digitalization. Implications for further research regarding practice-based insights on managers' views on industrial digitalization and its adaption during the pandemic are given. In addition, comparative studies with the contextual agenda could help further understand the challenges posed by leveraging industrial digitalization in the dynamic environment.

Given the above, this study cannot predict the overall perspective of the pandemic's impact on manufacturing SMEs, neither in the European nor the Swedish context. However, it can bring initial understanding to the potential reasoning of SME managers during the early phases and the potential factors to have in mind regarding the workplace, agendas and strategies, and the post-covid organization, relative industrial digitalization.

6. References

- [1] G. Vial, "Understanding digital transformation: A review and a research agenda," *J. Strateg. Inf. Syst.*, vol. 28, no. 2, pp. 118–144, 2019, doi: 10.1016/j.jsis.2019.01.003.
- [2] M. Sakurai and H. Chughtai, "Resilience against crises: COVID-19 and lessons from natural disasters," *Eur. J. Inf. Syst.*, vol. 00, no. 00, pp. 1–10, 2020, doi: 10.1080/0960085X.2020.1814171.
- [3] S. I. Hallstedt, O. Isaksson, and A. A. Ö. Rönnbäck, "The need for new product development capabilities from digitalization, sustainability, and servitization trends," *Sustain.*, vol. 12, no. 23, pp. 1–26, 2020, doi: 10.3390/su122310222.
- [4] M. Rapaccini, N. Saccani, C. Kowalkowski, M. Paiola, and F. Adrodegari, "Navigating disruptive crises through service-led growth: The impact of COVID-19 on Italian manufacturing firms," *Ind. Mark. Manag.*, vol. 88, pp. 225–237, Jul. 2020, doi: 10.1016/j.indmarman.2020.05.017.
- [5] D. Tilson, K. Lyytinen, and C. Sørensen, "Digital infrastructures: The missing IS research agenda," *Inf. Syst. Res.*, vol. 21, no. 4, pp. 748–759, 2010, doi: 10.1287/isre.1100.0318.
- [6] Y. Yoo, O. Henfridsson, and K. Lyytinen, "The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research," *Inf. Syst. Res.*, vol. 21, no. 4, 2010, doi: 10.1287/isre.1100.0322.
- [7] C. Legner *et al.*, "Digitalization: Opportunity and Challenge for the Business and Information Systems Engineering Community," *Bus. Inf. Syst. Eng.*, vol. 59, no. 4, pp. 301–308, 2017, doi: 10.1007/s12599-017-0484-2.
- [8] L. Carlsson, A. K. Olsson, and U. Lundh Snis, "Taking Care of Digital initiatives: Managers Approaching Industrial digitalization," in *Proceedings of the International Association for Computer Information systems - Europe*, 2021, pp. 22–24, [Online]. Available: https://iacis.org/conference-europe/Proceedings/IACIS-Europe_2021_Proceedings.pdf.
- [9] T. Zheng, M. Ardolino, A. Bacchetti, and M. Perona, "The applications of Industry 4.0 technologies in manufacturing context: a systematic literature review," *Int. J. Prod. Res. ISSN*, pp. 1–33, 2020, doi: 10.1080/00207543.2020.1824085.
- [10] P. Osterrieder, L. Budde, and T. Friedli, "The smart factory as a key construct of industry 4.0: A systematic literature review," *Int. J. Prod. Econ.*, vol. 221, no. August 2019, p. 107476, 2020, doi: 10.1016/j.ijpe.2019.08.011.
- [11] S. Nahavandi, "Industry 5.0-a human-centric solution," *Sustainability*, vol. 11, no. 16, 2019, doi: 10.3390/su11164371.
- [12] L. Carlsson, M. Hattinger, A. K. Olsson, and U. Lundh Snis, "Desperately seeking Industrial Digital Strategy: A dynamic capability approach," *Int. J. Inf. Syst. Change Manag.*, vol. 12, no. 4, pp. 345–364, 2021.
- [13] S. Denning, "Christensen updates disruption theory," *Strateg. Leadersh.*, vol. 44, no. 2, pp. 10–16, 2016, doi: 10.1108/SL-01-2016-0005.

