TOWARDS UNDERSADING THE ROLE OF MIDDLE MANAGERS IN INDUSRTY 4.0 INITIATIVES

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Towards Understanding the Role of Middle Managers in I4.0 Initiatives

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Two years ago, I took a leap of faith, leaving my comfort zone and well-established life in India to embark on an incredible journey in the Netherlands for my master's degree. Reflecting on this experience, I realise how profoundly it has shaped me, both personally and academically. Navigating a new country and embracing a different culture, both inside and outside academia, has been a rollercoaster ride. Today, as I reach the end of this era, I am filled with gratitude and excitement for the future that awaits beyond my student life.

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Executive Summary

Industry 4.0 (I4.0) represents a transformative shift for manufacturing organisations, driving the integration of digital technologies into every aspect of operations. This shift demands a comprehensive, organisation-wide change affecting how businesses operate, compete, and deliver value. For organisations to successfully navigate this transformation, it is crucial to understand the impact of I4.0 on their processes, workforce, and competitive landscape.

While existing research has extensively explored the role of top managers and leadership practices in guiding organisations through digital transformation, there has been a significant gap in understanding the role of middle managers in this context. From a general management research perspective, there appears to exist research focusing on middle management roles in different change types, yet I4.0 projects still need to be addressed.

This study employed a qualitative, inductive approach using semi-structured interviews to generate theory and draw conclusions. The research targeted senior managers, middle managers, and change managers within the production and operations value chain of manufacturing organisations. Thirteen participants from various organisations in The Netherlands were involved. The interviews were recorded, transcribed, anonymised, and then coded to identify emergent themes.

The results provided valuable insights into organisations' journey towards digital transformation. As the level of implementation of I4.0 initiatives differed, the results were categorised into digitisation, digitalisation and digital transformation based on the value creation impact of implemented initiatives. organisations often struggle to involve middle managers in I4.0 initiatives because of traditional methods and processes used to carry out operations in the manufacturing landscape. challenges such as the perception of middle managers as only overseers of operations and complex project structures lack of time & resources limits their ability to contribute to organisational journeys towards digital transformation effectively. However, senior managers and change management experts highlighted the benefits of efficiently integrating middle managers in I4.0 initiatives such as accelerated implementation and strategic prioritising of operational problems that can be solved through digital technologies.

In the digitisation phase, middle managers play a crucial role in laying the foundation for digital transformation by understanding and implementing I4.0 technologies guiding their teams through initial adoption challenges. As organisations move into the digitalisation phase, They are responsible for building digital maturity within the organisation by developing employees' skills, fostering trust, and ensuring smooth technology adoption through continuous monitoring and feedback. They ensure that digital initiatives are aligned with strategic goals while integrating practical insights from the ground level. In the digital transformation phase, middle managers are crucial in sustaining digital change and fostering continuous innovation. They ensure that digital transformation is not a one-time activity but an ongoing process. They foster digital agility to sense and seize new market opportunities, integrate new technologies into scalable operations, and build digital networks with suppliers, customers, and third-party innovators.

This study fills a research gap by demonstrating the evolving role of middle managers as organisations progress through the phases of digital transformation. The findings highlight the need for specialised structures, such as a "centre of excellence," to manage multiple I4.0 initiatives effectively, balancing

top-down strategies with bottom-up insights. The study also revealed that traditional organisational structures might hinder digital transformation due to hierarchical barriers and bureaucracy, suggesting a need for more flexible and adaptive organisational frameworks.

The theoretical implications include demonstrating the evolving role of middle managers as organisations progress through various phases toward digital transformation. This study highlights middle managers' unique challenges at each stage, offering a nuanced perspective that views digital transformation as a gradual, phased process rather than a sudden, radical shift.

From a practical perspective, the study raises awareness among top managers about the crucial role of middle managers in driving I4.0 initiatives. It calls for rethinking middle managers' roles, empowering them as strategic partners rather than merely operational overseers. Organisations are advised to invest in building the competencies of middle managers, fostering a culture of continuous learning and collaboration, and creating environments that support their active involvement in digital transformation. By doing so, organisations can better leverage the unique position of middle managers to achieve sustainable digital transformation.

1. Introduction

1.1. Context of the study

Industry 4.0 (I4.0) has significantly transformed the industrial landscape, focusing on integrating digital technologies and automation. It transcends adopting a singular technology, representing a paradigm shift in value creation by incorporating multiple technologies and fostering specific design principles like real-time capability and virtualisation to facilitate a comprehensive redefinition of manufacturing processes (Ghobakhloo et al., 2023).

Organisations operate in a fast-paced, highly competitive environment, driving them to continuously seek innovative approaches to reduce costs, shorten time-to-market, and enhance operational efficiency to deliver higher-quality products that better satisfy customer demands. In recent years, many companies have initiated “digital transformation initiatives". Despite the agreed-on vagueness of the term, it is commonly used to describe all types of digital-related corporate change projects, from integrating digital tools into everyday business processes to full-scale organisational restructuration (H. et al., 2018).

To keep up with industry trends and maintain a competitive advantage, manufacturing companies are looking for efficient means to accommodate the integration of I4.0 concepts into their existing setups (Henderikx & Stoffers, 2023). Since I4.0 technologies cannot be bought off the shelf, Rather they require firms to be organised to apply them properly (Porter & Heppelmann, 2015).I4.0 initiatives involve a series of subprojects where organisations need to excel at existing business operations while simultaneously exploring and integrating new digital technologies and tools. This has created a highly complex and uncertain environment, making managing multiple projects increasingly challenging as companies move towards the fourth industrial revolution.

Beyond technological issues, moving towards I4.0 requires considering managerial, organisational, and strategic advances, presenting several challenges for managers in implementing an I4.0 transformation (Schneider, 2018). The transformation towards Industry 4.0 fundamentally changes how businesses operate, necessitating a significant shift in organisational culture and the role of people within the organisation. Organisations are on a continuous journey towards digital transformation, requiring changes in business processes and organisational culture.

Most companies are not yet fully prepared to face the challenges of digital transformation, such as fast-paced innovation, restructuring of business processes, or changes in organisational structures, which must be tackled when digital technology is introduced to organisations and their employees (Ashurst et al., 2008). The rapid changes arising from digitalisation generate high levels of uncertainty within organisations (Kraus et al., 2021). It requires leadership and leaders to seize digital opportunities within a highly dynamic business environment and cope with them successfully (Coreynen et al., 2017; Schwertner, 2017).

Given these complexities, middle managers are uniquely positioned to address these challenges due to their dual roles as strategic implementers and operational leaders. They are the crucial link between top management’s strategic vision and frontline employees’ operational reality. Middle managers play a key role in implementing strategy and converting strategic objectives into actionable goals. Their intermediate position allows them to act as interfaces between otherwise disconnected actors and domains

(Nonaka, 1994; Wooldridge et al., 2008). Middle managers are the "hub through which most strategic information flows" (S. W. Floyd & Lane, 2000), providing a complementary and contemporary view of the organisation. Hence, their involvement is essential in leading and supporting organisational change, converting organisational strategies into daily practices, and facilitating digitalisation (Klein, 2020; Stoker, 2006). As digital transformation unfolds, middle managers must continue to lead and manage the new digital organisation, demonstrating that their role goes beyond merely overseeing business units to actively participating in times of organisational transformation in the digital era.

Middle managers are critical in navigating the transformation towards Industry 4.0. They are the crucial link between top management's strategic vision and frontline employees' operational reality (S. W. Floyd & Wooldridge, 1997). They play a key role in implementing strategy and converting strategic objectives into actionable goals. Their intermediate position allows them to act as interfaces between otherwise disconnected actors and domains (Nonaka, 1994; Wooldridge et al., 2008). Middle managers are the "hub through which most strategic information flows" (S. W. Floyd & Lane, 2000), providing a complementary and contemporary view of the organisation. Hence, their involvement is essential in leading and supporting organisational change, converting organisational strategies into daily practices, and facilitating digitalisation (Klein, 2020; Stoker, 2006). As digital transformation unfolds, middle managers must continue to lead and manage the new digital organisation, demonstrating that their role goes beyond merely overseeing business units to actively participating in times of organisational transformation in the digital era.

Manufacturing organisations are trying to implement digital tools and technologies within their production lines. These organisations possess complex value chains, including R& D, supply chain, production, logistics and distribution, and marketing and sales. I4.0 technologies integrate various value chains, both internal and external to the organisation. However, this study focuses specifically on the production and manufacturing processes on the shop floor, which have been most affected by digitalisation and I4.0. Additionally, it examines the critical role of middle managers in implementing these I4.0 initiatives within these processes.

1.2. Knowledge Gap

As organisations strive to adapt to the new digital transformation era, the role of middle managers has become increasingly crucial in navigating the challenges and opportunities presented by technological advancements. Middle managers are responsible for implementing and sustaining digital change, facilitating knowledge sharing, and developing skills within their teams to ensure a successful transition towards I4.0 (Klein, 2020). However, they often struggle to balance embracing new technologies with maintaining existing operational processes

While general management research has explored the roles of middle managers in various types of organisational change (Wooldridge et al., 2008), there is a notable gap in the literature regarding their specific involvement in digital transformation initiatives within manufacturing organisations (Henderikx & Stoffers, 2023). Although the strategic contributions of middle managers are well recognised—such as their ability to develop innovative ideas, enhance organisational effectiveness, and execute strategic plans (S. W. Floyd & Wooldridge, 1997) - studies lack robust data on their role in facilitating and implementing I4.0 initiatives.

Furthermore, significant attention has been given to the importance of top management support and end-users role in technology implementation, yet middle managers' involvement remains underexplored. Despite their essential role in converting organisational strategies into daily practices and facilitating

digital processes, middle management has received little focus when conceptualising leadership for overseeing digital transformations (Gfrerer et al., 2021; Nadkarni & Prügl, 2021).

Given that digital transformation is prevalent across many organisations, it is evident that leadership challenges at the middle management level are highly relevant (Henderikx & Stoffers, 2023; Vial, 2019). Middle managers must lead and manage new digital organisations, yet the impact of digital transformation on the leadership of middle management has not been thoroughly investigated. Hence, further research is needed to understand middle managers' involvement in I4.0 initiatives in manufacturing organisations, providing insights into their leadership challenges and contributions to successful digital initiatives.

1.3. Research Question

To address the knowledge gap highlighted above, The central question to this research emerges as,

RQ: What is the role of middle managers in implementing and facilitating I4.0 initiatives in manufacturing organisations?

Sub-research Questions

SRQ1: What challenges do middle managers face in implementing Industry 4.0 initiatives?

Purpose: To identify and understand the obstacles and difficulties middle managers encounter during implementing I4.0 initiatives.

SRQ2: How do middle managers interact with top-level management and operational staff, and what are the interdependencies?

Purpose: To explore the communication dynamics and dependencies between middle managers, senior management, and frontline employees during adopting I4.0 initiatives. This can provide insights into the effectiveness of organisational communication strategies and how these interactions influence the success of I4.0 implementation.

SRQ3:What strategies and key steps do middle managers employ to overcome the challenges in implementing I4.0 initiatives?

Purpose: To investigate the practical approaches and strategies middle managers use to address and overcome the challenges they face while implementing I4.0 initiatives. Understanding these strategies will provide actionable insights into how middle managers can effectively drive and sustain I4.0 initiatives in manufacturing organisations.

1.4. Connection to Management of Technology

My research on the implementation and facilitation of Industry 4.0 initiatives by middle managers in large-scale manufacturing organisations closely aligns with the core objectives of the Management of Technology program. The program emphasises leveraging technology to enhance customer satisfaction, corporate productivity, profitability, and competitiveness. By providing insights into the role of middle managers and the challenges they face, my thesis contributes to understanding how to manage I4.0 initiatives within organisations effectively. This aligns directly with the program's goal of using technology as a corporate resource to drive innovation and improve organisational outcomes.

2. Therotical Background

This section outlines Industry 4.0 and its transformative impact on manufacturing and digital transformation and provides insight into the differentiation of digital domains of digitisation, digitalisation, and digital transformation. Key themes include organisational and managerial challenges in implementing I4.0, defining middle managers and their involvement in initiatives. Lastly, leadership styles are examined in the context of I4.0.

2.1. Industry 4.0

2.1.1. Industry 4.0 in Manufacturing

Industry 4.0 (I4.0), also known as the fourth industrial revolution, involves the integration of novel digital technologies into manufacturing to enhance autonomy, efficiency, and social responsibility. First coined at the Hanover Fair in 2011 and later adopted by the German government in 2013 as a strategic initiative, Industry 4.0 aims to revolutionise the manufacturing industry (Li et al., 2018).Manufacturing firms are constantly evolving to face digital disruption. The increasing use of digital technologies aims to improve processes, reduce costs, and enhance customer offerings. Industry 4.0 marks the transition from mechanical to electrical, to digital, and now to smart manufacturing, characterised by automation and intelligent systems networking. Industry 4.0 is a top strategic priority for many manufacturing companies. It is an umbrella term for various technologies that collectively prepare companies to become smart factories of the future.

Implementing Industry 4.0 is not a single project but a series of subprojects to integrate these technologies into day-to-day operations. Industry 4.0 transcends the adoption of a singular technology. It represents a paradigm shift in value creation, incorporating multiple technologies and fostering specific design principles like real-time capability and virtualisation to facilitate a comprehensive redefinition of manufacturing processes (Ghobakhloo et al., 2023).

I4.0 has the potential to enhance operational efficiency and foster innovation within manufacturing organisations, offering operational excellence and increased flexibility through the automation and connectivity of processes (Dalenogare et al., 2018).

2.1.2. I4.0 and Digital Transformation

Industry 4.0, characterised by integrating advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and big data analytics, is pivotal in driving digital transformation in manufacturing and other sectors.

Digital transformation involves a comprehensive overhaul of organisational processes, structures, and business models to leverage digital technologies fully (Vial, 2019). By adopting Industry 4.0 technologies, organisations can transition from traditional manufacturing practices to more agile, data-driven operations. This transformation enhances operational excellence and creates new opportunities for value creation and competitive advantage (Schwab, 2016).

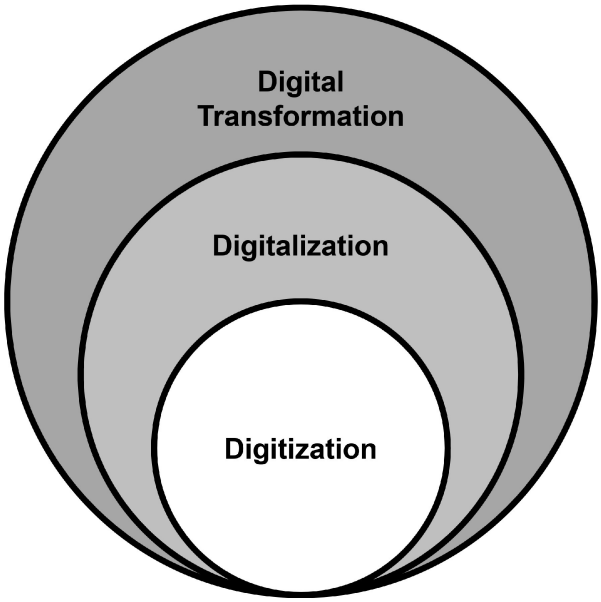

Figure 1: Depiction of digital domain based on (Tagscherer & Carbon, 2023)

In essence, Industry 4.0 provides the tools and frameworks necessary for digital transformation, facilitating a shift towards smarter, more connected, and more responsive manufacturing environments (Lasi et al., 2014). As organisations integrate these technologies, they embark on a continuous journey of innovation and improvement, fundamentally changing how they operate and deliver value to customers. As organisations journey through the integration of these technologies, it becomes an ongoing process that requires constant assessment and adjustment of work processes and people to extract value (Rüßmann et al., 2015).

2.1.3. Digital Domains: Digitisation, Digitalisation, & Digital Transformation

Digitalisation is a major trend impacting society and business, drawing significant attention from researchers and practitioners (Reis et al., 2018; Schallmo et al., 2017). Despite this, related terms are often used interchangeably and lack universally accepted definitions (Schallmo et al., 2017).

Digitisation, the process of converting analogue information into digital data, allows for quick, inexpensive, and accurate information transfer without altering value-creation activities in the organisation (Brennen & Kreiss, 2016; Verhoef et al., 2021).

Digitalisation involves transforming existing processes through digital technologies, enhancing customer experiences, and streamlining operations (Verhoef et al., 2021). This transformation is often project-based and can occur in various areas within a company, leading to significant changes in business operations (Martínez et al., 2022; Nyagadza, 2022).

Digital transformation is a broad concept that goes beyond digitalisation, adapting firms to new organisational structures and skill sets needed to remain viable and relevant in a digital landscape. It surpasses earlier ideas like IT-enabled change (Benjamin & Levinson, 1993) and business-process reengineering (Grover et al., 1995), which focuses on enhancing existing processes. Digital transformation introduces new business models by implementing innovative business logic to create and capture value (Pagani & Pardo, 2017). Beyond integrating digital technologies, it leads to significant organisational and social changes within companies (Reis et al., 2018).

The three digital domains may seem straightforward at first glance, but they all hide layers of complexity amid their implications for value creation, technology management, business strategy, and organisational culture (Tagscherer & Carbon, 2023).

2.2. Implementing I4.0 Initiatives

2.2.1. Organisational & Managerial Challenges for I4.0

I4.0 is not a single technology or project but a series of sub-projects in which organisations must implement multiple initiatives while keeping up with the pace of the changing industry landscape. Implementing I4.0 demands profound changes within organisations and their managerial frameworks. Literature defines Industry 4.0 as a confluence of digital technologies, requiring businesses to rethink their foundational structures and strategic approaches (Geissbauer et al., 2016). Organisational adaptation to I4.0 involves technological upgrades and a holistic reconfiguration of management practices, culture, and workflows (Arnold et al., 2016). Challenges identified from the literature are as follows,

Lack of Coherent Digital Strategy & Resource Scarcity

As per Ghadge et al. (2020); Müller et al. (2018), a coherent digital strategy is essential for successful I4.0 implementation. Many organisations struggle with aligning digital initiatives with their overall business strategy, leading to fragmented efforts. Financial and technological resources are often scarce, further complicating the implementation process. Developing a clear, integrated strategy that outlines the path towards digital transformation and allocates necessary resources effectively is critical (Berman, 2012).

Human Resources – Building Digital Capability & Workforce Development

The shift towards Industry 4.0 requires a workforce with advanced digital skills and competencies. Organisations must identify the necessary competencies and invest in education and training programs to build these skills (Kamble et al., 2018). This includes redefining job roles, providing continuous learning opportunities, and leveraging technological advancements to enhance employee qualifications (Petrillo et al., 2018). Adopting new technological procedures and methods necessitates a shift in the human resources mindset. Studies have observed that a lack of skilled workforce and natural resistance to changes in the work environment can be detrimental to adopting Industry 4.0 technologies (Kamble et al., 2018). Therefore, there is an increasing need to continuously promote the retraining of staff to adapt to these new technologies.

