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Smart Manufacturing Through Digital Shop Floor Management Boards

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Abstract
Smart manufacturing, an offspring from Industry 4.0 (I4.0), defines the future for the manufacturing industry. Smart manufacturing leads to digitalization of the shop floor, which is automated, computerized and complex. To stay competitive, digitalization of the shop floor management (SFM) boards will be instrumental in improving performance management and continuous improvement. The purpose of this paper is to improve the understanding of SFM board meetings in the era of I4.0. The paper explores the current adaptation level of digital SFM boards, and identifies influencing *forces for* and *forces against* a further transition from analogue to digital SFM boards. Based on a survey and a subsequent workshop with practitioners, this paper reveals that digital SFM boards have not yet been adapted at shop floor level, and currently, practitioners are stuck to the standardized procedures and manual processes. The *forces against* a further adaptation are a managerial mindset stuck in an Industry 2.0 era and immature technologies to digitize the visualization of real-time data. The *forces for* are the need of enhancing data transparency within and across teams, which means elimination of information silos and time-consuming manual updates of SFM boards.

Keywords Shop floor management · Industry 4.0 · Smart manufacturing · Digital SFM boards

1 Introduction

In the digital era of Industry 4.0 (I4.0), the concept of smart manufacturing highlights the importance of big data and the use of these data in a smarter way through digital technologies [1, 2]. This evolution influences shop floor management (SFM) activities, as many characteristics of smart manufacturing aim to utilize the analytical power of real-time data by using more technological equipment as computing platforms and communication technologies [3, 4]. In a smart manufacturing practice, SFM is digitalized [5]. Digital SFM provides an effective way to monitor, diagnose and prognosticate activities at shop floors [5, 6] entailing that digital SFM visualization boards offer new

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ways of working with real-time data, big data, and artificial intelligence [7, 8]. However, at present, the application of digital SFM visualization boards is still incipient [3] and full adaptations are rare to be found [5, 9].

In line with Mathiasen and Clausen [10], the fourth industrial revolution has skipped a digitalization of SFM boards; thus leaving the practitioners stuck in the Industry 2.0 (I2.0) era. Likewise, Holm [11] state that the interfaces of the shop floor information systems and communicating platforms look as they did 20–30 years ago. Hence, we lack understanding of what opportunities a digital board offers in terms of doing SFM, as the rapid development of intelligent communication technologies has only marginally reached the shop-floor.

This paper defines a digital SFM board as a digital physical object like a dashboard that has computing capabilities including analytical tools. Digital SFM boards makes it possible to improve the quality of and reduce the cost of processing, monitoring, and analyzing performance management (PM) and continues improvement (CI) data, thus reducing decision-making response-time.

Accordingly, this paper aims to identify the current adaptation rate of digital SFM boards as well as investigating the *forces for* and *forces against* a further adaption of digital boards to aid in decision-making at SFM meetings. To guide the research, we ask, "what is the current adaption rate of digital SFM board?" and "what forces influence a further adaptation of digital SFM boards?"

Methodologically, a mixed method is applied [12]. First, a quantitative study is accomplished to gain an overview of the current application of digital SFM boards, including *forces for* and *forces against* enhancing the adaptation rate; secondly, a qualitative study is conducted to gain a deeper understanding of the quantitative findings, especially the forces influencing the future adaptation of digital SFM boards.

The findings show that practitioners in the companies we have studied, lack understanding of the possibilities of applying digital SFM boards and they do only have limited experience with smart digital technologies at the SFM level; indeed, digitalization of SFM meetings is nearly non-existent. The *forces for* applying digital SFM boards are: elimination of information silos and elimination of time-consuming manual updates of analogue SFM boards. The *forces against* are: immature data foundations, unsuitable IT architectures and organizational procedures being stuck in the habitual ways of facilitating SFM. This paper opens new ways to improve our understandings of forces influencing the transition into a smart manufacturing SFM board meeting practice. Companies, which are capable of automating the data treatment and information handling at the SFM level and eliminating information silos, will operate in a smart manufacturing practice, in which data and information flow easily across boundaries, enhancing both intra- and interorganizational communication and collaboration.