- [14] A. Yeow, C. Soh, and R. Hansen, "Aligning with new digital strategy: A dynamic capabilities approach," *J. Strateg. Inf. Syst.*, vol. 27, no. 1, pp. 43–58, 2018, doi: 10.1016/j.jsis.2017.09.001.
- [15] M. Nasiri, J. Ukko, M. Saunila, T. Rantala, and H. Rantanen, "Digital-related capabilities and financial performance: the mediating effect of performance measurement systems," *Technol. Anal. Strateg. Manag.*, vol. 32, no. 12, pp. 1393–1406, 2020, doi: 10.1080/09537325.2020.1772966.
- [16] D. K. Rigby and S. Tager, "Leading a Digital transformation," 2014. [Online]. Available: <http://www.bain.com/publications/articles/leading-a-digital-transformation.aspx>.
- [17] J. C. Alves, W. Hao, T. C. Lok, and Y. Luo, "Crisis Management for Small Business during the COVID-19 Outbreak: Survival, Resilience and Renewal Strategies of Firms in Macau," Jun. 2020, doi: 10.21203/rs.3.rs-34541/v1.
- [18] H. V. Hult, A. Sigrídur, and L. Norström, "Reconfiguring professionalism in digital work," *Signs Actions An Int. J. Inf. Technol. Action, Commun. Work.*, vol. 12, pp. 1–17, 2021, Accessed: May 25, 2022. [Online]. Available: <http://www.sysiac.org/>.
- [19] M. Sony and S. Naik, "Key ingredients for evaluating Industry 4.0 readiness for organizations: a literature review," *Benchmarking An Int. J.*, vol. ahead-of-p, 2019, doi: 10.1108/BIJ-09-2018-0284.
- [20] S. J. Barnes, "Information management research and practice in the post-COVID-19 world," *Int. J. Inf. Manage.*, p. xx, Jun. 2020, doi: 10.1016/j.ijinfomgt.2020.102175.
- [21] A. Kramer and K. Z. Kramer, "The potential impact of the Covid-19 pandemic on occupational status, work from home, and occupational mobility," *J. Vocat. Behav.*, vol. 119, p. 103442, Jun. 2020, doi: 10.1016/j.jvb.2020.103442.
- [22] D. Ivanov, "Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case," *Transp. Res. Part E Logist. Transp. Rev.*, vol. 136, p. 101922, Apr. 2020, doi: 10.1016/j.tre.2020.101922.
- [23] L. Boone, "Tackling the fallout from COVID-19," in *Economics in the Time of COVID-19*, R. Baldwin and B. Weder Di Mauro, Eds. London: CEPR Press, 2020, pp. 37–45.
- [24] T. Wuest, A. Kusiak, T. Dai, and S. Tayur, "Impact of COVID-19 on Manufacturing and Supply Networks — The Case for AI-Inspired Digital Transformation," 2020. doi: <http://dx.doi.org/10.2139/ssrn.3593540>.
- [25] S. Kim, B. Choi, and Y. Lew, "Where is the age of digitalization heading? The meaning, characteristics and implications of contemporary digital transformation," *Sustainability*, vol. 13, no. 16, 2021, doi: 10.3390/su13168909.
- [26] H. Hussin, M. King, and P. Cragg, "IT alignment in small firms," *Eur. J. Inf. Syst.*, vol. 11, no. 2, pp. 108–127, 2002, doi: 10.1057/palgrave/ejis/3000422.
- [27] J. J. Van Bavel *et al.*, "Using social and behavioural science to support COVID-19 pandemic response," *Nat. Hum. Behav.*, vol. 4, no. 5, pp. 460–471, May 2020, doi: 10.1038/s41562-020-0884-z.
- [28] C. Goodhart and M. Pradhan, "Future imperfect after coronavirus | VOX, CEPR Policy Portal," Mar. 27, 2020. <https://voxeu.org/article/future-imperfect-after-coronavirus> (accessed Jul. 02, 2020).
- [29] G. Berisha and J. S. Pula, "Defining Small and Medium Enterprises: a critical review," *Acad. J. Business, Adm. Law Soc. Sci.*, vol. 1, no. 1, pp. 17–28, 2015, Accessed: Jul. 07, 2020. [Online]. Available: <https://www.researchgate.net/publication/276294683>.
- [30] B. Czarniawska, *Narratives in Social Science Research*. California: SAGE Publications, Ltd, 2004.
- [31] V. Braun and V. Clarke, "Reflecting on reflexive thematic analysis," *Qual. Res. Sport. Exerc. Heal.*, vol. 11, no. 4, pp. 589–597, 2019, doi: 10.1080/2159676X.2019.1628806.
- [32] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qual. Res. Psychol.*, vol. 3, no. 2, pp. 77–101, 2006.
- [33] V. Braun and V. Clarke, *Thematic Analysis*, 1st ed. London: SAGE Publications Ltd, 2022.
- [34] E. Kottika *et al.*, "We survived this! What managers could learn from SMEs who successfully navigated the Greek economic crisis," *Ind. Mark. Manag.*, vol. 88, pp. 352–365, Jul. 2020, doi: 10.1016/j.indmarman.2020.05.021.
- [35] M. Nasiri, J. Ukko, M. Saunila, and T. Rantala, "Managing the digital supply chain: The role of

smart technologies,” *Technovation*, vol. 96–97, 2020, doi: 10.1016/j.technovation.2020.102121.