Organisational Culture – Continuous Learning & Collaboration

Creating a culture that supports continuous learning, experimentation, and collaboration is vital for adopting I4.0 technologies (Schneider, 2018). Organisations need to foster an environment where risk-taking and pilot projects are encouraged. Collaboration across different departments, such as mechanical and software engineering, is essential to break down silos and drive innovation (Kane et al., 2015). Promoting a culture that values these attributes can significantly enhance an organisation's ability to implement I4.0 initiatives successfully (Schneider, 2018).

Hierarchy and Organisational Structure

Rigid hierarchical structures can impede the agility required for organisations moving towards digital transformation. Flattening hierarchies and decentralising decision-making processes can help organisa-

tions respond more quickly to technological changes and market demands (Foerster-Metz et al., 2018). The flat structure reduces the distance between employees and the top management, allowing quicker communication and collaboration across hierarchical layers (Shamim et al., 2016). Hence, flexible organisational structures that support rapid decision-making and cross-functional teams are better suited for the dynamic nature of I4.0 environments.

Besides more agile decision-making, the empowerment of lower hierarchies is expected to increase the motivation of employees (Alade & Windapo, 2021; Tagscherer & Carbon, 2023).In addition, empowered employees in the decision-making process are more likely to be more innovative and receptive to cultural change (Guinan et al., 2019).

Ineffective Change Management

Technological advancements have dramatically transformed the nature of organisational change. Previously, change was viewed as a transactional process, often straightforward and manageable. However, with the advent of Industry 4.0, change has become radical, open-ended, continuous, and exceedingly complex ("Barriers to the adoption of industry 4.0 technologies in the manufacturing sector: An inter-country comparative perspective", 2020). This transformational nature of change presents significant challenges for organisations, making it difficult to implement successfully Anderson & Ackerman (2010).

Ineffective change management can lead to several issues, including employee resistance, misalignment of goals, and disruption of operations. Organisations need to implement comprehensive change management frameworks that include clear communication, continuous training, and involvement of all management levels to ensure a smooth transition. This also involves defining approaches for management control (e.g., central or decentralised), implementing specific responsibilities and dedicated management units, and effectively managing the overall process of change (Schneider, 2018).

2.3. Middle Management in Organisation

2.3.1. Defining Middle Managers

Huy (2001) defines middle managers as one level above line managers and two below the CEO. As opposed to senior managers' goal- and policy-setting functions, middle managers ensure the strategic execution of operation (Reynders et al., 2022), including reacting to the rapid changes and complexities digital ecosystems bring (Henderikx & Stoffers, 2023). Middle managers are positioned two or three levels below the CEO, overseeing supervisors while also being supervised by higher-level management (Dutton et al., 1997).

The distinguishing feature of middle management, however, is not where they sit in the organisation chart. Rather, what makes middle managers unique is their access to top management and their operations knowledge (Wooldridge et al., 2008). Such a functional designation comprises different types of mid-level professionals, including general line managers, functional line managers, and team project-based executives. This combination enables them to function as mediators between the organisation's strategy and day-to-day activities (Nonaka, 1994).

2.3.2. Middle Managers in Organisational Transformation

Specific Roles and Balancing Act

Kuratko et al. (2005) defined the role of middle managers in strategic renewal in organisations as follows: "Middle-level managers endorse, refine, and shepherd entrepreneurial opportunities and identify, acquire, and deploy resources needed to pursue those opportunities". Due to their unique position, the middle management perspective has been declared one of the main areas in strategy process research (Hutzschenreuter & Kleindienst, 2006).

Middle Managers Involvement in Organisation

Middle managers take actions that can have either upward or downward influence. S. Floyd & Woolridge (1992) defined four types of middle management involvement in organisational activities:

- **Championing alternatives:** Middle managers often spot and develop emerging operational-level initiatives. They promote the initiatives to top management rather than developing initiatives.
- **Synthesising information:** This means middle managers help top management interpret information in the strategic context. They translate ambiguous and uncertain data in a strategic context as they are involved in the day-to-day activities of the organisation.
- **Facilitating adaptability:** They facilitate adaptability when implementing initiatives as strategic plans do not always reflect the reality of operations; hence, middle managers foster flexible organisational arrangements and help new ways of doing things emerge in the organisation.
- **Implementing deliberate strategy:** Middle managers align organisational actions or activities with strategic goals and translate the strategy into tangible actions to achieve strategic goals.

Middle Managers as Change Agents

Huy (2002) argued that middle managers are vital change agents, performing four distinct yet interrelated roles during the implementation of change: entrepreneur, communicator, therapist, and tightrope artist. Each role necessitates a careful balance between strategic and operational change aspects. Similarly, S. W. Floyd & Wooldridge (1997) asserted that middle managers bridge the strategic and operational levels of the organisation through their roles in mediation, negotiation, and interpretation.

Top-Bottom Interaction Dynamics

Middle managers can negatively influence change if they do not support it (S. Floyd & Woolridge, 1992; Huy, 2002). Therefore, maintaining an open dialogue between middle and top managers is crucial. Building on the four middle manager role expectations identified by S. Floyd & Woolridge (1992), Mantere (2008) identified factors that enable these roles. He argued that reciprocal actions from top management are necessary to meet these role expectations. For instance, top management must be responsive to the synthesised information provided by middle managers to fulfill this expectation (Mantere, 2008). Additionally, Mantere (2008) highlighted the importance of adopting a dialogical approach to the strategy process and granting legitimacy to middle managers by top managers to empower their strategic agency.

Middle Managers as Key Actors in Strategy and Adaptation

Strategy formulation and implementation are social learning processes when all company employees adapt to the changing environment, and middle managers are key actors in these processes. Following the increased attention to the strategic role that middle managers play in organisations, three core motivations for their further research emerged in the literature (Christodoulou et al., 2022):

- **Connecting Operational and Strategic Levels:** Middle managers connect the operational and strategic levels of the organisations, between the top and frontline managers, due to their positioning in the organisational structures (S. Floyd & Woolridge, 1999).
- **Complementary Strategic Agents:** While top management is primarily responsible for setting the organisation's strategy, middle managers are considered crucial complementary strategic agents. In modern organisations that operate across various industries and regions, leadership is distributed throughout the organisation, with middle managers serving as intermediaries between different functions, divisions, and levels (Balogun & Johnson, 2004). Due to their distinct information sources and interpretive frameworks, middle managers can offer valuable insights into strategy formulation (Wooldridge et al., 2008). In the context of Digital Transformation, a study by Hess (2016) evaluated the role of middle management and identified it as a significant contributor to the development of emergent digital strategies that contribute to the organisational environment even before the top management comes forward with the deliberate digital transformation strategy.
- **Identification of Gaps and Capability Development:** Due to their closer positioning to operational activities, middle managers are more likely than top managers to identify gaps in the organisation's capabilities, impacting economic performance (King & Zeithaml, 2001). Middle managers use this knowledge to develop initiatives to build and improve existing capabilities.

Constraints and Strategic Formulation

Macro studies often implicitly assume that middle managers merely react to the environment rather than shape it, depicting them as constrained by structures, missions, cultures, strategies, climate, and protocols (Raelin & Cataldo, 2011). This assumption limits recognising their role in strategy formulation within the organisation.

S. Floyd & Woolridge (1994) suggest that middle managers hold the position between strategies and operations, giving them a unique insight into the nature of strategic requirements. Due to this position, middle managers should not be viewed as obstacles but as sources of knowledge (Herzig & Jimmieson, 2006). Middle managers in boundary-spanning positions with access to internal and external knowledge and extensive operational knowledge are invaluable sources of innovative ideas for organisations (Paavola et al., 2017). As S. Floyd & Woolridge (1994) noted, middle managers can have a substantial grasp of the strategic concept and aid in its implementation.

2.4. Digital Leadership & Middle Managers for I4.0

Different studies have different interpretations of leadership, and no definitive definition exists. However, most definitions of leadership contain fundamental elements such as 'group,' 'influence,' and 'goal.' In the context of a middle manager in digital transformation, Christodoulou et al. (2022) defines leadership as a manager's ability to enhance the organisation's long-term viability. He further elaborates on the leadership aspect of middle managers as follows:

- Setting agendas rather than reacting to them, identifying problems, and starting a change for improvement rather than just being a change management facilitator (Pearce et al., 2010).
- Influencing others to accept responsibility and make everyday decisions toward achieving a particular set vision (Rowe, 2001).

2.4.1. Need for Leadership 4.0

As digitalisation leads to a transformation of production, logistics, communication, and human resource management, organisations need innovative approaches to create value from digitalisation, connected smart devices, and establish new ways of communication and collaboration. Organisations must adapt their capabilities to handle new challenges in the continuously changing environment. Companies must develop a robust digital culture and ensure clear leadership drives the change. Digital technologies influence not only the area of information technology but also how businesses are managed and what kinds of leadership styles are applied. Leadership 4.0 stands for leadership in the age of Industry 4.0 (Oberer & Erkollar, 2018). These 4.0 leaders are called digital leaders.

Literature highlights that not every leader in a tech company is a digital leader. What makes a leader a digital one is not the area the company is working in. It is a question of leadership style and the abilities of these leaders to inspire their employees to innovate and hold onto their ideas. Oberer & Erkollar (2018) defines '4.0 Leadership Style for Digital Leaders' as "Digital leadership (leadership 4.0) is a fast, cross-hierarchical, team-oriented, and cooperative approach with a strong focus on innovation." The study by Oberer & Erkollar (2018) created a leadership matrix in the context of I4.0 based on leaders' concern for innovation, technology, and concern for people.

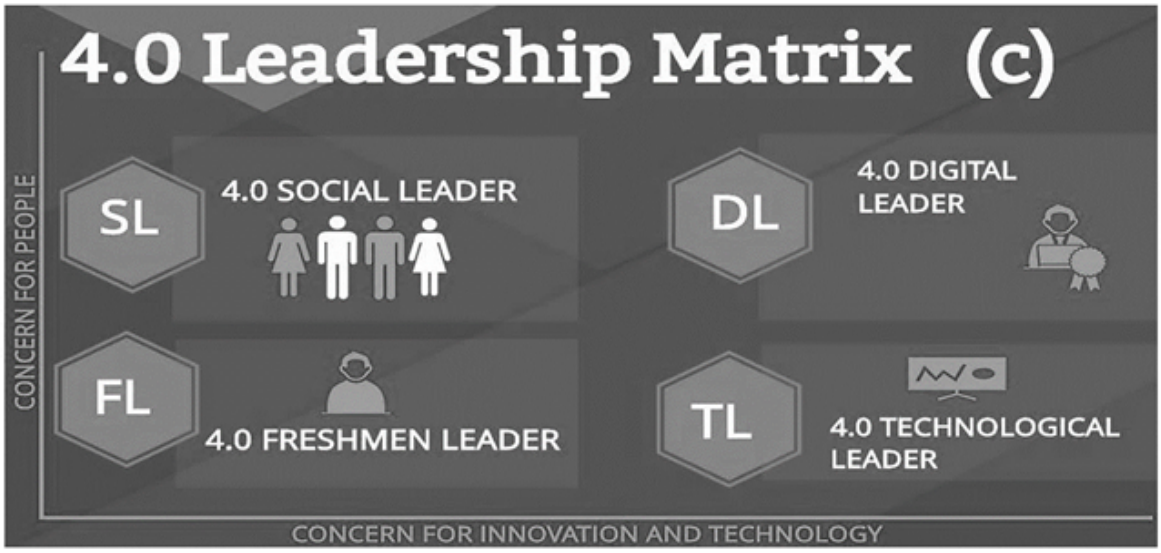

Figure 2: Leadership Matrix (Oberer & Erkollar, 2018)

The digital leadership styles are defined as follows:

- **FL (4.0 Freshmen Leader):**
  - Focuses on traditional manufacturing structures with primary emphasis on the finalised product.
  - Lacks focus on employees.
  - Customer needs are of minor interest.

  - Emerging technologies are not prioritised.
- **SL (4.0 Social Leader):**
  - Creates a friendly atmosphere for employees.
  - Innovation and technology are not primary concerns.
  - Supporting employees is important.
- **TL (4.0 Technological Leader):**
  - Determines how new technology can be used to deliver enhanced value.
  - Strong focus on innovation.
  - Low focus on employees.
- **DL (4.0 Digital Leader):**
  - Understands how technology impacts people.
  - Aligns the organisational model with human nature.
  - Integrates essential elements of digital leadership.

2.5. Conclusion

The theoretical background started with Industry 4.0 and highlighted its transformative potential in manufacturing by integrating advanced technologies. The shift from traditional to smart manufacturing marks a significant evolution, enhancing operational efficiency and creating new opportunities for value creation and competitive advantage.The digitisation, digitalisation, and digital transformation section clarifies the often-confused terms and their distinct implications. Digitisation refers to converting analogue information into digital data, while digitalisation involves transforming business processes through digital technologies. Digital transformation encompasses comprehensive changes to business models and organisational structures. Recognising these differences is crucial for businesses to develop effective digital strategies.

Organisational challenges in implementing Industry 4.0 are also discussed, including the need for a coherent digital strategy and developing a digitally skilled workforce. Many organisations struggle with aligning their digital initiatives with overall business strategy, leading to fragmented efforts. Building digital capabilities through continuous education and training is vital for adapting to new technological advancements and overcoming resistance to change.

The pivotal role of middle managers in bridging strategic and operational levels is explored, highlighting their influence on adaptability and innovation. Middle managers play a critical role in championing new initiatives, synthesising information for top management, and facilitating the implementation of strategic plans. Their unique position allows them to mediate between the strategic directives of top management and the practical realities of day-to-day operations. The importance of fostering a culture of continuous learning and collaboration is underscored as essential for the successful adoption of Industry 4.0 technologies. A supportive organisational culture encourages risk-taking, pilot projects, and cross-departmental collaboration, vital for driving innovation and adapting to technological advancements.

Lastly, the need for innovative digital leadership is emphasised. Effective digital leaders are critical in guiding organisations through the complexities of digital transformation, inspiring employees, and aligning technological advancements with business objectives. Leadership 4.0, characterised by a cooperative, innovation-focused approach, is necessary to navigate the dynamic and evolving Industry 4.0 landscape.

3. Research Methodology

3.1. Research Design

The research design for this study follows an exploratory qualitative approach, focusing on understanding the involvement of middle managers in I4.0 initiatives, the challenges they face, outlining key elements for advancement and their role in these initiatives. According to Saunders & Lewis (2017) a qualitative interview research approach is considered most appropriate because it primarily depends on the participant's perspective of the phenomenon under investigation and enables researchers to explore these subjective points of view to fully understand meanings and beliefs (Flick, 2022).

Semi-structured interviews will be conducted to collect data, and an inductive approach will be used to generate themes. The section will further discuss the ethics procedure, data collection methods, and analysis process.

3.1.1. Collaboration with Eviden

This research is conducted in collaboration with Eviden, a technology leader in data-driven, trusted, and sustainable digital transformation. Currently, Eviden Netherlands has four offices, which are located in Amstelveen, Eindhoven, Groningen, and Utrecht. The company provides several services, such as cybersecurity, cloud services, and advisory services in digital transformation.

The research is specifically executed for the Digital Transformation Consulting (DTC) department of Eviden, particularly focusing on the Product Life Cycle Management/Manufacturing Execution Systems (PLM/MES) team. This team guides manufacturing clients in various industries in participating in a digital future by implementing I4.0 technologies that improve production processes. The PLM/MES team consists of technological and organisational change management experts who play a critical role in assisting clients with the implementation of I4.0 technologies

3.1.2. Target Population

The fourth industrial revolution has significantly impacted the manufacturing industry, driving changes in business operations, work processes, production methods, and customer value delivery. Manufacturing organisations are currently on a journey to implement digital tools and technologies within their production lines. These organisations possess complex value chains, including areas such as R&D, supply chain, production and manufacturing, logistics and distribution, and marketing and sales. However, this study focuses on the production and manufacturing processes on the shop floor, which have been most affected by digitalisation.

The target population for this study comprises manufacturing organisations that have embarked on their digitalisation journey and the managers responsible for navigating these new changes. It includes three distinct groups. These groups are selected due to their unique roles and perspectives in implementing I4.0 initiatives.

In this study, the term "middle management" is recognised as a broad and potentially ambiguous category. To ensure clarity and precision in identifying the target population, I have adopted the definition of

middle managers as provided by (Netland et al., 2020). This definition enables the accurate identification and inclusion of individuals who hold intermediary roles between senior management and operational staff within the corporate structure and are responsible for implementing strategic initiatives. This approach ensures that the study addresses the correct set of respondents who play a crucial role in executing organisational strategies.

Table 1 summarises the corporate structure, which includes strategic, tactical, and operational management levels, along with their respective roles and responsibilities.

Middle Managers

Middle managers, often holding titles such as plant managers or department heads, play a crucial intermediary role between senior management and operational staff. They translate strategic directives from senior management into actionable tasks on the shop floor. This involves overseeing daily operations, ensuring alignment with organisational goals, and managing the performance and development of frontline employees.

They are pivotal in facilitating the adoption of digital initiatives because they bridge the gap between strategic plans and operational execution. Their ability to influence both upward and downward within the organisational hierarchy makes them key players in successfully implementing digital initiatives. Understanding their experiences and challenges provides valuable insights into the practicalities of digitalisation on the shop floor.

Senior Managers

Senior managers are at the helm of strategic planning and decision-making within the organisation. They set overarching goals, create policies, and provide the necessary resources and support for initiatives across the company. Their focus is on long-term strategic objectives and overall business performance.

They are crucial for setting the vision and providing the necessary support for I4.0 initiatives. Their commitment and support are often cited as critical success factors for digital transformation projects. By including senior managers in the study, we can gain insights into the strategic considerations and support mechanisms essential for driving digital initiatives from the top.

Consultants – Business & Change Management

Consultants in business and change management bring external expertise and perspectives to the organisation. They assist in developing and implementing strategies for digital transformation, provide specialised knowledge on change management practices, and help navigate the complexities associated with technological adoption.

They offer an objective viewpoint and extensive experience working with organisations on similar projects. Their role in facilitating digital change, advising on best practices, and addressing organisational challenges makes their insights valuable for understanding the broader implications of I4.0 adoption. Including consultants in the study helps identify common pitfalls and successful strategies observed across different organisational contexts.

3.1.3. Sampling Strategy

For this study, a purposive sampling strategy was chosen based on specific criteria to ensure that the selected participants have the relevant experience and insights necessary for the research objectives as

Level (Planning & Control)	Activities	Level (Management)	Role	Description
Strategic Management	Deploy goals Create policy Review means of tactical management	Senior Management	Managing Director Senior Managers	Chief Executive -Highest in organisational hierarchy Most decision power C-suite executive -Highest in the hierarchy of division/business unit
Tactical Management	Deploy means Review actions of operational management based on means	Middle Management	Plant Managers Department Managers	Plant General Manager - Translating strategy set by senior management into action Highest in depart. hierarchy - Intermediary between site & first-line management - Translating strategy set by the site and senior management into action
Operational Management	Devise implementation plans Review actions on a day-to-day basis	Lower Management	First-line Managers Front-line Managers	Lowest management level in the hierarchy -Management of non-managerial staff Leader and supervisor of shopfloor operators

Table 1: Corporate Structure Based on (Netland et al., 2020; Reynders et al., 2022)

whose organisations have experience in implementing I4.0 initiatives

Industry: Manufacturing

The focus is on manufacturing organisations due to their complex value chains and significant impact on the economy. Manufacturing is also one of the sectors most affected by implementing I4.0 technologies.