The following sections are structured as follows: the first section explains the theoretical background of the study and presents theoretical findings regarding forces influencing the digital transition at the SFM level. The second section presents the methodological considerations. In the third section the analysis of the current adaption rate and forces influencing a further adaptation of digital SFM boards are presented followed by a discussion and the conclusion.

2 Theoretical Background

The term "shop floor" origins from the Japanese word "Genba" and it addresses the place where value is created [13]. The shop floor is the point of convergence between information flows, material flows, and flows of following up activities [4]. Despite a common definition of the constituents of a shop floor does not exist, this paper considers SFM board meetings as a managerial system that facilitates the communication and control of the PM and CI activities at the shop floor level [3, 9].

I4.0 has a strong impact on the manufacturing set-up [3], and has thus attracted attention from governments, industries, and researchers, but still many aspect of the new digital opportunities are unknown and uncertain [14]. I4.0 can be understood as a digital transformation of the business foundation, where smart manufacturing is on the forefront, but the question is, to what extent companies at the manufacturing level has adapted this type of industrial transformation? Because of smart manufacturing enables companies to achieve a high performance level and thereby competitive advantages [15–18], the rate of adapting digital technologies is of great interest.

In smart manufacturing practices, practitioners witness new technological equipment and IT-systems as for instance digital technologies [4], big data equipment [6], and artificial intelligence [19]; manufacturing has evolved and thus automated, computerized and complex [20]. The smart manufacturing and digital technologies go hand-in-hand and highlights the importance of big data and the use of data in a smarter way [1, 2]. In other words, these digital technologies have a huge impact on managing PM and CI activities at the SFM level [21, 22].

The prevalent academia understanding of smart manufacturing illustrates a future state of manufacturing in which machines, products, and practitioners act digitally and intelligently together; everything including the practitioners are digitally connected via the internet [7]. The aim of this connectivity is to form connected platforms for sharing information and knowledge and to exploit data in a smarter ways through more advanced data analytics [4, 23]. In general, however companies lack capabilities to share information and knowledge, meaning that they have loads of unutilized data. Likewise, only few companies have yet explored the benefits of working with such digital opportunities at SFM level [3, 7, 8], and the companies do only show a slow progress in their adaptation and use of this kind of technological systems [14, 24].

SFM board meetings are often accomplished in open locations and managed by a foreman [3, 13]. At present, the prevalent understanding is that SFM meetings are accomplished by using analog visualization boards [9]; i.e., analog communication approaches are mostly applied at shop floor level. Iuga et al. [25] state that analogue communication results in lots of waste time at SFM levels. This, combined with the fact that shop floor practitioners are accomplishing PM and CI activities by following standard operating procedures and manual processes without any supportive technologies to support decision-making [9, 11, 14] results in ineffective SFM board meetings.

However, the focal point for the practitioners is to achieve high manufacturing efficiency, low manufacturing cost, high product quality, and high employee satisfaction [7]. Likewise, because of intensive competition in the market, it is crucial that shop floor practitioners are continuously capable of being responsive, reliable, resilient, and relational to enhance the competitive position of the company [15]. In addition, the practical realities illustrate that the accomplishment of SFM activities are becoming more complex and uncertain, for which it is important that the information is up-to-date and communicated

properly [26] within and across shop floor teams. Hence, the executions of SFM activities require the right amount of information as well as reliable and up-to-date information, which calls for the use of digital technologies [10].

To recap, SFM draws on analog systems, but manufacturing faces new advances in information technologies as cloud computing, Internet of Things, Big Data and artificial intelligence that leads to a smart manufacturing era [6, 27]. To adapt these digital opportunities there is a need to converge the manufacturing physical world and virtual world [6]. Based on the above, next section addresses the forces influencing the digital transition of the SFM level.