Size of Organisation: Large

Large organisations are selected because they typically have more resources, structured processes, and established management hierarchies. Large organisations are more likely to undertake substantial innovation initiatives, including I4.0 projects, due to their greater resource capacity and organisational complexity. Studying large organisations increases the likelihood of encountering comprehensive and successful examples of I4.0 initiatives, providing richer data for analysis. This makes them ideal for studying the challenges and strategies of implementing I4.0 initiatives.

Accessibility and Willingness to Participate

Organisations and individuals that are accessible and willing to participate are prioritized. This ensures a higher response rate and the availability of detailed and relevant data.

Geographical Location: Netherlands

The study focuses on organisations located in the Netherlands. This geographical focus allows for a more manageable scope.

By using purposive sampling, this study aims to gather rich, detailed data from participants who will provide valuable insights into implementing and facilitating I4.0 initiatives in manufacturing organisations. This approach ensures that the sample is relevant and aligned with the research objectives, leading to more meaningful and applicable findings.

3.1.4. Ethics Approval

The research was conducted after approval from the Human Research and Ethics Committee (HREC) of TU Delft. Consent was obtained from all the participants, and they willingly participated in the interviews. The TU Delft data steward verified the data management plan for the study. The interviews were conducted online via Teams, and all the data is stored in the TU Delft account.

3.1.5. Participants

In qualitative research, sample size determination is not primarily driven by statistical calculations but rather by data saturation. Data saturation is when collecting additional data no longer leads to new insights or themes (Guest et al., 2006).

I used network of Eviden and my professional network to reach out to participants. It was easier to get access to Eviden's internal resources for the study, I used LinkedIn to find participants in the manufacturing industry. I reached out to 80 potential candidates. Keeping to the 300-character restriction present on the online social network LinkedIn, I used the following message to reach out to people.

"Hi! I'm a student from TU Delft conducting research on the role of middle managers in implementing I4.0 initiatives in manufacturing. I would love to interview you for my research, as that would give me

great insights. Please let me know if that's possible. Looking forward to a positive response!"

I had a response rate of 16%. Upon receiving the participant's contact details, the emails were sent to the participant, along with an MS Teams meeting link. When participants accepted the meeting invite, I sent the email along with a consent form. This consent form had received approval from HREC. Table 2 presents an overview of the participants who participated in this research.

3.2. Data Collection Method

Conducting interviews to gather data on a topic of interest is a widely used technique in business research. To gain a general understanding of the issues related to I4.0 and create initial impressions, open-ended questions were asked at the beginning of the interviews (Sekaran R., 2019).

Each interview lasted for 60 minutes. Evaluating the interviewees' comments and noting any potentially important concerns, I followed up with increasingly targeted questions based on their initial responses. This funnelling approach, as described by Sekaran R. (2019), facilitated the transition from broad to narrow themes.

The interview protocol for each participant in the study is detailed in the Appendix, with each question linked to a specific research sub-question it aims to address. Since middle and top-level managers have distinct roles and responsibilities in implementing I4.0 initiatives, it was essential to tailor some interview questions to each group. This approach ensured a comprehensive understanding of how each role contributes to successfully implementing and managing I4.0 technologies in manufacturing organisations.

Label	Group	Title	Industry
MM1	Middle Manager	Maintenance Manager	Chemical
MM2	Middle Manager	Operations Excellence Manager	Healthcare
MM3	Middle Manager	Operations Excellence Manager	Chemical
MM4	Middle Manager	Operations Excellence Manager	Safe storage solution
MM5	Middle Manager	Production Manager	Safe storage solution
MM6	Middle Manager	IT Program manager & MOMS solution owner	Food Production
SM1	Senior manager	Global Smart Manufacturing and Industry 4.0 Manager	Healthcare
SM2	Senior manager	Global Operations Excellence Manager	Safe storage solution
SM3	Senior Leader	PLM Manager	Semiconductor
C1	Consultant	Change & Transformation consultant	Advisory
C2	Consultant	Senior Business Consultant	Advisory
C3	Consultant	Change & Transformation consultant	Advisory
C4	Consultant	OCM & Success Advisory practice lead	Advisory

Table 2: Interview Participants

3.3. Data analysis method

For analysing the gathered interview data, I utilised Braun & Clarke (2006) six-phase guide on thematic analysis. Initially, I familiarised myself with the data by re-listening all interview recordings and thoroughly reading the transcripts. This step was essential to gain an in-depth understanding of the collected information. Following this, I manually coded the transcripts, identifying patterns by labelling data relevant to the research questions. In the third phase, I searched for themes by grouping the identified codes to create a coherent map of the key patterns within the data. After mapping the themes, I paused to review and ensure a plausible fit between the coded data and the identified themes. Each theme needed a clear and distinct meaning relevant to the research questions and the dataset.

The review process led to several theme refinements, enhancing their clarity and relevance (Braun & Clarke, 2006). Once finalised, I developed detailed descriptions for each theme, which provided a structured framework for the findings section of the write-up (Braun & Clarke, 2006). This methodical approach ensured a comprehensive and accurate analysis, aligning to understand how middle managers facilitate and implement I4.0 initiatives in large-scale manufacturing organisations.

An example of a quote and code as follows:

Quote "We are constantly waiting for other factories and the digitalisation head in top management to give us the go-ahead to order new equipment to facilitate this." – MM1

Code Challenge: Dependencies on factories & and issues in centralised governance

During the coding stage total of 478 initial codes were created with 117 sub-codes. I mapped these codes into 18 overarching themes

4. Results

This section will present the qualitative findings from 13 semi-structured interviews conducted with middle managers, senior managers, and change management experts to answer the main research question: **"What is the role of middle managers in implementing and facilitating I4.0 initiatives in manufacturing organisations?"**. The chapter is organised into distinct phases of digital transformation: Digitisation, Digitalisation, and Digital Transformation.

First, the rationale behind the bifurcation of the phases is explained and based on this, the cases are divided into phases: digitisation & digitalisation. The results begin by exploring the involvement of middle managers in I4.0 initiatives and the benefits of involving them. This is followed by a thorough examination of the challenges they face during each phase of digital transformation. The findings also highlight the strategies and key steps necessary to overcome these challenges, underscoring the crucial role of middle managers in driving organisational change and ensuring the success of digital transformation efforts.

The Journey Towards Industry 4.0

The level of implementation of I4.0 initiatives varied across different cases, leading to the categorisation of the findings into distinct phases. Understanding these phases—digitisation, digitalisation, and digital transformation—is crucial to comprehending how middle managers navigate and influence the journey towards I4.0. Each phase reflects a different stage in the organisation's digital evolution. Furthermore, various implementation approaches, including strategy, goals & KPIs, and project-specific efforts, further contextualise the roles and actions of middle managers in driving these initiatives. The phases of digital transformation are detailed as follows:

- **Digitisation:** Digitisation is the foundational step, which primarily includes converting analogue information into digital format. For the shop floor, data is collected from various machines in centralised systems. It changes the process, but digitisation does not change value-creation activities (Verhoef et al., 2021).
- **Digitalisation:** Digitalisation represents a significant step beyond basic digitisation, focusing on integrating and optimising processes using advanced digital technologies. It enables real-time data utilisation, enhanced collaboration, advanced automation, and improved process flexibility. These changes lead to more efficient, agile, and customer-centric operations, setting the stage for a comprehensive digital transformation. This stage enables businesses to optimise specific areas, enhancing overall operational efficiency and generating additional value within the company.
- **Digital Transformation:** Encompasses digitalisation and extends beyond it, impacting overall business strategy, organisational structure, and company culture (Bloomberg, 2018; Verhoef et al., 2021; Vukšić et al., 2018). It integrates digital technologies, driving organisational and social changes, altering value offerings, and transforming business models to enhance value creation.

Implementation Approach: Prerequisites

The managers explained implementation approaches as follows:

- **Strategy:** The organisation has established an overarching I4.0 strategy focused on business innovation, with continuous support from top management, investments in training, and fostering a shared digital culture.
- **Goals and KPIs:** The organisation has defined clear business objectives and key performance indicators (KPIs) either for specific functions or departments or by initiating several I4.0 projects to support ongoing business operations.
- **Project:** The organisation is engaged in one or a few standalone projects, each involving a single function or a limited team.

Below is the table describing the qualitative interviews and its parameters. The major bifurcation regarding the implementation phase was the type of initiatives and value creation. E.g. MM1 explained the initial implementation of the Distributed Control System (DCS) system but the inability to scale the system and its extract value & usability. Hence, it is categorised as the initial digitisation phase.

Label	MM Function	Main business	Approach	I4.0 Initiatives	Implementation Phase
MM1	Maintenance	Chemical	Projects	DCS, initial automation of machines	Initial- Digitisation
MM2	Operations	Healthcare	Projects	Cobot, initial automation	Initial- Digitisation
MM3	Operations	Chemical	Strategy	Predictive maintenance, Digital work instruction, and training using AR	Advanced- Digitalisation
MM4	Operations	Safe storage solutions	Goals & KPIs	IoT, software systems, product traceability	Advanced- Digitalisation
MM5	Production	Safe storage solutions	Goals & KPIs	IoT, software systems, product traceability	Advanced- Digitalisation
MM6	IT	Food production	Strategy	MES	Advanced- Digitalisation

Table 3: Overview of Interviews

4.1. Middle Managers in I4.0 Initiatives

4.1.1. Involvement of Middle Managers in I4.0 Initiatives

Understanding the role of middle managers in implementing I4.0 initiatives also requires examining their current involvement in these processes. Insights from senior managers and consultants who assist organisations in deploying such initiatives reveal that the degree of middle managers' involvement varies significantly. This variation is influenced by organisational structure, culture, and the individual attributes of the middle managers themselves, particularly their capacity to drive digital transformation.

Several participants noted involvement challenges of middle managers in I4.0 initiatives; a summary of challenges is highlighted in Table 4

- **Lack of time**

  In manufacturing organisations, I4.0 initiatives are often implemented as subprojects, typically managed by specialised project teams. Participants SM2, C1, C2 & C3 highlighted lack of time as a major barrier due to their demanding workloads and daily operational responsibilities. These time pressures severely limit their ability to engage fully with these digital initiatives.

  C1 also highlighted that top managers often feel they can avoid involving middle managers in I4.0 initiatives, thinking it's only technical implementation.

- **Organisation of I4.0 Projects**

  Complex project structures and undefined implementation phases limit middle managers' involvement. SM3 and C3 emphasised that large projects with prolonged timelines hinder middle managers' ability to allocate time effectively. This makes it difficult for middle managers to balance their regular responsibilities with the demands of overseeing I4.0 initiatives.

  > "....Because if they (middle managers) were part of the project team, the department would not be managed anymore. So that's why they are not part of project teams. And I think it's also because the projects are too big" -SM3

  > "If the projects are smaller... the steps would be easier and faster. Middle management can be involved much more because they can support their teams better." -SM3

  SM3 suggested organising projects into smaller, manageable parts to facilitate better involvement and planning for middle managers. This approach allows for incremental progress and makes it easier for middle managers to contribute meaningfully without overwhelming their existing workloads.

  Additionally, I4.0 initiatives are often driven by specialised project teams, which typically do not include middle managers. Participants highlighted that this exclusion occurs because organisations do not consider middle managers to be crucial participants in these teams. Hence, they are not assigned the time and required resources to participate in projects. This disconnect further diminishes their ability to influence and support the digital transformation processes effectively.

- **MM Skill and Digital Mindset**

  Another significant challenge to middle managers' involvement in I4.0 initiatives is their lack of skills to manage digital change within their departments and teams. Senior consultants (C2 and C3) pointed out that middle managers often get promoted based on tenure rather than their digital competencies. This leads to a gap in their ability to support and drive digital transformation.

  > "Managers are often promoted because they've been with the company for a long time, not necessarily for their management skills. This is particularly common in manufacturing." -C2

  Additionally, many middle managers perceive digital change as a slow process that won't significantly impact them during their tenure. As C3 mentioned,

  > "I see a lot of middle managers who have been with the organisation for a long time. They often don't feel the urgency to adapt to digital changes, thinking it won't happen quickly enough to affect them." -C3

These factors contribute to a reluctance and need for more preparedness among middle managers to engage effectively in I4.0 initiatives. SM2, C2, and C3 further highlighted the need for an organisational digital mindset.

- **Perception of I4.0 Initiatives as Extra Work**

  A prevailing challenge among middle managers is the perception that involvement in I4.0 initiatives is separate from their core responsibilities but rather an additional burden. This mindset stems from a traditional view of their roles, where their primary focus has been on maintaining current operations rather than driving innovation.

  Several participants noted that middle managers often see digital transformation tasks as "extra work" outside their regular duties. This perception can lead to reluctance to engage with new initiatives and a lack of proactive involvement in digital change efforts. For instance, C2 observed,

  > "Many middle managers think of I4.0 projects as something extra that adds to their workload rather than part of their essential responsibilities. They don't see it as integral to their role."

Challenge	Explanation	Participants
Lack of time	Middle managers are overwhelmed with daily operational responsibilities, limiting their involvement in I4.0 initiatives. Top managers often underestimate their role, viewing these initiatives as purely technical.	SM2, C1, C2, C3
Organisation of I4.0 projects	Complex project structures and large-scale initiatives with undefined timelines make it difficult for middle managers to allocate time effectively. The exclusion from project teams due to the project's size further reduces their involvement.	SM3, C3
Middle manager skills and digital mindset	Middle managers often lack the digital skills and mindset needed to manage digital change, partly due to being promoted based on tenure rather than competency in digital transformation.	C2, C3, SM2
Perception of I4.0 initiatives as extra work	Middle managers often perceive I4.0 initiatives as additional tasks outside their core responsibilities, leading to reluctance and a lack of proactive engagement. They perceive digital change won't happen fast in the organisation and will not significantly impact their roles during their tenure.	C2

Table 4: Orgnisational challenges in involving middle managers in I4.0 initiatives.

4.1.2. Benefits of Middle Manager Involvement in I4.0 Initiatives

Involving middle managers in I4.0 initiatives, as highlighted by senior managers and change management consultants, offers substantial advantages. Their strategic and operational insights position them to drive digital transformation more effectively across the organisation. The following points summarise the key benefits of their involvement:

- **Accelerated Implementation and Strategic Prioritization**

Middle managers' involvement can significantly expedite the implementation and adoption of I4.0 initiatives. Their ability to prioritise critical improvements over superficial changes ensures that the transformation efforts are timely and impactful. SM2 recalled how middle managers, with their on-the-ground experience, can discern what truly matters in the implementation process, sharing,

> "I think it would speed up the process involving them. They also know what really matters, not just nice things to improve, but really important ones." -SM2.

This insight highlights the practical impact of their involvement in making sure that the most crucial improvements are addressed first.

- **Strategic Problem-Solving and Cross-Departmental Coordination**

  With a deep understanding of the company's operations and technical background, middle managers are well-equipped to identify and address the most pressing business challenges. SM3 noted that middle managers' technical acumen and familiarity with other departments greatly enhance their ability to solve the right problems. SM3 shared,

  > "Middle managers are really used to being technical and understand what's happening. They also know other people in the organisation, making it easier to communicate and close the gap between engineering and production."-SM3

  This comment highlights the unique position of middle managers in leveraging their organisational networks. Their familiarity with various departments and individuals across the organisation enables them to facilitate effective communication and collaboration. SM2 and C2 further emphasised that middle managers, with their broad connections and understanding of different functions, are essential in ensuring that I4.0 initiatives are implemented efficiently and aligned with the organisation's broader strategic goals

- **Enhanced Employee Engagement and Change Adoption**

  Due to their proximity to the workforce, middle managers are pivotal in communicating the importance of I4.0 initiatives and managing employee resistance due to digital change. Their hands-on approach allows them to address employee concerns directly, fostering a more adaptive and receptive environment for change. C2 emphasised the importance of middle managers in organisational change management (OCM), stating,

  > "Middle management is the most important role in helping people change. They can communicate in a way that resonates and addresses resistance or doubts. They know their teams well, making them the most effective group for implementing change in OCM projects."- C2

  > "The boundary to go to your own manager is quite low, and the middle management knows their own people. That's why we want them involved in every project we do within OCM."- C1.

These observations illustrate how middle managers' close relationships with their teams enable them to effectively manage change, ensuring that digital transformation efforts are both accepted and embraced by employees.

Organisational challenges in involving middle manager's I4.0 initiatives underscore the need for a more inclusive and supportive approach to digital transformation. I4.0 and digital technologies impact the entire organisation, requiring awareness and involvement at all levels for successful implementation.

However, current practices often hinder middle managers due to time constraints, complex project structures, skill gaps in driving change, and perceptions of I4.0 initiatives as additional workload. Senior managers and change management consultants highlighted that to fully leverage I4.0's potential, top mangers must recognise the importance of middle managers' participation, provide necessary training, and integrate digital initiatives into their core responsibilities.

Creating an environment where middle managers have the time, resources, and skills to contribute is essential for driving effective, holistic digital transformation. Involving middle managers can expedite implementation and adoption, ensure critical business problems are addressed, enhance employee engagement and change adoption, and improve communication and collaboration across functions. By leveraging middle managers' unique positions and skills, organisations can ensure a more effective, efficient, and comprehensive implementation of I4.0 initiatives, ultimately maximising the benefits across the organisation.

4.2. Phase I: Digitisation

As explained in Table 3, digitisation represents the foundational step in an organisation's journey towards digital transformation, where analogue information is converted into digital formats and initial digital tools are implemented, but it does add value to existing operational activities.

This section delves into middle managers' experiences (MM1 and MM2) as they implement and facilitate stand-alone I4.0 initiatives within their respective functions or departments. These initiatives, primarily driven by the need to enhance data visibility and operational efficiency, were initiated with high enthusiasm for the potential of digital technologies. However, the section will highlight the challenges these middle managers encountered, particularly in implementing and scaling these initiatives to create value-added processes that can enhance operational efficiency. The following analysis will provide insights into the manager's challenges, such as a lack of understanding of I4.0 amongst management levels and difficulty in proving benefits, which makes it challenging to secure the necessary support and resources. Additionally, misalignment within the organisation, marked by conflict, control issues, and limited collaboration, further complicates the digitisation process.

Finally, the section will examine the strategies and key steps taken to overcome these challenges and discuss the implications for middle managers' role in advancing the broader digital transformation journey

4.2.1. Challenges in Digitisation Phase

I. Understanding of Industry 4.0 in the Organisation

- **Perceptions about I4.0:**

  A significant challenge in implementing and proposing I4.0 initiatives is the lack of a well-established understanding of I4.0 among various management levels, particularly at the top. This insufficient grasp of I4.0 concepts creates obstacles, as noted by MM1. The abstract nature of their knowledge about I4.0 makes it difficult to drive and support digital initiatives effectively.

  > "I think that is very important also for top management to understand what Industry 4.0 is. And I still feel that a lot of people don't capture the concept behind it. So it's more about data gathering at this moment before you can build on top of it." – MM1

  > "What they wanted to do was to get more data out of the distribution control system,

> the process dynamics of our factory. And that's what they called Industry 4.0." – MM1

The lack of understanding of I4.0 poses a challenge to exploiting the benefits of I4.0 initiatives and scaling up local initiatives.

- **Lack of Clear Direction:**

  I4.0 initiatives are often driven as stand-alone projects by bottom-level middle managers and frequently encounter difficulties in executing subsequent steps. This lack of a clear unified direction hampers progress and creates confusion among managers.

  > "When I came into this company, they had this project running called Industry 4.0. So I was like okay interesting. So you're implementing Industry 4.0. But what are you exactly going to do? there was no good answer to it." – MM2

II. Misalignment:Conflict Control & Limited Collaboration

- **Diminished Interaction with Top Management:**

  Middle managers often experience a lack of communication and alignment with top managers, which hampers the execution of I4.0 initiatives on the shop floor. This diminished interaction is also a symptom of a lack of shared roadmaps and goals, leading to inefficiencies and misaligned efforts in digitalisation projects.

  > "I know he (top manager) has a roadmap in his mind but it has not been shared or it's not a common goal of each different site to get along." – MM2

  > "He initially collaborated with us to identify digitalisation opportunities at the factory. But right now our contact is a bit diminished. And I think that has to do with the fact that at our site we are at a quite high level already. So he is first focusing on the sites that still capture data from machines by hand like writing." – MM1

  Managers often find themselves out of sync with the strategic objectives due to inadequate interaction. Managers pointed out that only a few people in top management understand digitalisation but it is not cascaded down below managerial levels.

- **Dependency on Factories & Issues in Centralised Governance:**

  Implementation is often halted due to dependencies on the progress of other factories, leading to difficulties in scaling up the systems. This dependency not only slows down the overall digitalisation process but also highlights the issues arising from centralised governance. Both MM1 and MM2 emphasise that excessive control from top management and dependencies on other sites hinder the progress of digital initiatives.

  > "We were stopped by the head of digitalisation because he said he wanted the same system for all different sites. We were already at the point of ordering such a system, but he said he was still trying to get other facilities to the same level. He wanted to order it for every site at once but it's been four years already." – MM1

  > "We are constantly waiting for other factories and the digitalisation head in top management to give us the go-ahead to order new equipment to facilitate this." – MM1

  MM1 also points out that initial collaboration with top management has waned because the focus has shifted to less advanced sites, leaving their factory to operate without continued support.

- **Conflicting Ideas:**

Conflicting ideas between middle managers and top management regarding the direction of digitalisation projects create obstacles in further developing and achieving the desired level of digitalisation as pointed out by MM. These conflicts often result in stalled projects and a lack of coherent strategy across different management levels.

> "That is a difficulty for me as a middle manager because I'd like to have the system further developed and get it to the level of data visualisation and analysis for maintenance activities. But now you're confronted that someone at a higher level is stopping you. Because he's got other ideas with it." – MM1

III. Unclear ROI and Uncertainty for Industry 4.0 Projects:

Managers face significant challenges in implementing and scaling up I4.0 initiatives; they also encounter issues in selling new initiatives to top managers because they cannot demonstrate the benefits of new digitalisation opportunities.

- **Difficulty in Proving Benefits:** Demonstrating the advantages of new digitalisation opportunities is challenging, making it hard to justify the investment.
- **Need for Clear ROI:** Securing top management support requires a clear Return on Investment (ROI). Without this, getting approval for new initiatives becomes problematic. Middle managers also explained the absence of defined criteria for evaluating projects, complicating the approval process.

  MM4 explains the challenge of convincing top management to invest in I4.0 projects due to unclear ROI.

  > "One of the biggest challenges you face is convincing top management to invest in certain parts. For instance, we have a good project idea, but the ROI must be calculated. We don't have clear boundaries to determine if the ROI is good or bad. This uncertainty does not help as my colleagues are unsure whether the project will fail or succeed. Knowing these boundaries would help." – MM1

  MM6 discusses the difficulty in justifying the benefits of I4.0 projects, which impacts the willingness of top management to invest.

  > "For Industry 4.0 projects, the ROI isn't clear. Getting more data in the system usually helps in the future, but you can't say whether this additional data will make us 10% more efficient or save X amount of money. And if you don't have an ROI you better not come to the top management because they won't invest." – MM2

4.2.2. Overcoming Challenges: Managerial Insights

Digitisation refers to converting analogue information into digital formats, such as scanning paper documents or collecting data from sensors and machinery on a factory floor. This foundational step is crucial for the advancement of I4.0 initiatives. Digitisation provides the necessary data that forms the backbone of I4.0 technologies. Without digitised data, many advanced analytics, automation, and integration efforts central to I4.0 would be impossible. In the case of M1 and M2, the initial enthusiasm for technological advancement triggered digitisation, leading to ad hoc initiatives typically starting at the departmental and independent function levels. These initiatives lacked direction and were characterised by unguided efforts, hindering further scaling.

Middle managers in this phase discussed digitisation initiatives in their organisations. This technical conversion enables further digitalisation activities but does not directly create value. Instead, it prepares

the ground for subsequent stages where digital technologies can enhance business processes, products, or models. This section provides an analysis of the challenges and key insights managers discussed for overcoming these challenges in terms of top management involvement and middle managers' contributions to I4.0 initiatives. Figure 3 shows an overview of the digitisation phase.

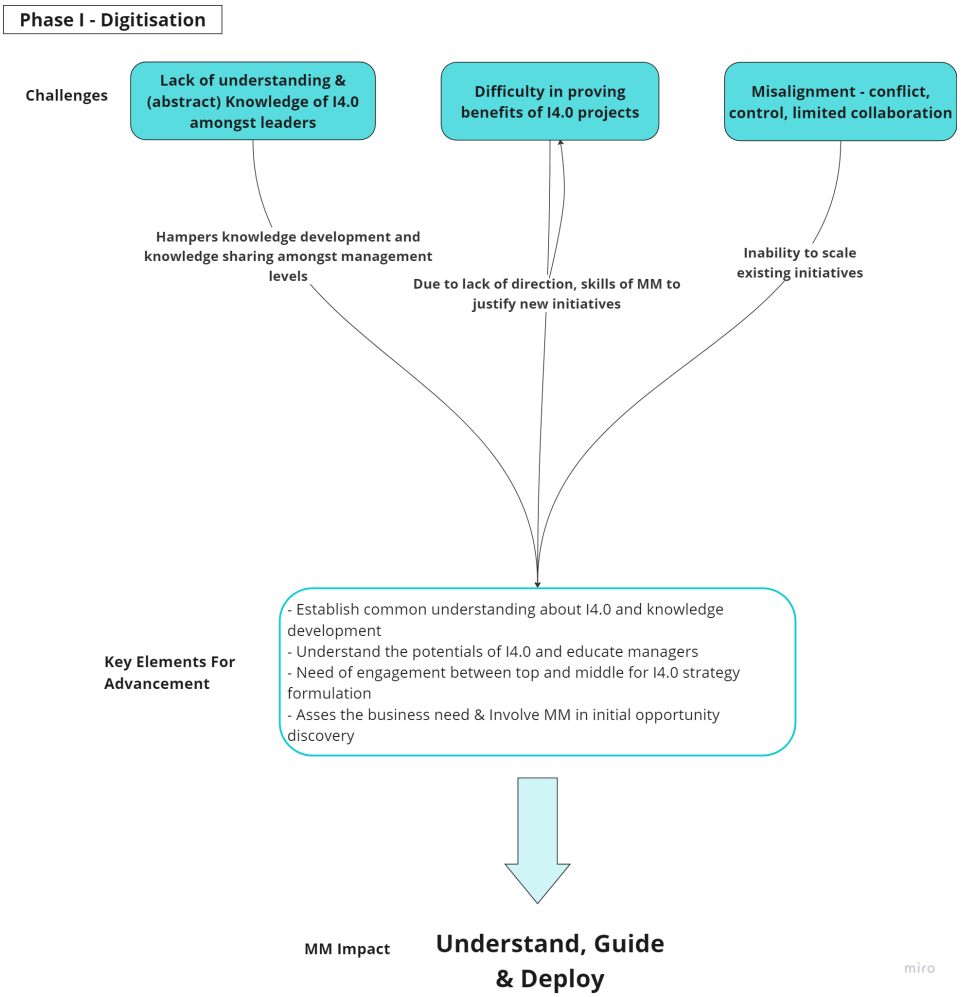

Figure 3: Overview of Digitisation Phase

From the manager's perspective, it was clear that the top management and local factory managers were not aligned to implement local I4.0 initiatives and bring new ones. The main reason was **lack of established understanding of I4.0.** Managers described I4.0 as an abstract form of knowledge that only a few people in the organisation could take advantage of, with this knowledge not being effectively cascaded down to managerial levels. They expressed a feeling of lack of direction and necessary competence for moving to the next stage, which is digitalisation. The lack of understanding and abstract form of knowledge negatively impacts knowledge development and knowledge-sharing abilities to formulate and evaluate new I4.0 initiatives also results in conflicting ideas.

Managers in this phase also highlighted difficulties in proving the Return on Investment (ROI) as converting analogue information into digital format does not help in value-creation activities, nor they provide any immediate benefits. They expressed a lack of skills and competence to justify new initiatives, calling for the skill development of managers. The organisations are at the initial stage, focusing on gathering and storing large amounts of data without clearly understanding its purpose or value, known as

"data hoarding". However, data hoarding and setting up technical infrastructure are necessary to move to the next stage of digitalisation.

Conflicting ideas, centralised control, and limited collaboration between top and middle management emerged as the main challenges to scaling up existing stand-alone initiatives. Top management is trying to control the digitalisation of the organisation without a clear digital roadmap, which is hindering progress and stalling local I4.0 initiatives. This also highlights top management's lack of ability to see the bigger picture and not involving factory managers in formulating an overall digitalisation roadmap. The friction between management levels is negatively impacting the implementation of I4.0 initiatives and the effective adoption of I4.0 technologies at the factory level. While there is a lack of established understanding about I4.0, MM1 pointed out that it is not the responsibility of middle management to educate top-level executives. Instead, top management should take proactive steps to ensure executives are well-informed about I4.0 opportunities. This involves formulating an initial digital roadmap in collaboration with middle managers grounded in the organisation's business needs. By involving middle managers in these initial discussions, top management can better address relevant business problems and create a cohesive digitalisation approach. Middle managers can then focus their efforts on educating their own teams and shop-floor employees, bringing everyone on the same page. MM1 expressed that there are initial efforts taken by top management to educate executives about I4.0 through training and workshops. He expressed that this would help bring everyone on the same page and further discuss ideas for the digitalisation of local factories. Employee resistance was present in both instances, but it was not evident as these organisations struggled to formulate an initial digital roadmap.

Organisations in this phase must foster a shared understanding of I4.0 to exchange ideas and secure top management support to establish foundational technical infrastructure. Involving managers in initial discussions, collaborating with external experts for competence building, and exchanging ideas between managerial levels are crucial for the digitalisation of the factory. Hence, the main role of middle managers in this phase is to understand the I4.0 opportunities, guide the employees in implementing initial initiatives, and deploy them on the shop floor.

4.3. Phase II: Digitalisation

Digitalisation represents a critical step beyond the foundational digitisation phase and includes initiatives that create value-added activities within an organisation. During this phase, the focus transitions from basic digitisation to the strategic application of digital technologies to enhance business processes, increase efficiency, and drive value creation. Several middle managers discussed projects such as predictive maintenance, creating real-time information dashboards, and implementing product traceability to address customer complaints. **Essentially, digitalisation involves leveraging digital technologies to transform existing operational processes**. In this phase, multiple middle managers (MM3, MM4, MM5, and MM6) described distinct challenges in implementing I4.0 initiatives on the shop floor.

This section explores the critical role of middle managers during the digitalisation phase, focusing on the challenges they encounter while implementing I4.0 initiatives. It is divided into two main parts: the first addresses how middle managers navigate top-down strategies, while the second examines how they integrate bottom-up insights to identify new digitalisation opportunities. The analysis also highlights the strategies used to overcome obstacles such as employee resistance, skill gaps, and organisational inertia, emphasising the pivotal role of middle managers in driving successful digital transformation.

4.3.1. Challenges: Top-down implementation of I4.0 initiatives

The top-down approach to digitalisation requires middle managers to implement I4.0 initiatives on the shop floor as part of the existing digital roadmap and strategy. These initiatives aim to enhance operational processes to achieve efficiency by reducing human errors, cutting costs, and improving overall productivity.

C1, SM1, and several middle managers mentioned initiatives such as digital work instruction, digital training methods via VR, new software systems to operate the machines, etc.

An example of the I4.0 initiative:

MM6 mentioned the implementation of digital work instruction to operate the machine as a crucial initiative within their organisation. They identified a knowledge gap in how younger and older employees operate the machines. As per MM6, the younger employees were reluctant to read the work instructions that contained only texts with no images and videos. Meanwhile, older employees who had worked in factories for 20 years relied on their memory regardless of any changes in software and systems. This gap affected the manufacturing line's overall equipment efficiency (OEE) and decreased productivity.

To address this issue, MM6's organisation implemented digital work instructions to enhance employee engagement. These instructions included images and videos to create a more engaging work environment. This approach helped reduce machine operation errors by making the instructions more accessible and understandable for all employees, ultimately improving productivity and efficiency on the manufacturing line.

Implementing such tools and new systems on the shop floor changes traditional processes used to carry out tasks. Despite these objectives, middle managers face significant challenges in terms of communication, employee adaptation, and balancing ongoing operations with new project implementations.

I. Communication and Alignment

Effective communication and alignment emerged as important themes while implementing I4.0 initiatives on the shop floor. As per senior managers (SM1, SM2) and consultants (C2, C3), communication sets the stage for employees to learn about new changes in the work process.

- **Involving middle managers**

  Senior managers and consultants highlighted the importance of involving department and plant heads when communicating the digital change to their employees.

  > "We can benefit a lot when we bring the head of the department because then not only someone from operations excellence sitting in the office saying that we need to change. Leaders are also involved in the decision."– SM1

  This highlights the necessity of including leaders in the communication process to enhance employee credibility and acceptance of digital changes. By involving heads of departments, the change message is reinforced, making it more likely to be embraced.

- **Setting the right tone and common language to communicate the change**

  C1, MM6, and SM2 mentioned challenges in getting the right message across to the shopfloor employees while implementing digital tools and systems. Effective communication requires using language that resonates with all employees, avoiding overly corporate jargon.

  > "Strategies often use corporate language but in the implementation phase, this is

not something understandable by shop floor employees. We need to ensure the communication is clear and relatable to everyone involved." – C1

This emphasises the importance of clear and relatable communication. Using complex corporate language can alienate employees on the shop floor, making it crucial to adapt the message to be easily understandable to all levels of the organisation.

- **Lack of structured approach for communicating change**

  SM1, SM2, C1, MM3, MM4, and MM6 highlighted that in manufacturing companies, the employees working on manufacturing lines who are impacted by change due to the implementation of digital technologies don't have access to laptops and emails. This makes it challenging to communicate about the new tools or systems on the manufacturing line. Additionally, since manufacturing factories operate in different shifts with a large number of employees, middle managers need to guide their first-line managers about the change which can then be cascaded down across different shifts.

  > "Most shop floor employees who are the primary ones impacted by these changes don't have email addresses or laptops. While some roles do have email access, about 80% of the shop floor workers do not. Because of this, a structured and systematic approach to communication and cascading information is much more effective."– C1

  This highlights a common challenge in manufacturing settings where traditional communication channels like emails are not viable for most shop floor employees. This necessitates a more structured and systematic approach to communication where middle managers play a crucial role in ensuring that first-line managers are well-informed and capable of passing down information accurately to their teams across various shifts.

II. Employee Resistance and Adaptation

Middle managers face significant resistance from employees, especially those accustomed to traditional methods and systems. This resistance hampers the adoption of new tools and systems and poses challenges for implementing I4.0 initiatives effectively. The section outlines the main factors contributing to employee resistance and the strategies employed by middle managers to address these challenges.

- **Resistance to Change**

  Employees often resist new digital tools and systems due to long-standing habits. MM6 highlighted this issue:

  > "At the beginning, they don't like it or are resistant. They've been doing the same thing for 20 years and don't see the need to change". – MM6

- **Fear of Job Replacement**

  MM4 mentioned shopfloor employees feel threatened by the new I4.0 initiatives as they perceive increased automation and new systems will replace their jobs. This was evident when MM4's organisations were implementing an Autonomous Mobile Robot (AMR) to streamline material movement on the floor and eliminate unnecessary movements by people. The initiative was driven by top managers and the main drivers were to reduce cost and streamline the process.

  > "...So the main idea is always to get cost savings, especially on the European side. Cost pressure is high and every person is expensive."– MM4

  MM4 explains such initiatives often spread fear in employees and pose an obstacle for employees

to adopt new tools and systems.

- **Skepticism and Disconnect**

  Employee resistance often comes due to a lack of understanding and fear of the unknown. Workers who have been using the same processes and systems for years may feel threatened by new technologies. This fear and skepticism are further intensified when there is a perceived disconnect between shop floor employees and office staff. Several managers, as well as consultants, pointed out that in manufacturing organisations, there is a notable divide between office employees and shopfloor employees.

  > "There is a lot of skepticism from the shop floor because they feel disconnected from the employees in the office and think we don't understand their daily struggles."– MM6

  Middle managers and first-line managers play important roles in Technology Sensemaking amongst employees as highlighted in both MM6 & MM4. MM6 emphasized the importance of explaining the benefits of new tools and systems to employees,

  > "The most important thing is to explain why we are implementing new tools and systems, what's the benefit to them." – MM6

  MM4 further elaborated on the necessity of open communication and addressing employee fears directly,

  > "Employees often worry that new technologies will replace their jobs. It's essential to stop and talk to them, explaining how the new systems will benefit everyone. Being open and explaining helps create a friendly environment." – MM4

  By clearly explaining the reasons behind digital initiatives and how they will benefit the employees, middle managers can help alleviate fears and build trust.

- **Lack of Trust and Historical Failure**

  Trust and open culture play important roles in the adoption of digital tools and systems. When past digital initiatives fail, they undermine employee motivation and willingness to participate in new projects, posing a significant obstacle to adoption.

  > "...No one was really scared. They also saw other initiatives like that from the years before or similar digitalisation & optimization initiatives, and they failed. And they were like, it might fail anyway." – MM6

  This quote from MM6 highlights the impact of historical failures on current digital initiatives. Employees become skeptical and disengaged, anticipating that new projects will likely meet the same fate. This lack of trust hinders the adoption of new technologies and systems.