3 Forces Influencing the Digital Transition of the SFM Level

The paper interprets and defines the influencing *forces for* and *forces against* the digital transition as follows:

- The influencing *forces for* the digital transition are defined as the opportunities for achieving full data transparency and to enhance the competitive situation both in a short and long term; i.e., through the new ways of working with real-time data, big data, and artificial intelligence.
- The *forces against* the digital transition are disadvantages in terms of immature data foundation and of practitioners' capabilities to use digital technologies in SFM board meetings; as for the latter, practitioners are incapable of utilizing data through the digitized technologies.

The literature addressing the digital transition at the SFM level is very limited and only few researchers have attempted to systematize the practical realities [3]. Torres et al. [5] state that the impact of digitalization is going to be more evident at shop floor level as it is the focal point in manufacturing companies. The new way of working will require that practitioners have useful support systems that can aid in the decision-making; needed information should always be available at the right time and space [5, 7].

Holm [11] suggests that SFM practitioners should form self-controlled teams and apply a holistic approach in their work with digital technologies. This paves the way for achieving a high degree of flexibility, adaptability, and initiative in terms of further adaptations of digitalized technologies. Zhuang et al. [4] propose addressing the planning and following up activities related to PM and CI activities with the aim to evolve SFM from a single point and isolated decision-making system characterized by "information silos in the business," to a smart intelligent and digital SFM systems. Torres et al. [5], Hertle et al. [13] and Winby and Mohrman [16] agree that the digital transition creates many new opportunities to enhance the performance at the SFM level, but these authors do also highlight that a successful transition requires huge managerial attention on both technical and social issues. Hence, the digital transition of the SFM level is resource demanding and time consuming, which requires full managerial support related to technological and organizational changes. Hence it is a necessity that the company invests resources in developing and supporting their competences both technological- and organizational wise.

Meissner et al. [3] and Torres et al. [5] state that digitalization is a catalyst for following up on and enhancing performance at the SFM level; they argue that PM, CI (problem solving management), and leadership are the main activities to be conducted at the SFM level.

In a conceptual paper, Meissner et al. [3] have mapped the influencing *forces for* and *forces against* of digitalizing PM-, CI- and leadership activities at the SFM level. The influencing *forces for* are; (1) opportunities of using real-time data and enhancing data transparency; (2) digital information network among practitioners; (3) accessibility of information increases and is straightforward; (4) digital technologies to support solving PM and CI activities within and across teams. The influencing *forces against* are related to the application of digital technologies including Big Data, because it requires changes in both managers' and practitioners' capabilities and it requires a huge technological transformation. More specifically, disadvantages are; (1) practitioners and managers lack of capabilities; (2) "data blindness syndrome, meaning practitioners may become incapable of understanding applicable data, as they rely too much on the technological capabilities"; (3) cultural barriers against new working procedures and technologies. Meissner et al.'s [3] findings in regard of the influencing *forces for*- and *against* a digital transition at SFM level, do not reflect upon the negative side effects of applying digital SFM, beside mentioning the risk of achieving the "data blindness syndrome". Hence, the academic understanding provide a limited view on the practical gains from applying digital SFM boards.

To recap, *forces for* and *forces against* the digital transition of the SFM level are categorized into a Force Field Analysis [28], see Table 1.

The next section accounts for the applied methodology.

4 Methodology

The research is an empirical study based on the retroductive approach [29]. Accordingly, the knowledge generation has ran in iterative loops between empirical- and literature analyses. The empirical data have been collected through a mixed methods study [12], starting with a quantitative study based on a survey, and then a qualitative study based on the accomplishment of a workshop with practitioners. Furthermore, the authors have implemented analog SFM boards in more than 40 companies.

Based on the authors' knowledge achieved through many years of experience in the field, we put forward a hypothesis claiming that the current adaptation of digital SFM boards is close to be non-existent. Hence, the purpose of the quantitative study was to gain a broad understanding of the current adaptation level of digital SFM boards. Thus, the survey did not have the purpose of providing a detailed understanding of the phenomenon

Table 1 *Forces for* and *forces against* a digital transition of the SFM level

Influencing forces for the digital transition of the SFM level	
Influencing *forces for*	Influencing *forces against*
Real-time and reliable data	Cultural barriers
Enhanced data accessibility	Low competence level
Enhanced data transparency	Data blindness
Early problem detection	Resource demanding
Data driven decision-making	Time consuming
Enabling communication via network	Unstructured data storage
Improved data foundation	Limited organizational support
Enhanced competitiveness	Low utilization of data

being studied; it was more important for the authors to gain a sufficient understanding before accomplishing the qualitative data collection.