- **Generational Technology Gap and Lack of Digital Skills**

  Older employees often hesitate to adopt new digital tools, creating a generational divide that complicates the implementation process. This gap was evident in the case of MM6's organisation, where digital work instructions were introduced to enhance employee engagement and reduce human error in machine operations. MM6 highlighted the differences in how employees of various ages perceive and adapt to new systems.

  > "We create a gap with the oldest generation because they aren't familiar with tablets and don't want to use new technology." – MM6

  > "...Implementing new digital tools I have observed the skill gaps, particularly older

employees who are less tech-savvy." – MM4

These quotes emphasize the challenge of bridging the digital skills gap between younger and older employees. The reluctance of older employees to embrace new technologies hinders overall progress. Hence, managers need to address these skill gaps.

III. Balancing operations and disruption due to digital projects

Managing daily operations while implementing new digital projects presents a significant challenge for middle managers. Integrating digital tools and systems often requires changes to established processes, disrupting the regular workflow and affecting productivity.

> "It's always a challenge to change something on the shop floor and in the production process without disrupting daily operations." – MM4

Middle managers need to carefully plan and coordinate the introduction of new digital initiatives to minimise disruptions. This involves scheduling implementations during downtime or low-production periods and ensuring adequate employee training and support, as highlighted by MM3, MM4 & MM5.

The dual responsibility of maintaining smooth daily operations while driving digital transformation demands a strategic approach. Middle managers often juggle these responsibilities, ensuring that production targets are met while also pushing forward with new technology adoption. This balancing act is crucial to avoid resistance from employees who may already be skeptical about the benefits of digital change.

4.3.2. Overcoming Challenges: Implementing I4.0 Top-Down Approach

In the Digitalisation phase, several managers mentioned driving I4.0 initiatives through integrating top-down strategies and bottom-up insights, with middle managers playing crucial roles in this convergence. This section highlights the challenges outlined above and key insights from middle managers on how to overcome these challenges. An overview of the digitalisation phase is shown in Figure 4.

General View about I4.0 Strategy and Initiatives:

Some managers (MM3 & MM6) made it clear that their organisations had a specific strategy for I4.0 and could discuss the details of multiple initiatives, pointing out managerial challenges while implementing these initiatives on the shop floor. However, others noted that while there was a broad, global strategy for digitalisation, this strategy did not translate effectively to the local level within their specific factories. This disconnect meant that managers tended to focus more on local initiatives when discussing their role in implementing and facilitating I4.0 projects, as these were more concrete and manageable compared to the overarching global strategy.

These managers were not only able to discuss top-down initiatives but also demonstrated an understanding of I4.0, enabling them to propose department-level projects that could be aligned with the overall strategy. They mentioned distinct challenges when implementing projects via both top-down and bottom-up approaches.

One notable difference in the organisation in the digitalisation phase is that *External collaboration* for implementing the I4.0 initiatives. Managers mentioned that their organisation not only collaborated with external parties for technical expertise but also collaborated to adopt change management practices. For example, MM3 pointed out top-down approach for I4.0 as,

> "I4.0 projects were initiated by the Vice President of Operations. He said, 'We need to improve our plant emissions, so let us bring in a consultancy group to evaluate our operations and provide recommendations for moving from A to B.' Thus, we began with the VP and then involved the consultancy group." – MM3

The main challenges present in the top-down approach were communication & alignment, employee resistance, and adaptation stemming from ineffective change management. Several middle managers highlighted the importance of change management in this phase as I4.0 initiatives transform existing work processes and methods.

Middle managers presented a good level of understanding of I4.0 initiatives. Some mentioned involvement in project formulation, while others explained lack of involvement during the project planning phase hampering their ability to understand and facilitate the initiatives. Yet, managers shared the idea that they (managers) needed to be involved in the process, arguing,

> "If you're not involved, it is difficult to realise there is something new you need to understand." – MM5

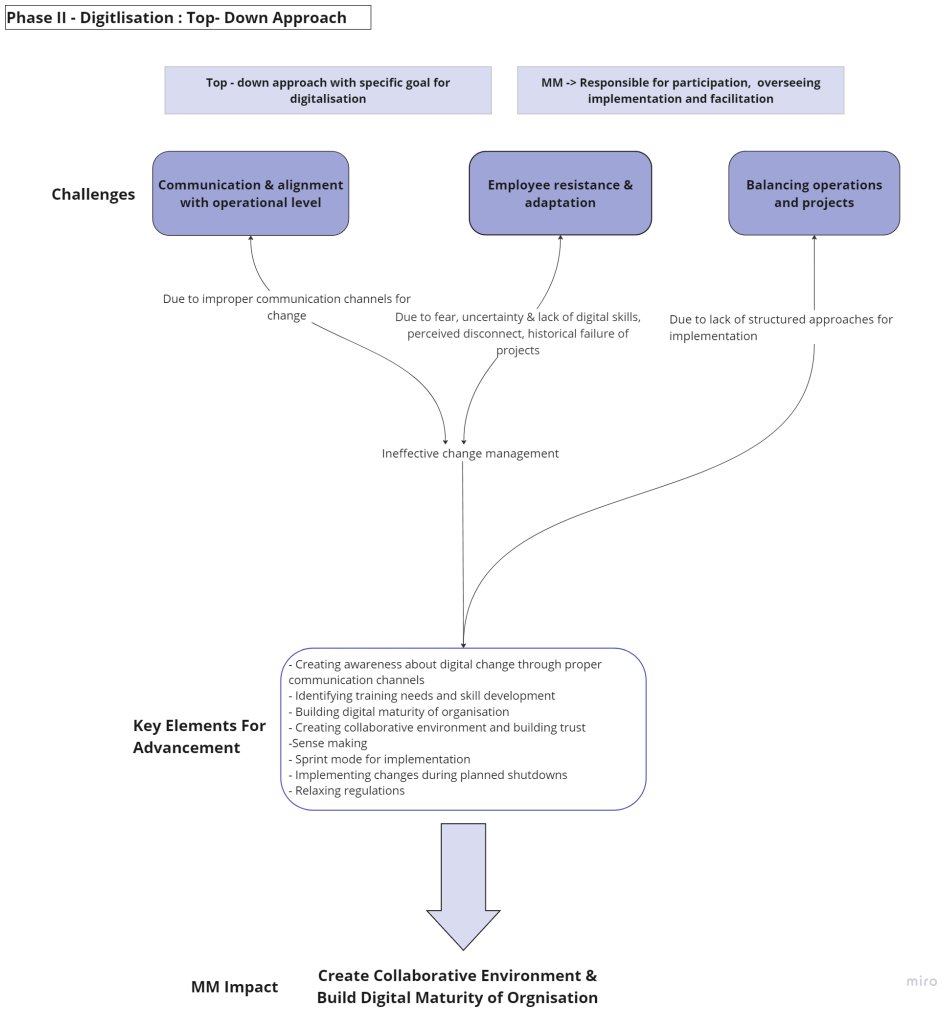

Figure 4: Overview of Digitalisation Phase: Top-Down Approach

Key Steps for Advancement:

The first identified challenge "Communication and alignment" is in the pre-change phase which included a lack of structured approaches for communicating change and ineffective language used to explain the use of new systems and tools which led to employee resistance to change. Change management experts (C1, C2 & C4) emphasized two key practices for overcoming these challenges: the manager's role in the sense-making of new systems and tools and the use of common language to communicate the need for digital change.

Establishing proper communication channels & using a common language for communicating change:

A significant challenge highlighted by multiple middle managers was the unavailability of effective channels for communicating change. The main reason for this was the majority of shopfloor employees don't have access to computers and emails, making it difficult to reach a wider number of employees at once. MM3, MM4 & MM6 highlighted creative methods in communicating the change of new digital systems and tools, which included using big digital dashboards on the shop floor, TV screens in common areas, or hanging flyers and information boards near places where employees frequently gather, such as coffee machines. These methods are essential for creating awareness about initiatives and keeping employees informed about new changes on the shop floor.

Another challenge middle managers faced was using complex corporate languages to explain the use of new systems and tools making it difficult for employees to adapt to change. Managers explained the importance of sense-making in helping employees understand new systems and tools and their relevance to the organisation. By breaking down complex corporate language into simpler terms, managers can make the information more accessible. Simplifying the language and making it relatable to all employees ensures that everyone understands the changes and their importance, facilitating smoother transitions and reducing resistance.

Building Up the Digital Maturity of the Organisation:

In the top-down approach for implementing new I4.0 initiatives, MM pointed out another challenge for them is "Employee Resistance and Adaptation". The main reasons are uncertainty, lack of knowledge & digital skills, and fear of replacement amongst others.

Managers highlighted the necessity of a strategy encompassing human aspects and developing competencies. They stressed the significance of prioritising learning and skills development related to the organisation's digital maturity, which was considered crucial when discussing digitalisation and effective facilitation practices. Change experts C1, C2 & C4 further confirmed this. Managers believed it was essential for every employee to understand digitalisation, its impact on them, and how employees are expected to participate in organisational development. They viewed digital maturity as a critical mechanism for enabling change. For instance, the requirement for practical training and general competency in organisational transformation was mentioned when defining maturity.

Key aspects identified for building digital maturity include:

1. **Identifying Training Needs and Building Skills of Employees:**
   - Bridging the Generational Technology Gap: Recognising the differences in digital proficiency between younger and older employees and addressing them through targeted training.
   - Peer Support: MM3 mentioned effective practices such as pairing up older employees with

younger ones, allowing the younger employees to guide and assist them in operating new systems and tools, thus facilitating smoother transitions.

2. **Creating Collaborative Environments, Building Trust, and a Resilient Culture:**
   - Bridging the Office vs. Shopfloor Gap: Effectively addressing employees' fears through open communication and fostering a culture of transparency.
   - Building Trust: Several managers highlighted a lack of trust among employees due to the failure of past I4.0 initiatives, which hampers the adoption process. To build a resilient culture, managers need to establish trust through consistent and honest communication, involving employees in decision-making, and demonstrating the tangible benefits of new initiatives.
   - Open Culture: Encouraging an open culture where feedback is welcomed and acted upon, and where employees feel valued and understood.
3. **Continuous Feedback and Monitoring:**
   - Aftercare: MM3 & MM6 highlighted the importance of checking in with employees which they termed as "Aftercare". Which is Providing ongoing support after the initial implementation phase to ensure sustained adoption and adaptation. This involves checking in with employees regularly to address any issues and provide additional training if necessary.
   - Gemba Walks and Standard Leadership Work: Conduct regular Gemba walks, which involve managers observing the actual workplace to understand the processes and challenges employees face. This practice helps in maintaining alignment with organisational goals and identifying areas for continuous improvement.
   - Feedback Mechanisms: Implementing regular feedback and monitoring mechanisms to track progress and address any issues promptly. This could include surveys, meetings, and performance reviews to gather insights and make necessary adjustments.

Structured Implementation of Projects & Relaxing Regulations:

Managers highlighted balancing regular operations and implementing I4.0 projects as a challenge, emphasising on need for structured approaches for implementation. MM3 mentioned working in **"Sprint mode"**, which involved breaking projects into short & iterative cycles and testing them on small portions before implementing them on multiple lines. This approach was taken when I4.0 initiatives included implementing new software systems such as Manufacturing Execution Systems, product traceability software, etc. MM5 mentioned planning implementation during the planned factory shutdown, Flexible production stops for installations & involving the production planning department to minimise disruptions of daily operations.

SM3 (Senior manager) & C3 highlighted the importance of **relaxing regulations** concerning the performance and adaptability of the employees at the start during the initial stage of projects.

> "... when dealing with new systems and tools we need (middle) managers who are willing to have their team being less efficient, less productive, which is in contradiction to what they need to do from their (top) managers" – SM3

This underscores the struggle middle managers face in accepting reduced productivity during initial changes while managing expectations from top managers who anticipate immediate efficiency and fewer errors with new digital systems. Middle managers need to navigate these challenges by requesting relaxation from top managers and supporting their teams during the transitions.

By focusing on these key aspects, managers can effectively address the challenges of employee

resistance and adaptation, ensuring a smoother and more successful implementation of top-down I4.0 initiatives. Middle managers play a crucial role in this process by facilitating sensemaking, providing support addressing training needs, and fostering a collaborative and trusting environment.

4.3.3. Challenges: Integrating Bottom-Up Insights for Digitalisation

This section outlines the key challenges middle managers face in integrating bottom-up insights into I4.0 initiatives. These challenges include identifying digital opportunities at the operational level, aligning these initiatives with broader corporate strategies, securing adequate budget and resources, and overcoming resistance to change due to organisational misalignments. Additionally, the section examines the need for specialised structures to manage and coordinate these initiatives effectively. These insights highlight the complexities that middle managers navigate in driving successful digital transformation from the ground up.

I. Need to Find Opportunities at the Bottom

Senior managers (SM1 & SM2) explained that while there is a strategy for digitalisation, individual factories need to come up with their ideas and opportunities for digitalisation to improve existing processes.

> "Even though we have a corporate strategy for digitalisation, each factory needs to come up with their requirements and need for digitalisation for process improvements." – SM1

Similarly, SM2 emphasized the importance of staying connected with the shopfloor to understand and solve their issues through digital technologies.

> "It's important to stay in touch with the shopfloor to solve the issues they are facing by implementing new digital tools and systems." – SM2

> "They (factories) know their problems best." – SM2

These insights highlight the necessity for proactive engagement from middle managers and their teams. They need to identify opportunities that can solve specific business problems and align them with the broader corporate digitalisation strategy.

II. Aligning Initiatives with Digital Strategy and Standardisation

Middle managers are tasked with not only identifying opportunities but also ensuring these initiatives align with the overarching digital strategy. This involves investing in solutions that address specific business problems, justifying these investments to top management, and adhering to the organisation's emphasis on standardisation.

> "It's crucial to link digital initiatives to existing problems. Convincing top management of a problem they don't see yet is a big challenge. We had to calculate potential savings to justify the investment." – MM4

This highlights the need for middle managers to act as translators between the operational realities and strategic goals, ensuring that proposed digital initiatives have a clear, justified impact on business processes.

III. Budget & Resources Availability

A significant challenge identified by several middle managers is the availability of budget and resources necessary to implement digital changes. This includes the need for financial investment as well as human resources such as engineers, supervisors, and training personnel.

> "The top one is budget. The second one is resource availability to implement the change. To implement something, I do need engineers, I do need supervisors. We do need to train people. Hence, money is the biggest one by far. And then it's resource availability." – MM6

This emphasizes the importance of securing adequate funding and resources to ensure successful digitalisation efforts. Without sufficient budget and personnel, even well-planned initiatives can struggle to get off the ground. Several managers highlighted the need to prove the **"Business case"** and demonstrate value. Hence, while running bottom-up initiatives, top management support, financial & skilled human resources, and alignments emerge as common themes to successfully run the projects. The middle managers are required to act as opportunity identifiers, aligning with the management levels and translating the needs from the shop floor to top management.

IV. Resistance to Change

Middle managers are expected to identify opportunities to implement digital initiatives, but their unique position is often confronted with resistance due to misalignment & organisational structural challenges.

- **Misalignment between IT and Operations**

  MM6 highlighted initial resistance due to misalignment between IT and operations which are managed by different top managers. This misalignment causes hindrances in project execution. Digitalisation requires seamless collaboration between IT and operations, as both departments play crucial roles in implementing I4.0 initiatives. However, when these departments operate in silos under different top managers, the lack of coordination can lead to delays, misunderstandings, and resistance to change.

  > "To execute the project, you need to collaborate with your IT director and your operations director. In our case, they are managing 10 factories, it was clear that the two weren't aligned. I first sat down with the IT director and the operations director, but they couldn't find common ground." – MM6

  As highlighted by MM6, the lack of a unified approach from top management can create significant barriers, making it difficult to implement and sustain I4.0 initiatives.

- **Disconnect Between Top and Bottom Levels**

  MM4 highlighted the difficulty of convincing top managers to support digital projects due to a disconnect between the upper management and the shop floor. This disconnect is due to top managers' lack of understanding of the operational challenges faced by those on the shop floor.

  > "The upper you go, the lesser they know." – MM4

  MM4 emphasizes that as one moves higher in the organisational hierarchy, there is a diminishing awareness of the day-to-day operational struggles on the shop floor. Hence, it is the responsibility of middle managers to bridge this gap, ensuring that the realities of shopfloor challenges are communicated effectively to top management. Both these instances highlight the importance of alignment between the top and middle levels when initiatives come from the bottom level.

V. Need for Specialized Structures

The need for a specialized structure to run I4.0 projects is evident to avoid conflicts and misalignments. As I4.0 integrates IT and operations, there is a need for these two functions to operate in synergy. MM3's organisation addressed this by creating a "center of excellence" to oversee Industry 4.0 topics, ensuring better alignment and reducing resistance.

> "We adopted a new structure by creating a 'center of excellence' to manage Industry 4.0 initiatives within the organisation." – MM3

This "center of excellence" serves as a dedicated entity that focuses on the strategic and operational aspects of digital transformation, ensuring that the initiatives are well-coordinated and effectively executed. By centralising the management of I4.0 projects, the organisation can better streamline processes, allocate resources efficiently, and foster a culture of innovation and continuous improvement. This approach not only enhances the coherence and integration of digital initiatives but also mitigates the risk of misalignment and resistance that often arises from fragmented efforts.

4.3.4. Overcoming Challenges: Integrating Bottom-up Insights

This section explores how middle managers navigate and overcome the challenges of integrating bottom-up insights into I4.0 initiatives. It underscores their crucial role in identifying opportunities at the operational level and aligning these with the broader digital strategy. Additionally, it highlights the strategies middle managers use to address organisational barriers such as rigid structures, budget constraints, and the need for standardisation. By creating centralised functions, fostering knowledge sharing, and embracing experimentation, middle managers serve as catalysts for innovation and continuous improvement in the journey toward digital transformation. The following analysis details the approaches and solutions they employ to effectively manage these challenges and integrate operational insights into successful digitalisation efforts.

Several middle and senior managers emphasised the need to identify opportunities at the bottom level, irrespective of the presence of a digital strategy. MM3, MM4, MM5, and MM6 discussed various opportunities identified by their teams. They perceived themselves as acting on articulated agendas while simultaneously searching for formal agendas on digitalisation. An overview of the digitalisation phase and middle managers for integrating bottom-up insights are shown in Figure 5.

The main challenges that emerged from integrating bottom-up insights for the formalisation of I4.0 initiatives include aligning opportunities with the digital strategy, rigid organisational structures, budget and resources, and difficulties in getting project approvals due to misalignment between top managers.

A critical challenge is the requirement for a formal business case to get initiatives approved. This necessity can stifle small innovative initiatives but also provides an opportunity to make pilot projects more visible within the organisation. Top managers want to understand the business value behind pilot projects and know what resources are being allocated, viewing this as part of a transparent exploration process for the entire company. As per MM5 & MM6, the orgnisation has a strong focus on standardisation. Standardisation, although aimed at saving resources and streamlining operations throughout the organisation, often forces initiatives to fit into predefined moulds, thus shutting down creativity and innovation.