The preparation of the questions in the survey reflects the authors' practical experience and empirical knowledge gained within this area and a conducted literature review. The survey was constructed digitally and sent to around 900 companies in Denmark. The survey was available for the companies in a period of three months, 97 companies answered the survey. All companies involved in the survey were informed about the purpose of collecting the data and have given their consent for applying the received answers in scientific work and publication.

The data from the survey provided interesting patterns, but obviously some of these needed further investigation. Indeed, some of the findings from the survey raised new questions to investigate, which the authors addressed at the workshop.

The workshop was conducted at Aarhus University. Both private and public companies were invited, including all companies, which had answered the survey. 38 companies participated in the workshop. All participating companies have accepted that all kinds of data collected during the workshop would be applied in scientific work and publication; all 38 companies have given their consent.

As illustrated in Table 2, the workshop consisted of three steps.

The data collection followed the Café Seminar method [30]. The purpose of using the Café Seminar approach was to achieve a common understanding among the three authors of this paper, in terms of both the underlying causes to the current adaptation of digital SFM boards and the forces influencing the digital transition of SFM visualization boards. Throughout the workshop, the data collection was based on an exchange of experience among all participating companies, which paved the way for the authors to gain new understanding of the phenomenon being studied.

As mentioned elsewhere, the authors' interpretation of the results from the survey indicated that the companies did not have the same prerequisites for answering the questions in the survey. Accordingly, at the outset of the workshop a presentation was conducted with the purpose of forming a common understanding of digital SFM visualization boards among all the participants; thus, the companies participating in the workshop had the same prerequisites when doing the Café Seminar.

The five questions discussed at the Café Seminar were developed by two of the authors, which were used to form five question-stations. Each of the five question-station was facilitated differently, but in general, the focal point was to encourage open dialogues from several perspectives. The companies were divided into five groups, and each of the group discussions at the five Café Seminars was managed by a station-manager who had to facilitate the process, observe, and take notes. The Café Seminar was divided into four steps (Table 3).

The next section presents the empirical findings in the survey and in the workshop.

Table 2 The three steps discussed in the workshop

Workshop program	*Step 1* Presentation of theoretical perspectives of digital boards in operational environments at the SFM level, including a presentation of the digital bord solutions available
	Step 2 Presentation of the data generated from the survey, including our findings. The results were discussed in plenum with the participating companies
	Step 3 Practical workshop—the companies were divived into groups and should answer and discuss different questions developed by the authors

Table 3 The four steps of the Café seminar

Structure of the Café seminar method workshop	*Step 1* Open dialogue. Every participant in each group shares their viewpoint in terms of the question. A common answer for the group was developed (15 min rotation period) *Step 2* Rotation to the next question-station. There were in total five question-stations, thereby four rotations. The process in each question-station followed step 1 *Step 3* Return to the first question-station. Joint discussion about all answers from the five groups. A common generic answer at each question-station was developed *Step 4* Joint presentations. Each facilitator presented the answers from the question-stations

5 Empirical Findings and Analyzing the Data

First, the findings from the survey are presented; secondly, the workshop data is analyzed.

The survey provides an overview of the current application of board meetings in companies and the adaptation rate of digital SFM boards. Table 4 summarizes these findings.

The findings in Table 4 indicate that board meetings are an activity that are often used. Roughly, 75% of the companies are aware of digital SFM boards and 21% of the companies state that they apply both digital and analogue SFM board to manage meetings. However, less than 10% of the companies do only apply digital SFM boards to manage board meetings. Hence, these findings show high application of SFM board meetings, but low use digital SFM boards.