Aligning Opportunities with Digital Strategy and Rigid Organisational Structures:

The delays and resistance to adopting new initiatives by top managers were due to two main reasons:

- Top management's effort to align everything with the digital strategy and a strong focus on standardisa-

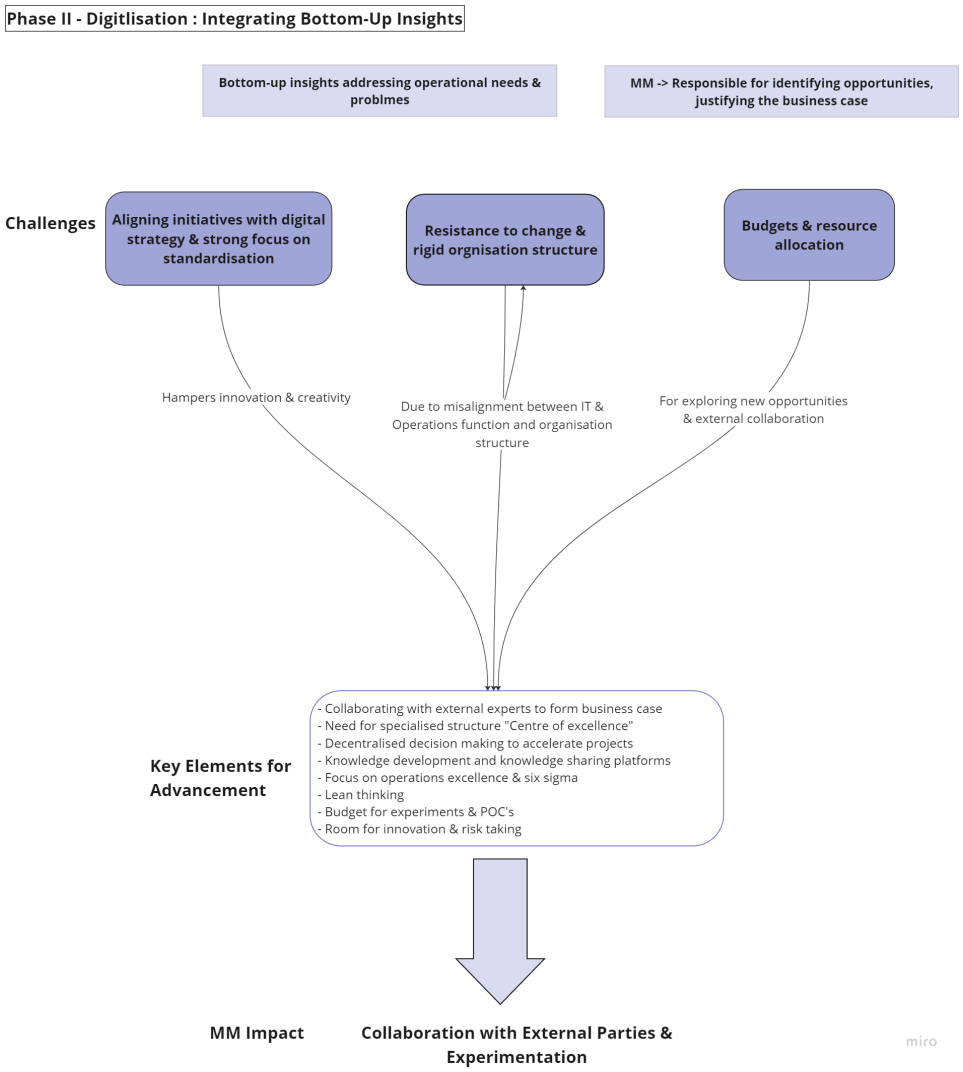

Figure 5: Overview of Digitalisation Phase: Integrating bottom-up insights

tion to save costs. This alignment hampers the exploration process for new initiatives.

- Approval is needed from two different functions (IT & Operations) within a rigid organisational structure. This makes it difficult to communicate new opportunities identified at the bottom and negatively impacts managers' and employees' enthusiasm and motivation to suggest new improvements through digital technologies.

This situation reflects a clash between the traditional business structure and the need to adapt to new digital demands. From a management perspective, the committed design of flexible initiatives becomes essential.

Managers emphasised the need for a centralised function that provides a coherent view for I4.0, thus accelerating project approval and ensuring smooth execution.

MM3 mentioned their organisation addressed this misalignment issue by creating a **"Centre of Excellence"** for running multiple I4.0 topics (They did not merge two functions). This structure facilitates the management of I4.0 projects. It **decentralises decision-making**, empowering local factories to suggest new initiatives that can be included in upcoming financial plans, thereby saving on

bureaucracy and overcoming rigid structural barriers. MM3 also mentioned the availability of sufficient budgets to run multiple pilot projects, strong collaboration with external experts and top management support for innovative initiatives.

By having a centralised function, budgets to try out new projects, and collaborating with external experts, organisations can better manage I4.0 projects, fostering innovation while maintaining alignment with the overall digital strategy. This approach not only helps overcome organisational barriers but also promotes a culture of continuous improvement and innovation.

Knowledge Development and Knowledge Sharing Platforms:

Knowledge sharing and collaborative learning emerged as pivotal themes in the digitalisation phase. Middle managers highlighted the importance of collaboration and communication, utilising global online platforms to share experiences and insights across different factories. MM3 emphasised that these platforms provide opportunities for experimenting and sharing Proof of Concepts (POCs), allowing managers and employees to learn from each other and try out new initiatives in their own factories. A global online community for sharing I4.0 POCs was particularly valuable, as it facilitated learning from other factories and organisations. Managers mentioned the importance of these efforts to collectively foster a culture of continuous learning and improvement, which is crucial for successful digitalisation initiatives.

Opportunity Identification Approaches:

Managers emphasised the need for experimenting and risk-taking to keep up with fast-paced environments. They mentioned several approaches to identify opportunities, such as lean thinking (reducing waste and linking this to I4.0 projects), and using Six Sigma methodologies amongst others. Notably, these middle managers appeared enthusiastic about I4.0 opportunities and exhibited experimental abilities. MM3, MM4, and MM6 also mentioned attending summits and conferences for I4.0 and keeping an eye on industry trends as essential practices for staying informed and driving innovation.

4.3.5. Summary of the Digitalisation Phase

This section highlighted the challenges middle managers faced in driving I4.0 initiatives. In the digitalisation phase, organisations had strategies for implementing I4.0 projects, which included running multiple projects and building business cases for digitalisation. Middle managers faced significant challenges in managing employee resistance, operational disruptions due to digital change, and ineffective change management.

The digitalisation phase for I4.0 initiatives includes value-creation activities focused on process optimisation and visibility. Consequently, initiatives in this phase involved changes in existing work processes or methods, requiring the implementation of proper change management methods. Key elements for advancement are highlighted, along with the impact of middle managers in facilitating these initiatives.

A central finding was that middle managers are crucial in creating a collaborative environment and building the organisation's digital maturity when implementing top-down strategies for I4.0. This role involves fostering teamwork, promoting a culture of continuous learning, and ensuring employees are prepared to adapt to new digital tools and processes. Due to their proximity to operational realities, middle managers could integrate bottom-up insights to address operational needs and problems. However, they faced challenges in building a business case to approve these new initiatives. To effectively integrate these insights into the existing digital strategy, middle managers emphasised the importance of collaborating

with external experts. This collaboration helps showcase the business value of I4.0 initiatives.

Another critical insight is the need for organisational flexibility to incorporate new initiatives. Top management should be open to adjusting processes to support innovative projects proposed by middle managers. This flexibility, combined with external collaboration, enables organisations to foster a culture of continuous improvement and innovation. Employee resistance was notably observed when initiatives were implemented through a top-down approach. Conversely, managers reported higher levels of engagement and enthusiasm from employees when initiatives were driven from the bottom up. Employees perceived these bottom-up initiatives as more beneficial because they were grounded in day-to-day realities and directly addressed pressing operational problems by introducing new tools and systems.

In this phase, middle managers played pivotal roles by building digital maturity within the organisation. They were responsible for identifying training needs, fostering a culture of collaboration, and ensuring that employees were equipped with the necessary skills to adapt to digital changes. Moreover, they collaborated across departments and with external experts, integrating both top-down strategies and bottom-up insights to ensure alignment between strategic goals and operational realities. Finally, middle managers accelerated the process of digital transformation by driving process optimisation, encouraging knowledge sharing, and experimenting with new tools and systems to foster continuous improvement.

In this phase, middle managers were critical in building the organisation's digital maturity. They identified training needs, fostered collaboration, and ensured employees were prepared for digital changes. Middle managers aligned operational realities with strategic goals by integrating top-down strategies with bottom-up insights and collaborating with external experts. Additionally, they accelerated digital transformation by driving process optimisation, encouraging knowledge sharing, and experimenting with new tools to foster continuous improvement.

4.4. Phase III: Digital Transformation

Digital Transformation (DT) represents a continuous and pervasive evolution within organisations, driven by the disruptive nature of digital technologies. Unlike digitalisation, which involves the optimisation of existing processes and tasks, DT goes beyond by rearranging these processes to shift the business logic of the firm (Li et al., 2018; Gölzer & Fritzsche, 2017) and transform its value creation process. DT requires organisations to continuously integrate technology with strategic operations, ensuring flexibility in design to respond effectively to environmental turbulence and maintain competitiveness (Zott et al., 2011). By implementing innovative business logic, DT enables organisations to create and capture new forms of value, ensuring they remain agile and resilient in an ever-changing digital landscape (Pagani & Pardo, 2017; Zott et al., 2011).

Upon reviewing various cases, **the interviews did not identify instances of fully realised digital transformation**. Instead, the characteristics and insights discussed here have been extrapolated from existing literature. This section focuses on the essential elements required to move towards digital transformation from a managerial perspective, specifically highlighting the crucial and valued role of middle managers in facilitating digital change.

4.4.1. Essential Components of Digital Transformation

Digital transformation represents a holistic evolution in organisational strategy, culture, and competencies aimed at creating novel value propositions for customers. This process involves integrating advanced

technologies such as the Internet of Things (IoT), autonomous systems, strategic alignment, and extensive business model transformation. The following key components are essential for achieving successful digital transformation:

- **A Well-defined vision:** Clear strategic direction to guide the transformation process.
- **Comprehensive digital strategy:** A roadmap that aligns digital initiatives with the overall business strategy.
- **Skilled resources:** Deployment of knowledgeable personnel capable of driving and sustaining digital initiatives.

Digital transformation not only reshapes internal operations but also drives innovation beyond organisational boundaries, integrating external networks and ecosystems (Jacobides et al., 2018; Prince et al., 2014). To fully leverage these opportunities and ensure sustained success, organisations must focus on key strategic imperatives that guide their transformation journey.

As identified by Verhoef et al. (2021), several strategic imperatives are crucial for organisations aiming to achieve digital transformation:

Digital Agility

Digital agility refers to the organisation's ability to sense and seize market opportunities enabled by digital technologies (Lee et al., 2015; Lu & Ramamurthy, 2011; Tallon & Pinsonneault, 2011). It is vital for a firm's survival in today's dynamic and unpredictable markets (Chakravarty et al., 2013). To navigate these challenges, firms must be flexible enough to:

- Adapt organisational roles in response to changing customer needs and new digital technologies.
- Respond swiftly to intensified competition resulting from the blurring of market boundaries and removing entry barriers (Chakravarty et al., 2013; Lee et al., 2015).
- Continuously modify and reconfigure existing digital assets and capabilities (Eggers & Park, 2018; Lavie, 2006).

Middle managers' role in building digital agility: As firms progress towards digital transformation, the role of middle managers becomes increasingly critical in establishing and maintaining digital agility at the operational level. Managers are instrumental in developing dynamic capabilities within the organisation, enabling it to continuously sense and seize new opportunities presented by digital technologies. They are responsible for:

- **Embracing and driving change:** Understanding and embracing technological changes in practice. Middle managers act as change agents, translating the strategic vision into actionable plans that align with daily operations (Devadoss & Pan, 2007; Huy, 2002).
- **Developing dynamic capabilities:** Cultivating an environment that encourages continuous learning and adaptability, allowing the organisation to remain agile and competitive (Karimi & Walter, 2015). As DT demands continuous change, building organisational adaptability and the ability to respond quickly to external shifts becomes crucial (Hanelt et al., 2021; Benner, 2007).
- **Establishing agile and scalable digital operations:** Ensuring that digital operations are both agile and scalable to meet the evolving demands of the digital landscape (Hanelt et al., 2021).

Hence, managers are essential in fostering digital agility, ensuring that organisations can swiftly adapt to changing market conditions and leverage digital technologies effectively.

Digital Networking Capability

The success of digital transformation heavily depends on the digital networking capabilities that middle managers can help cultivate. As the literature suggests, firms increasingly derive competitive advantage from their external networks rather than solely from internal resources (Koch & Windsperger, 2017; Libert et al., 2016). Middle managers, situated at the intersection of operational and strategic layers, are uniquely positioned to identify and engage with key external partners. By leveraging their understanding of market needs, emerging technologies, and customer demands, they can pinpoint stakeholders—suppliers, customers, or third-party innovators—who offer the most value. Actively seeking out and engaging these partners, middle managers can expand the firm's ecosystem and facilitate the co-creation of value, which is essential for sustaining competitive advantage in a digital environment (McIntyre & Srinivasan, 2017). Without such proactive involvement, firms risk missing opportunities to innovate and adapt in the fast-paced digital landscape.

Thus, middle managers play a pivotal role in cultivating digital networks that are vital for sustaining competitive advantage and driving successful digital transformation.

Digital Resources

A critical strategic imperative of digital transformation is attracting and integrating a new generation of workers who are not only tech-savvy but also adaptable to rapid technological advancements (Amladi, 2017). Middle managers play a pivotal role in this process by creating an environment that appeals to these workers, fostering a culture that values continuous learning and innovation. Additionally, they are responsible for establishing a synergy between technology and human capabilities, ensuring that the workforce can leverage digital tools effectively while maintaining the human touch that drives creativity and problem-solving (Bajer, 2017). By attracting and integrating this new generation of talent, organisations can secure the skilled resources necessary to sustain their digital transformation efforts and maintain a competitive edge.

In essence, middle managers are key to building a technologically proficient and adaptable workforce, ensuring the sustained success of digital transformation initiatives.

In this phase, middle managers take on a pivotal role in ensuring that the organisation not only adapts to the ongoing digital changes but also fosters a culture of continuous innovation. By aligning digital initiatives with strategic goals, cultivating robust external networks, and developing a tech-savvy and adaptable workforce, middle managers must ensure that digital transformation is not a one-time event but an ongoing process. Their ability to lead, sustain, and scale digital initiatives ensures that the organisation remains competitive and resilient in an ever-evolving digital landscape.

4.5. Role of Middle Managers in I4.0 Initiatives

This section outlines an integrative overview of the role of middle managers in I4.0 initiatives, synthesising findings from a thematic analysis conducted with middle managers, senior managers, and consultants in manufacturing organisations. The analysis reveals that effective digital transformation requires a comprehensive understanding of the digital journey, the triggers that drive this journey, the outcomes

of various initiatives, and the pivotal role of middle management in facilitating digital change. The integrative overview is presented in Figure 6,

1. **Digital Journey**

   The digital journey comprises three phases: digitisation, digitalisation, and digital transformation. The cases are divided into these three phases based on the level of implementation of I4.0 in the participant organisations.

2. **Triggers** The analysis identifies various triggers that initiate and drive the digital journey. Digitisation triggers include initial enthusiasm, ad hoc initiatives, and unguided efforts, mostly from individual departments. Digitalisation is driven by digital strategy, decentralised decision-making, and external collaboration for technical expertise. A clear vision, a comprehensive digital strategy, and the deployment of skilled resources propel digital transformation. These significant triggers highlight the motivations and actions that encourage organisations to implement various I4.0 initiatives and move towards digital transformation.

3. **Outcome of Initiative**

   The outcome of initiatives is presented based on the type of I4.0 initiative the organisation is taking. For example, the outcome of setting up basic infrastructure includes initiatives such as implementing a distributed control system for data collection. These initiatives do not fall under I4.0 and its technologies, but without this step, I4.0 is not possible; hence, it is considered a foundational step. Similarly, for digitalisation, building business cases means undertaking multiple I4.0 initiatives, utilising real-time data, optimising processes, and introducing new digital tools and systems, which are important. Digital transformation requires smart factories, business model changes, strategic alignment, and comprehensive and continuous change. These factors are relevant as they pinpoint the critical components for effective digital transformation, offering insights into organisational priorities at each stage.

4. **MM Role & Impact for Digital Change**

   The thematic analysis highlights the pivotal role of Middle Management (MM) in facilitating digital change across all phases of the digital journey.

   Phase I: Digitisation

   During the digitisation phase, middle managers play a pivotal role in laying the groundwork for successful digital transformation. Their responsibilities extend from understanding the potential of I4.0 technologies to actively participating in the initial stages of implementation and guiding their teams through the changes. The key areas where middle managers contribute include:

   - **Understanding and promoting I4.0:**
     - Educate and raise awareness: Middle managers are responsible for educating themselves and their teams about the capabilities and benefits of I4.0 technologies. This involves understanding how these technologies can enhance operational efficiency and drive long-term value.
     - Participating in initial opportunity discovery: MMs actively participate in the early stages of opportunity discovery, identifying potential areas where digital tools can be applied to improve processes. This includes exchanging ideas with other management levels to explore the potential impact of I4.0 across the organisation.
   - **Guiding & deploying initiatives:**

- Establishing common understanding: Ensuring alignment on the shop floor regarding digitisation goals and sense-making of new systems and tools.

- Providing direction: Leading the initial implementation of new tools, addressing resistance, and fostering a supportive environment.

Middle managers ensure that digitisation efforts are aligned with strategic goals, facilitating a smoother transition and laying the groundwork for more advanced digital transformation initiatives.

Phase II: Digitalisation

In the digitalisation phase, middle managers are essential in implementing I4.0 projects encompassing multiple initiatives and the development of business cases for digitalisation. As work processes evolve with the introduction of new digital tools and systems, MMs are crucial in driving these changes. Their responsibilities are broadly categorised into three areas:

- **Build: change management and building digital maturity**
  - Identifying training needs & skill development: MMs focus on developing employees' digital skills, bridging generational gaps, and encouraging peer support, which is vital for enhancing the organisation's digital maturity.
  - Building trust and collaborative culture: MMs create an environment of openness, ensuring that employees feel secure in expressing concerns, which builds trust and resilience necessary for adopting new technologies.
  - Continuous monitoring & feedback: MMs implement strategies like aftercare and standard leadership work to ensure sustained adoption of digital tools while negotiating with top management to relax performance expectations during the initial stages of digital adoption.
- **Collaborate: stakeholder engagement & strategic alignment**
  - Balancing top-down and bottom-up approaches: MMs incorporate operational insights into the digital strategy to align initiatives with strategic goals and shopfloor operational needs. They also address gaps between strategy and execution to facilitate smoother implementation.
  - Collaborating with external experts: With a deep understanding of I4.0's potential, MMs are adept at formulating new initiatives and collaborating with external experts to bring in fresh perspectives, showcase the business value of I4.0 and enhance organisational capabilities.
- **Accelerate: process optimisation and innovation**
  - Knowledge development & sharing: MMs promote knowledge sharing and development by leveraging global online platforms, enabling the exchange of Proof of Concepts (POCs) across different factories. This fosters a continuous learning and innovation culture, ensuring that best practices are effectively disseminated across the organisation.
  - Lean thinking and operational excellence: MMs drive lean initiatives, focusing on process optimisation while balancing the need for standardisation with opportunities for innovation.