Companies were requested to specify their answers if they used digital SFM boards. The answers clearly illustrate that companies do not yet have a common understanding of SFM digital boards and the fundamental technological features to enable that. The majority of companies answer that their digital SFM boards consist of a computer- or a flat-screen, and that the embedded software in the digital board consists of standard Microsoft Office package programs. Likewise, none of the companies mentions any kind of smart technological features or any kind of advanced analytical tools to support decision-making processes. However, few companies answer that they have acquired new software applications, for instance "PowerBi" and "Trello," to enhance the visualization features. Apparently, the current adaptation rate of digital SFM boards is lower

Table 4 Application of board meetings and adaptation rate of digital SFM boards

Question	Percentage
Number of companies that conducts board meetings on a daily or weekly basis	81.70
Number of companies that has heard about digital SFM boards	75.30
Number of companies that uses both digital and analog SFM boards	21.00
Number of companies that only uses digital SFM boards	7.00

than 7%, which our survey indicates. More importantly, it seems the practitioners have not yet initiated a clarification of technical requirements and features in terms of developing a suitable information architecture platform for digitalizing SFM board meetings.

As for the data collected during the *workshop,* an initiating plenum discussion involving all participating companies supports the above statement, which indicates a much lower adaptation of digital SFM boards than depicted in Table 4. Indeed, during this discussion, it gradually became apparent that only one of the participating companies has practical experience in using digital SFM boards. The discussion also revealed that the practical experience with digital technologies to facilitate board meetings is nearly non-existent in the companies.

In the same way, the dialogues clearly showed a lack of common understanding among the participating companies regarding technical requirements and features to digitalize SFM boards. Most companies categorized TV-screens with simple visualization features as digital SFM boards, even though it did neither provide any positive influence on the response-time nor at the processes of monitoring and discussing PM and CI activities. These findings indicate that the practitioners do not yet have a sufficient understanding of what a digital SFM board is, and what opportunities it brings. It seems that practitioners lack understanding of digital SFM boards, and more importantly, what kind of possibilities for action such a digital board offers and the technical prerequisites for facilitating that.

Based on the discussions and notes taken during the Café Seminar, a number of *forces for* and *forces against* the transition from analog to digital SFM boards are identified. Table 5 summarizes these findings.

Table 5 shows that the key influencing *forces for* adapting digital SFM boards are the multiple opportunities, which are not just related to managing the activities at shop floor, but also to optimize various business processes across the company to improve the competitive situation in the future. The key influencing *forces against* the adaption of digital SFM boards are immature IT architecture and systems, low utilization of data and the cultural challenges related to managing the transition processes of both technical and organizational issues. This transition processes calls for changing the habitual way of working in companies, which will be resource demanding and time consuming, mainly due to the companies' current technical and managerial competence levels.

Table 5 Categorization of *forces for* and *forces against* for adapting digital SFM boards

Influencing forces for adapting digital SFM boards	
Influencing *forces for*	Influencing *forces against*
Data transparency (no "hidden factory" syndrome)	High investment
Data and information sharing via digital network	Habitual mindset/procedures
Elimination of information silos	Too inconsistent IT-systems
Elimination of time consuming updates of boards	Unsuitable IT architecture
Real-time/big data enabling efficient decision making	Immature technologies
Synchronizing data	Higher vulnerability if IT systems fails
Intelligent technologies for decision-making	Poor data quality in the company
Enhancing human capabilities for decision-making	Data blindness
Digitization is a prerequisite for competitiveness	Low commitment for changes at SFM level
	Managers deprioritizing the digital transition
	Low knowhow of the opportunities

6 Discussion

The analysis demonstrates a low adaptation rate of digital SFM boards, and that the practical experience with digital technologies to accomplish SFM board meetings is nearly non-existent in the companies.

Zhuang et al. [4] state that today's data and information assessment are defined as a single point manual and analogue decision-making system with low accessibility of information across functional boundaries and information silos in the company. The same authors suggest that the planning and following up activities related to PM and CI activities should evolve to smart manufacturing SFM in which the digital technologies enable communication and information sharing within and across both functional and organizational boundaries [4].