Phase III: Digital Transformation

Digital transformation represents a continuous and pervasive evolution within organisations, driven by the disruptive nature of digital technologies. It requires continuous adaption to shifting market dynamics and customer needs alongside the strategic deployment of digital technologies to meet these challenges. Middle managers play a crucial role in the transformation by effectively contributing in the following key areas,

- **Adapt**
  - Fostering digital agility: Middle managers play a vital role in sensing and seizing market opportunities through digital technologies. By integrating digital assets with other resources, they drive the transformation of business processes, leading to innovative products, services, and business models that keep the organisation competitive in a rapidly changing environment.
  - Embracing and driving change: As change agents, middle managers translate strategic visions into actionable plans, ensuring that the organisation remains agile and responsive to technological shifts.
  - Establishing agile & scalable operations: Middle managers ensure that digital operations are flexible and scalable, enabling the organisation to adapt to new market conditions and technological advancements swiftly.
- **Innovate & Sustain**
  - Cultivating digital networking: Middle managers build and sustain digital networks. They engage with external partners, including suppliers, customers, and third-party innovators, to expand the organisation's ecosystem. Their role goes beyond collaboration; they are responsible for constructing a digital business ecosystem that enables value co-creation, ensuring sustained competitive advantage in a rapidly evolving digital landscape.
  - Attracting and integrating skilled resources: A key role of middle managers is attracting and integrating a new generation of tech-savvy workers adaptable to rapid technological advancements. They create an environment that values continuous learning and innovation, ensuring the workforce can effectively leverage digital tools while maintaining the creativity needed for problem-solving.
  - Fostering a culture of continuous innovation: Middle managers ensure that digital transformation is not a one-time event but an ongoing process. They help cultivate a culture of continuous innovation, actively promoting exploration and experimentation with digital technologies and encouraging their teams to evolve and innovate constantly.

These roles emphasise the continuous nature of digital transformation and the critical impact of middle managers in ensuring that the organisation not only adapts to ongoing changes but also sustains and scales its digital initiatives for long-term success.

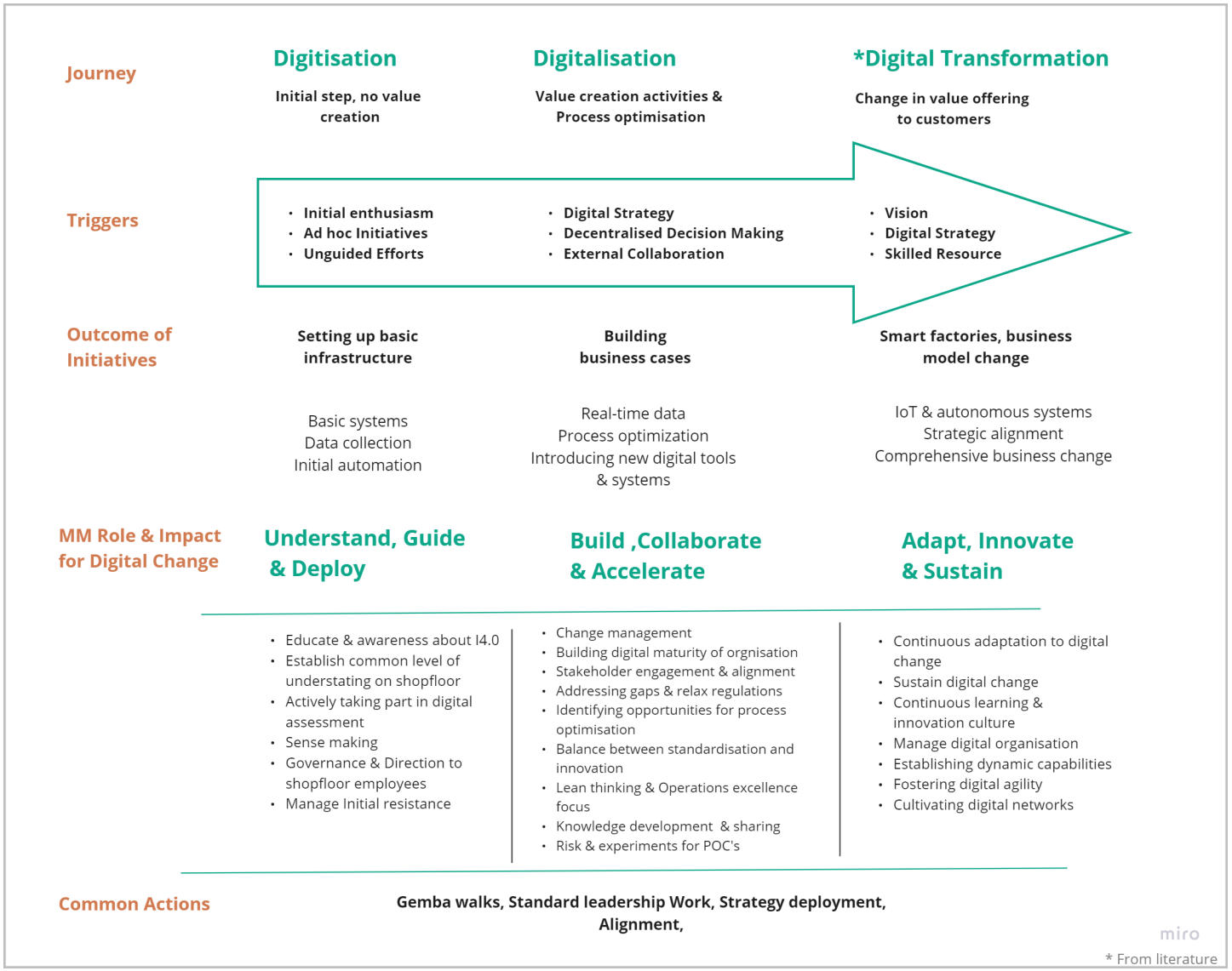

Figure 6: Integrative overview of the role of middle manager's in I4.0 initiatives

5. Discussion

This thesis investigates middle managers' pivotal roles and their impacts on implementing I4.0 initiatives. By conducting 13 in-depth interviews with middle managers, senior managers, and change management experts, the study uncovers the challenges encountered by middle managers during the digitisation and digitalisation phases on the shop floor. The research also identifies key practices and strategic steps middle managers employ to navigate and overcome these challenges, outlining their role in I4.0 initiatives.

In this chapter, the findings are interpreted and analysed in relation to the research question and objectives. The discussion integrates these findings with existing literature, comprehensively comparing and highlighting where the study confirms, expands, or diverges from established knowledge. Additionally, the theoretical and practical implications of the findings are explored, emphasising how they contribute to both academic understanding and practical application in the field. The chapter also addresses the study's limitations and considers their implications for interpreting the results. Finally, recommendations for future research are provided.

5.1. Analysis of Findings

5.1.1. Involvement of Middle Manager's I4.0 Initiatives

Firstly, the research findings shed light on the involvement of middle managers in I4.0 initiatives. Through interviews with senior managers and change management consultants, who play a crucial role in implementing digital transformation projects, a gap was revealed between the perceived and actual involvement of middle managers. This discrepancy highlights the challenges organisations face in fully leveraging the potential of middle managers to drive I4.0 initiatives.

Established research highlights the critical role of middle managers in driving organisational change by aligning strategic goals with operational realities and facilitating smooth implementation across all levels (Huy, 2002; S. Floyd & Woolridge, 1992). Their access to cross-functional networks and awareness of system dependencies makes them crucial in enhancing communication and managing organisational change (Bamford & Forrester, 2003; Huy, 2001). However, the findings indicate that, in practice, middle managers are often underutilised in I4.0 initiatives due to various challenges such as time constraints, complex project structures, skill gaps, and the perception that I4.0 initiatives add to their workload.

These challenges arise because organisations often do not allocate sufficient time and resources for middle managers to engage in I4.0 initiatives. Middle managers are expected to manage their regular operational responsibilities, leaving little room for involvement in projects like I4.0. Additionally, the complexity of I4.0 projects, with undefined and long timelines, coupled with a lack of targeted training, may leave middle managers feeling unprepared to contribute effectively, leading to a reluctance to engage fully. Insights from the (Field et al., 2023) align with these findings, highlighting how middle managers, often burdened with administrative tasks, are excluded from digital initiatives, diminishing their ability to navigate complex changes and foster team cohesion. Field et al. (2023) suggests that middle managers are essential for making work more meaningful and productive and that true organisational transformation can only occur with their involvement.

I4.0 projects are often managed by specialised teams, with middle managers frequently excluded from the decision-making process. While specialised teams are essential for implementing new technologies, involving middle managers during the opportunity discovery and change planning stages is equally crucial, as these changes will directly impact their teams. Firstly, their 360° perspective, coupled with deep operational knowledge, enables them to identify and address critical business problems (Dutton et al., 1997; S. Floyd & Woolridge, 1994; Harrington & Williams, 2004), making them invaluable assets in I4.0 opportunity discovery and initial phases of digital transformation. Secondly, as implementing new digital tools and systems directly impacts their teams, middle managers, who are deeply involved in managing daily challenges, are vital to the change planning stage (Bamford & Forrester, 2003).

The result also uncovered substantial benefits of involving middle managers. Their inclusion can lead to faster implementation and adoption of I4.0 initiatives because of their ability to communicate in every direction and influence those surrounding them (Dutton et al., 1997; Harrington & Williams, 2004). Additionally, middle managers enhance employee engagement and facilitate change adoption by effectively communicating the benefits of new strategic initiatives to the workforce and bridging communication gaps across functions, aligning with Huy (2002) findings.

Organisations must rethink the role of middle managers in I4.0 initiatives, not as mere administrative overseers but as key drivers for organisational transformation. As reflected in the findings of (Nadkarni & Prügl, 2021; Field et al., 2023), there is a need to reassess their responsibilities, provide them with the necessary training and support, and fully integrate them into the journey towards digital transformation. By doing so, companies can better harness the potential of middle managers to lead and sustain successful digital transformation efforts, ensuring that I4.0 initiatives are both effectively implemented and widely embraced across the organisation.

5.1.2. Middle Managers in Implementing and facilitating I4.0 Initiatives

The journey towards digital transformation involves several phases, each with distinct challenges and implications for organisational change. **The digitisation phase**, while foundational, presents significant hurdles that must be addressed to pave the way for successful digital transformation.

One of the key findings from this study underscores the struggle of middle managers in getting new initiatives approved and scaling up existing digitisation initiatives. This struggle is primarily due to the difficulty in proving the tangible benefits of I4.0 technologies and the lack of support from top management. However, the potential for top management to drive this transformation is immense, and their support can empower the entire organisation.

This difficulty is not unique to the organisations studied; it resonates with broader concerns in the literature. For instance, Hansen et al. (2011) emphasises that for digital initiatives to gain traction, top management must not only be aware of the technological capabilities but also possess a positive attitude towards embracing change (Dery et al., 2017). The findings from this study suggest that organisations rely on traditional top-down management styles consistent with the findings of Verhoef et al. (2021), which can stifle innovation and hinder the scaling of I4.0 initiatives. An abstract understanding of I4.0 among management levels hinders knowledge development and sharing, limiting the exchange of ideas about new opportunities and hence creating obstacles in identifying and formulating new I4.0 initiatives. Stentoft & Rajkumar (2020) emphasise that a shared understanding and knowledge of I4.0 across all levels is crucial for identifying and driving new initiatives. Similarly, Kane et al. (2017) and Warner & Wäger (2019) highlight the importance of a common organisational culture and shared language in pursuing digital transformation.

Furthermore, a lack of vision and a unified approach leads to a disconnect between top and local factory managers, with middle managers often reporting exclusion from strategic conversations. This exclusion is particularly problematic, as it can negatively impact organisational change if middle managers perceive that it should not be supported (S. Floyd & Woolridge, 1992; Sayer, 1998; Huy, 2002). Therefore, maintaining a dialogue between middle and top managers is essential to ensure their involvement and support in the change process. Huy (2002) underscores the importance of a unified vision across management levels, arguing that it is a key factor in the success of organisational changes. Similarly, Imran et al. (2020) highlight the necessity for leaders to have a clear vision of how digital technologies can shape the organisation's future. The findings from this study reinforce these perspectives, showing that efforts to drive I4.0 initiatives become fragmented without a unified approach, leading to suboptimal outcomes.

Moreover, the study found that the initial enthusiasm for adopting digital technologies often fades due to the challenges of scaling these initiatives. This is particularly concerning given the foundational nature of digitisation in the broader digital transformation process. As Hanelt et al. (2021) suggests, the absence of top management support and a lack of clear direction can result in "initiative fatigue," where the initial momentum is lost, and the organisation reverts to its old ways of working.

As organisations progress into the advanced phases of digital transformation, top management initiates multiple I4.0 initiatives, introducing various digital tools and systems that significantly impact daily operations. This phase of **digitalisation** brings several challenges, particularly as increased automation disrupts established work processes.

Employee resistance during this phase is a significant obstacle, often rooted in fears of job displacement (Staffen & Schoenwald, 2016), lack of digital skills (Kamble et al., 2018), and a lack of trust due to previous unsuccessful digital initiatives. These concerns can hinder the adoption of new technologies and slow the overall transformation process. Building trust becomes essential in the face of digitalisation. One effective way to foster trust within an organisation is through open and transparent communication, which helps alleviate fear and uncertainty about upcoming changes (Foerster-Metz et al., 2018; Vrana & Singh, 2021). Trust is crucial for ensuring that employees align with the organisation's vision and support the changes being implemented (Wrede et al., 2020). Middle managers, who are emotionally closer to staff than senior managers, better understand individual needs during organisational change, making them critical for sustaining change momentum (Huy, 2001). Additionally, middle managers have the trust of their subordinates (Lleo et al., 2017). By creating an environment where employees feel safe to voice their concerns, middle managers can mitigate resistance and build trust within the workforce.

The findings underscore the need to enhance organisational capabilities by prioritising employee skill development. This aligns with the research by Schwarzmüller et al. (2018), which emphasises the importance of building employee skills during digital transitions. The role of middle managers in this phase extends to developing digital maturity within the organisation, involving both upskilling employees and nurturing a culture that supports continuous learning and adaptation. There is a need for organisational structures that can support the implementation of I4.0 technologies and digital transformation to reduce hierarchical barriers and bureaucracy. The results reveal tensions due to hierarchical challenges and centralised decision-making. Hence, flat hierarchies and decentralise decision-making processes are essential for keeping up with the pace and complexities of fast-changing environments, aligning with the findings of Foerster-Metz et al. (2018)

One interesting insight that emerged from this study is that middle managers reported greater employee support for initiatives when change is initiated by middle managers and executed by top managers. This finding is consistent with the results of a previous study of Heyden et al. (2017). Middle managers

are pivotal in implementing top-down strategies and integrating bottom-up insights. They are crucial in bridging the gap between strategic objectives set by top management and operational realities. Results confirm this dual role, highlighting middle managers' contributions to strategy formulation and operational execution. Organisations often run multiple I4.0 projects in digitalisation, leading to a trade-off between standardisation and innovation. Middle managers play a crucial role in navigating this balance, ensuring that projects align with overall strategic goals while allowing room for experimentation and localised innovation.

Leaders who foster an experimental culture are vital during digital transformation. They need to demonstrate a willingness to experiment (El Sawy et al., 2020; Imran et al., 2021; Kane et al., 2018), create the conditions that encourage innovation (de Araujo et al., 2021; Diller et al., 2020), and empower their teams to take risks (Alos-Simo et al., 2017; Guinan et al., 2019). This experimental mindset is crucial for identifying effective digital solutions and allowing the organisation to adapt to a rapidly changing landscape (Kane et al., 2017). However, not all experiments will succeed, so leaders must approach failure constructively, using it to learn and improve (Bennis, 2013; Bolden & O'Regan, 2016; Imran et al., 2020). Top management's vision and support are key to empowering middle managers and employees to explore new ideas, test their feasibility, and integrate successful innovations into the broader organisational strategy.

Another highlight of this study is the importance of collaborating with external experts. External collaboration is essential for showcasing the business value of I4.0 initiatives and overcoming internal limitations. As highlighted by Foerster-Metz et al. (2018), such collaboration allows organisations to exploit I4.0 technologies better, experiment with multiple proofs of concepts, and enhance their capacity for innovation.

5.2. Theoretical Implications

Firstly, most studies have focused on senior management's roles when implementing I4.0 initiatives with little focus on middle managers and their contribution to organisations' digital transformation efforts. Even though scholars have highlighted the importance of middle managers when deploying organisational change (Huy, 2002).

Secondly, few studies have highlighted the importance of middle managers in digital transformation, focusing on their skills and behaviours (Henderikx & Stoffers, 2023; Torres et al., 2023). Christodoulou et al. (2022) highlighted the role of middle managers in formulating a strategy for digital transformation.

However, these studies often view digital transformation as a radical change phenomenon within the organisation and do not consider the steps organisations go through to reach ultimate digital transformation. They ignore the unique challenges organisations and middle managers face while implementing these initiatives on the shop floor in each phase and taking subsequent steps. This research brings a unique perspective by first illustrating managerial challenges based on the level of implementation of I4.0 initiatives and the organisation's journey to digital transformation. The bifurcation was based on the I4.0 initiatives and their "value creation" to the organisation. The phases in the digital transformation journey are as follows (Verhoef et al., 2021) :

- **Digitisation (Incremental Change)** – No value creation, as this requires the conversion of analogue information or paper-based information into digital. This phase sets the ground for organisations to move to the next stage.
- **Digitalisation (Incremental + Radical Change)** – Using digital tools and technologies to create

business value by altering existing processes and operations and increasing process visibility across the organisation.

- **Digital Transformation (Radical Change)** – Digital transformation goes beyond value creation and includes aspects of value offering to the customers. This entails a radical change in not only organisational operations but also business models and value offerings to the customer, requiring significant transformation of organisational structures, strategy, and human resources.

This study proposed an integrated approach for middle managers' involvement and contribution in I4.0 initiatives and their impact when organisations embrace these new changes. By outlining the challenges per phase of digital transformation, organisations can better equip themselves with methods and resources to address these challenges.

5.3. Practical & Managerial Implications

This study provides several practical and managerial implications for organisations, senior managers, and middle managers in the context I4.0 initiatives. The findings underscore middle managers' critical and evolving role as key drivers of digital transformation, challenging the notion that their roles are redundant in modern organisations. Instead of viewing middle managers as mere overseers of operational tasks, organisations should empower them as strategic partners in the digital transformation journey.