Mathiasen and Clausen [10] state that the fourth industrial revolution has skipped a digitalization of SFM boards; thus leaving the practitioners stuck in the I2.0 era meaning, that practitioners are accomplishing the PM and CI activities by following standard operating procedures and manual processes. Likewise, Holm [11] state that the interfaces of the shop floor information systems and communicating platforms are far behind as they look as they did 20–30 years ago. Hence, practitioners er without any supportive digital technologies to support decision-making at the SFM board meetings. Based on these findings, Fig. 1 depict the forces influencing the digital transition of the SFM level in regard of the technological maturity level and the accessibility of data and information.

The *vertical axis* on Fig. 1 shows the opportunities—from single point SFM in which information silos constrain the accessibility of information, to smart manufacturing SFM in which digital technologies enable communication and information sharing within and across both functional and organizational boundaries. The *horizontal axis* in Fig. 1 addresses the technological maturity ranging from the I2.0 era characterized by analogue manufacturing methods and operations to the I4.0 era in which digital

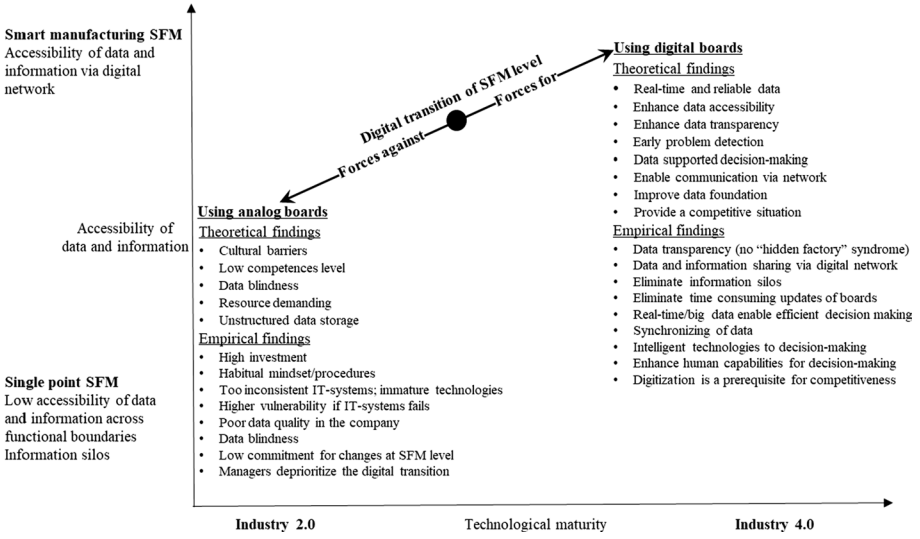

Fig. 1 Forces influencing the digital transition of the SFM level

technologies are embedded in all manufacturing processes and operations including suitable IT-architecture and data foundation.

In the middle of Fig. 1, the *forces for* using digital boards are listed in the right side, while *forces against* the digital transition of the SFM level appears at the left. The *forces against* results in the practitioners remaining in the I2.0 era and thus using analogue boards and the *forces for* result in a transition towards applying digital boards at SFM meetings. The *forces against* our findings stand out on two issues. First, the immature digital technology and minimal attention on the required data foundation if a company wants to go digital; i.e., too inconsistent IT systems and architectures, high vulnerability if IT systems fail, and poor data quality in the company. Second, the managerial approach characterized by the habitual way of doing SFM meetings; i.e., the managers deprioritize the digital transition of the SFM level, and in general, the practitioners seem to have a low commitment for changes.

The researchers addressing the technological progress claim that the practitioners witness an exponential development of digitized technologies [4], Big Data [6], and artificial intelligence [18]. If these researchers are right in their viewpoints, the necessary technologies are available to a successful transition from the analogue to digital boards at the SFM level. Accordingly, it might be reasonable to suggest that the key *forces against* the adaption of digital boards are managerial challenges related to managing the transition process; i.e., changing the habitual way of doing SFM meeting, enhancing the practitioners' capabilities, and facilitating a higher degree of commitments among the involved practitioners. The analysis in this paper illustrates that the practitioners' capabilities, procedures, and methods used today are incapable of handling the digital transition process, mainly because the current managerial mindset is stuck to the manual processes developed in the I2.0 era, and thus not yet has been adapted to the I4.0 era.

The analysis in this paper echoes the prevalent theoretical understanding [3, 20], emphasizing that digital technologies are a prerequisite for enhancing the performance at SFM level and for being competitive in the context of smart manufacturing. Holm [11] and Yin et al. [14] highlighted that the ongoing digitalization of operations in general will result in an increasing complexity and uncertainties at the SFM level. If managers do not realize that the SFM level is stuck in a managerial mindset formed at the Toyota Production Systems around 1950, the gap between the digitalization of business and the SFM level will increase to an unmanageable level. However, to discard this habit of applying analogue boards, the practitioners at SFM face several challenges. Our findings indicate that the current managerial approach at the SFM level is characterized by the habitual attitude of mind, in terms of performing PM and CI activities. Another challenge is the immature technologies at the SFM level to enable ongoing processing, monitoring, and analyzing PM and CI data and information. This paper suggests a more reflective mindset in terms of digitalization and managerial approach at the SFM board meetings; thus, gradually bringing the smart manufacturing opportunities to the force, if not, the managers will intentionally hinder the digital transformation at the SFM level. Holm [11] agrees upon this and suggests that the practitioners at the SFM level should form self-controlled teams, and thus take a holistic approach in their work with digital technologies, with the aims of achieving a high degree of flexibility, adaptability, and initiative.

Based on the empirical findings it was identified that only one of the participating companies in the workshop had experienced some of the advantages of applying a digital SFM board. As the information about the actual experienced advantages of the digital SFM was limited (the digital board was newly implemented in the company), it is hard to establish

whether the company have experienced remarkable differences in applying a digital SFM board instead of an analogue board to conduct SFM board meetings.

A prerequisite for being competitive in the future is the digital transition of shop floors [3, 19]. Accordingly, it causes wonder why the digital transition of SFM board meetings is rather slow-paced as demonstrated in our findings when the necessary technology is available. To gain an understanding of this paradox future research could address; (1) technical prerequisites for the digital transition of SFM board meetings; (2) managerial prerequisites for the digital transition of SFM board meetings. In addition, our empirical findings illustrate that the practical realities at shop floor levels in companies are characterized by an I2.0 habitual way of working and the use of non-digitized SFM systems. These findings pave the way for future research to clarify; (1) why companies are stuck in manual procedures and are still using immature technologies; (2) the technological readiness in companies including the necessary capabilities to enable a transition towards more advanced data analytics—i.e. descriptive-, diagnostic-, predictive- or prescriptive analytics (see Dai et al. [23]).

7 Conclusion

At the outset, this paper aimed at exploring the current and future adaptation of digital SFM boards, and the research was guided by the following research questions "what is the current adaptation rate of digital SFM board?" and "what forces influence a further adaption of digital SFM boards?".

Based on the authors' experience with implementing SFM boards, a survey was sent to 900 companies, and a Café Seminar in which 38 companies participated. We conclude the followings:

- Only very few companies has successfully accomplished a transition from analogue to digital SFM boards. In the same way, the companies lack understanding of and practical experience with digital technologies at the SFM level. Currently, the digital SFM board meetings are nearly non-existent in the companies we have analyzed.
- This study contributes to two new findings in terms of *forces for* the digital transition, which are elimination of information silos as well as elimination of time-consuming manual updates of the SFM boards. Automating the data treatment and information handling at the SFM level—collection, processing, and visualization—and eliminating information silos will enable data and information to flow easily across the boundaries, enhancing intra- and inter-organizational communication and collaboration.
- The analysis of the *forces against* a digital transition contributes to two new findings. First, the immature digital technology and unsuitable data foundation, i.e., too inconsistent IT systems, high vulnerability if IT systems fail, and poor data quality. Second, a habitual way of managing the SFM level, i.e., deprioritization of the digital transition of the SFM level and a low commitment for changes.

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