To leverage the full potential of middle managers, organisations should invest in their development, focusing on building competencies and leadership skills which can enable them to drive organisational change. This involves providing targeted training and fostering a culture of continuous learning, equipping middle managers with the tools needed to lead digital initiatives effectively. Additionally, the findings revealed middle managers play a crucial role in building digital maturity within the organisation by developing employees' digital skills, fostering trust, and ensuring that new technologies are adopted smoothly through continuous monitoring and feedback.

Top managers can use these findings to create environments that support middle managers in their roles as change agents. This includes implementing strategies that consider the human aspect of digital transformation and ensuring that all employees are engaged, informed, and motivated to embrace new technologies. By aligning digital transformation strategies with broader organisational goals and promoting cross-functional collaboration, middle managers can integrate top-down strategies with operational realities, ensuring that I4.0 initiatives are strategically aligned and operationally effective.

The study suggests that for organisations to navigate the journey towards digital transformation, they need to leverage the unique position of middle managers, promote external collaboration, and maintain a flexible approach to organisational change. These practices can help overcome the challenges identified in the study and pave the way towards more effective and sustainable digital transformation.

5.4. Limitations & Recommendations for Future Work

Participants & choice of sample: The selection of participants and sample choices in this study were inherently limited. The study relied on a purposive sampling strategy to ensure that participants had relevant experience and insights into I4.0 initiatives. However, the pool of participants was limited to those readily available and willing to participate, potentially omitting perspectives from a broader range of industries or organisational sizes. This limitation could impact the diversity and comprehensiveness of the findings.

Generalizability findings: While the proposed approach highlights the contributions of middle managers in the digital transformation journey, its generalizability is restricted. The findings are based on specific interviews and organisational contexts, which may not universally apply across all industries or geographies. Different organisational cultures, structures, and levels of digital maturity could influence the applicability of the proposed approach.

No participants in the digital transformation phase: Despite employing a purposive sampling strategy, the study did not include participants from organisations in the digital transformation phase. This was the effect of bifurcating the cases into different phases post-interview, as the middle managers experienced different challenges based on the level of implementation of I4.0 initiatives, and these challenges cannot be generalised under digital transformation. This gap also arose because the level of implementation of I4.0 projects within organisations remained unknown before the interviews, leading to an uneven distribution of cases across various phases of digital transformation. To address this, consultants and subject matter experts were included in the study for their insights on the roles and contributions of middle managers during the digital transformation phase, given their comprehensive understanding of the process.

Researchers' bias: Using interviews as the primary source of empirical data introduces potential researcher bias and subjectivity. One concern is that steering the conversation in a particular direction may influence the interviewee's responses, leading them to provide information they believe is expected by the interviewer. To minimise this, the study employed open-ended questions, allowing informants to freely discuss their ongoing I4.0 initiatives. However, interviews may provide insights into interviewees' perceptions rather than solely capturing their actual behaviours and practices. While interviews offer valuable subjective insights, they may not fully reflect the objective reality of participants' actions. Consequently, there is a need for further studies to test the resultant integrated approach objectively, beyond the subjective data obtained from interviews.

5.5. Future Recommendations

Recommendations for future work include involving middle managers in the digital transformation phase, where organisations have successfully deployed several digital technologies in both value creation and value offerings to their customers. This involvement can reveal the challenges middle managers face in reaching this stage and highlight best practices to sustain digital change and manage a digitally transformed organisation, which managers in phase I & II also adopt.

Additionally, this research focused on middle managers in manufacturing, specifically on production and operations management. Future studies could broaden the scope to include middle managers from different functions, providing a more comprehensive understanding of their efforts and strategies during the transition toward digital transformation.

Lastly, the proposed integrative overview of the role of middle managers in I4.0 initiatives can be further refined and validated through longitudinal studies examining middle managers' contributions as organisations progress toward digital transformation. This would provide deeper insights into the evolving role of middle managers and the dynamic challenges they encounter in this continuous journey.

6. Conclusion

This research aimed to explore the crucial role of middle managers in implementing and facilitating I4.0 initiatives within manufacturing organisations. The study reveals that middle managers are not just mere overseers of operational activities but act as the organisational glue during digital transformation. They facilitate communication between top managers and employees and help actively bring in ideas from internal and external sources. Their involvement is essential, requiring rethinking their role in modern organisations.

The impact of I4.0 and digital technologies extends across the organisation, requiring comprehensive involvement at all levels. However, current organisational practices often hinder middle managers' effectiveness due to a lack of assigned time and resources, complex project structures, and insufficient attention to upskilling middle managers to drive digital change. Top management must recognise the pivotal role of middle managers and equip them with the necessary tools & resources to drive digital transformation. Their involvement can accelerate implementation, address critical business issues, enhance employee engagement & change adoption, and improve cross-functional collaboration. Leveraging their unique position ensures a more efficient and successful implementation of I4.0 initiatives, maximising organisational benefits.

This study demonstrates that the journey towards full digital transformation is a gradual process rather than the radical shift often portrayed in existing literature. This insight is relevant for manufacturing organisations, where implementing digital technologies and tools impacts value-creation activities at different stages. This research contributes to a deeper understanding of the evolving role of middle managers in I4.0 initiatives, highlighting that their contributions vary and adapt as organisations navigate different phases of the digital transformation journey. These findings underscore the importance of recognising middle managers' distinct roles and challenges throughout the digital transformation journey, offering valuable implications for theory and practice.

In Phase I digitisation, their main role emerged as understanding the opportunities of I4.0, guiding employees in implementing initial initiatives, and ensuring initial initiatives are effectively deployed on the shop floor. Involving middle managers in creating I4.0 initiatives ensures these are grounded in operational realities and address the right business problems.

In Phase II, digitalisation, middle managers are instrumental in implementing multiple I4.0 initiatives and developing business cases for digitalisation. As new digital tools and systems transform work processes, middle managers take on the critical role of driving these changes. They focus on building digital maturity within the organisation by developing employees' skills, fostering a culture of trust, and ensuring that adopting new technologies is supported by continuous monitoring and feedback. Middle managers also bridge the gap between top-down strategies and operational realities by incorporating bottom-up insights into digital strategies and collaborating with external experts to enhance organisational capabilities. Their efforts in process optimisation and knowledge sharing accelerate the organisation's digital transformation, ensuring that initiatives are strategically aligned and operationally effective.

In Phase III, digital transformation, middle managers are crucial in driving continuous adaptation and innovation. They foster digital agility, integrate new technologies into scalable operations, and build digital networks to sustain competitive advantage. Additionally, they are responsible for attracting

a tech-savvy workforce and cultivating a continuous learning and innovation culture, ensuring the organisation remains responsive and resilient in a rapidly evolving digital landscape.

This study outlined an integrative overview of the role of middle managers in I4.0 initiatives, highlighting their dual role in managing top-down and bottom-up processes. This perspective not only addresses the challenges identified in each phase but also provides a structured pathway for organisations to leverage the unique position of middle managers in achieving sustainable digital transformation.

References

Alade, K., & Windapo, A. O. (2021, 6). Developing effective 4ir leadership framework for construction organisations. *Engineering, Construction and Architectural Management*, *28*, 1377-1396. doi: 10.1108/ECAM-07-2020-0576

Alos-Simo, L., Verdu-Jover, A. J., & Gomez-Gras, J.-M. (2017). How transformational leadership facilitates e-business adoption. *Industrial Management & Data Systems*, *117*(2), 382–397.

Amladi, P. (2017). Hr's guide to the digital transformation: ten digital economy use cases for transforming human resources in manufacturing. *Strategic HR Review*, *16*(2), 66–70.

Anderson, D., & Ackerman, A. L. (2010). *Beyond change management: How to achieve breakthrough results through conscious change leadership* (2nd Edition ed., Vol. 36). John Wiley & Sons.

Arnold, C., Kiel, D., & ingo Voigt, K. (2016, 12). How the industrial internet of things changes business models in different manufacturing industries. *International Journal of Innovation Management*, *20*, 1640015. doi: 10.1142/S1363919616400156

Ashurst, C., Doherty, N. F., & Peppard, J. (2008, 8). Improving the impact of it development projects: the benefits realization capability model. *European Journal of Information Systems*, *17*, 352-370. doi: 10.1057/ejis.2008.33

Bajer, J. (2017). Digital transformation needs the human touch. *Strategic HR Review*, *16*(2), 91–92.

Balogun, J., & Johnson, G. (2004). *Organizational restructuring and middle manager sensemaking* (Vol. 47).

Bamford, D. R., & Forrester, P. L. (2003). Managing planned and emergent change within an operations management environment. *International journal of operations & production management*, *23*(5), 546–564.

Barriers to the adoption of industry 4.0 technologies in the manufacturing sector: An inter-country comparative perspective. (2020, 6). *International Journal of Production Economics*, *224*, 107546. doi: 10.1016/j.ijpe.2019.107546

Benjamin, R. I., & Levinson, E. (1993). *A framework for managing it-enabled change* (Vol. 34).

Benner, M. J. (2007). The incumbent discount: Stock market categories and response to radical technological change. *Academy of Management Review*, *32*(3), 703–720.

Bennis, W. (2013). Leadership in a digital world: Embracing transparency and adaptive capacity. *Mis Quarterly*, *37*(2).

Berman, S. J. (2012, 3). Digital transformation: opportunities to create new business models. *Strategy & Leadership*, *40*, 16-24. doi: 10.1108/10878571211209314

Bloomberg, J. (2018). Digitization, digitalization, and digital transformation: confuse them at your peril. *Forbes. Retrieved on August*, *28*(2019), 1–6.

Bolden, R., & O'Regan, N. (2016). Digital disruption and the future of leadership: An interview with rick haythornthwaite, chairman of centrica and mastercard. *Journal of Management Inquiry*, *25*(4), 438–446.

Braun, V., & Clarke, V. (2006, 1). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*, 77-101. doi: 10.1191/1478088706qp063oa

Brennen, J. S., & Kreiss, D. (2016, 10). Digitalization. In (p. 1-11). Wiley. doi: 10.1002/9781118766804.wbiect111

Chakravarty, A., Grewal, R., & Sambamurthy, V. (2013). Information technology competencies, organizational agility, and firm performance: Enabling and facilitating roles. *Information systems research*, *24*(4), 976–997.

Christodoulou, I. P., Wasim, J., Reinhardt, R. J., & Ivanov, K. (2022, 11). The strategic role of middle managers in the formulation and implementation of digital transformation projects. *Strategic Change*, *31*, 613-622. doi: 10.1002/jsc.2528

Coreynen, W., Matthyssens, P., & Bockhaven, W. V. (2017, 1). Boosting servitization through digitization: Pathways and dynamic resource configurations for manufacturers. *Industrial Marketing Management*, *60*, 42-53. doi: 10.1016/j.indmarman.2016.04.012

Dalenogare, L. S., Benitez, G. B., Ayala, N. F., & Frank, A. G. (2018, 10). The expected contribution of industry 4.0 technologies for industrial performance. *International Journal of Production Economics*, *204*, 383-394. doi: 10.1016/J.IJPE.2018.08.019

de Araujo, L. M., Priadana, S., Paramarta, V., & Sunarsi, D. (2021). Digital leadership in business organisations. *International Journal of Educational Administration, Management, and Leadership*, 45–56.

Dery, K., Sebastian, I. M., & van der Meulen, N. (2017). The digital workplace is key to digital innovation. *MIS Quarterly Executive*, *16*(2).

Devadoss, P., & Pan, S. L. (2007). Enterprise systems use: Towards a structurational analysis of enterprise systems induced organizational transformation. *Communications of the Association for Information Systems*, *19*.

Diller, M., Asen, M., & Späth, T. (2020). The effects of personality traits on digital transformation: Evidence from german tax consulting. *International Journal of Accounting Information Systems*, *37*, 100455.

Dutton, J., Ashford, S., O'Niell, R., Hayes, E., & Wierba, E. (1997, 5). Reading the wind: how middle managers assess the context for selling issues to top managers. *Strategic Management Journal*, *18*, 407-423. doi: 10.1002/(SICI)1097-0266(199705)18:5<407::AID-SMJ881>3.0.CO;2-J

Eggers, J. P., & Park, K. F. (2018, 1). Incumbent adaptation to technological change: The past, present, and future of research on heterogeneous incumbent response. *Academy of Management Annals*, *12*, 357-389. doi: 10.5465/annals.2016.0051

El Sawy, O. A., Kræmmergaard, P., Amsinck, H., & Vinther, A. L. (2020). How lego built the foundations and enterprise capabilities for digital leadership. In *Strategic information management* (pp. 174–201). Routledge.

Field, E., Hancock, B., & Schaninger, B. (2023, Jun). *Don't eliminate your middle managers.* Retrieved from https://hbr.org/2023/07/dont-eliminate-your-middle-managers

Flick, U. (2022). *An introduction to qualitative research.*

Floyd, S., & Woolridge, B. (1992). Middle management involvement in strategy and its association with strategic type: A research note. *Strategic Management Journal*, *13*, 153-167.

Floyd, S., & Woolridge, B. (1994, 11). Dinosaurs or dynamos? recognizing middle management's strategic role. *Academy of Management Perspectives*, *8*, 47-57. doi: 10.5465/ame.1994.9412071702

Floyd, S., & Woolridge, B. (1999, 12). Knowledge creation and social networks in corporate entrepreneurship: The renewal of organizational capability. In (p. 123-144). DE GRUYTER. doi: 10.1515/9783038212843.160

Floyd, S. W., & Lane, P. J. (2000, 1). Strategizing throughout the organization: Managing role conflict in strategic renewal. *Academy of Management Review*, *25*, 154-177. doi: 10.5465/amr.2000.2791608

Floyd, S. W., & Wooldridge, B. (1997, 5). Middle management's strategic influence and organizational performance. *Journal of Management Studies*, *34*, 465-485. doi: 10.1111/1467-6486.00059

Foerster-Metz, U. S., Marquardt, K., Golowko, N., Kompalla, A., & Hell, C. (2018, 5). Digital transformation and its implications on organizational behavior. *Journal of EU Research in Business*, 1-14. doi: 10.5171/2018.340873

Geissbauer, R., Vedso, J., & Schrauf, S. (2016). Industry 4.0: Building the digital enterprise. *2016 Global Industry 4.0 Survey*.

Gfrerer, A., Hutter, K., Füller, J., & Ströhle, T. (2021, 2). Ready or not: Managers' and employees' different perceptions of digital readiness. *California Management Review*, *63*, 23-48. doi: 10.1177/0008125620977487

Ghadge, A., Kara, M. E., Moradlou, H., & Goswami, M. (2020, 3). The impact of industry 4.0 implementation on supply chains. *Journal of Manufacturing Technology Management*, *31*, 669-686. doi: 10.1108/JMTM-10-2019-0368

Ghobakhloo, M., Iranmanesh, M., Foroughi, B., Tseng, M.-L., Nikbin, D., & Khanfar, A. A. A. (2023, 9). Industry 4.0 digital transformation and opportunities for supply chain resilience: a comprehensive review and a strategic roadmap. *Production Planning & Control*, 1-31. doi: 10.1080/09537287.2023.2252376

Grover, V., Jeong, S. R., Kettinger, W. J., & Teng, J. T. (1995, 6). The implementation of business process reengineering. *Journal of Management Information Systems*, *12*, 109-144. doi: 10.1080/07421222.1995.11518072

Guest, G., Bunce, A., & Johnson, L. (2006, 2). How many interviews are enough? *Field Methods*, *18*, 59-82. doi: 10.1177/1525822X05279903

Guinan, P. J., Parise, S., & Langowitz, N. (2019, 11). Creating an innovative digital project team: Levers to enable digital transformation. *Business Horizons*, *62*, 717-727. doi: 10.1016/j.bushor.2019.07.005

Gölzer, P., & Fritzsche, A. (2017). Data-driven operations management: organisational implications of the digital transformation in industrial practice. *Production Planning & Control*, *28*(16), 1332–1343. Retrieved from https://doi.org/10.1080/09537287.2017.1375148 doi: 10.1080/09537287.2017.1375148

H., B., A., R., & A., M. (2018). Unlocking success in digital transformations. *McKinsey & Company.*. Retrieved from https://www.mckinsey.com/business-functions/organization/our-insights/unlocking-successin-digital-transformations

Hanelt, A., Bohnsack, R., Marz, D., & Antunes Marante, C. (2021). A systematic review of the literature on digital transformation: Insights and implications for strategy and organizational change. *Journal of management studies*, *58*(5), 1159–1197.

Hansen, A. M., Kraemmergaard, P., & Mathiassen, L. (2011). Rapid adaptation in digital transformation: A participatory process for engaging is and business leaders. *MIS Quarterly Executive*, *10*(4).

Harrington, D., & Williams, B. (2004). Moving the quality effort forward–the emerging role of the middle manager. *Managing Service Quality: An International Journal*, *14*(4), 297–306.

Henderikx, M., & Stoffers, J. (2023). Digital transformation and middle managers' leadership skills and behavior: a group concept mapping approach. *Frontiers in Psychology*, *14*. doi: 10.3389/fpsyg.2023.1147002

Herzig, S. E., & Jimmieson, N. L. (2006, 12). Middle managers' uncertainty management during organizational change. *Leadership & Organization Development Journal*, *27*, 628-645. doi: 10.1108/01437730610709264

Hess, T. (2016). *Understanding digital transformation strategy formation: Insights from europe's automotive industry.* Retrieved from http://aisel.aisnet.org/pacis2016

Heyden, M. L. M., Fourné, S. P. L., Koene, B. A. S., Werkman, R., & Ansari, S. S. (2017, 11). Rethinking 'top-down' and 'bottom-up' roles of top and middle managers in organizational change: Implications for employee support. *Journal of Management Studies*, *54*, 961-985. doi: 10.1111/joms.12258

Hutzschenreuter, T., & Kleindienst, I. (2006, 10). Strategy-process research: What have we learned and what is still to be explored. *Journal of Management*, *32*, 673-720. doi: 10.1177/0149206306291485

Huy, Q. N. (2001). In praise of middle managers. *Harvard Business Review*, 72-79.

Huy, Q. N. (2002, 3). Emotional balancing of organizational continuity and radical change: The contribution of middle managers. *Administrative Science Quarterly*, *47*, 31-69. doi: 10.2307/3094890

Imran, F., Shahzad, K., Butt, A., & Kantola, J. (2020). Leadership competencies for digital transformation: Evidence from multiple cases. In (p. 81-87). doi: 10.1007/978-3-030-50791-6_11

Imran, F., Shahzad, K., Butt, A., & Kantola, J. (2021). Digital transformation of industrial organizations: Toward an integrated framework. *Journal of change management*, *21*(4), 451–479.

Jacobides, M. G., Cennamo, C., & Gawer, A. (2018, 8). Towards a theory of ecosystems. *Strategic Management Journal*, *39*, 2255-2276. doi: 10.1002/smj.2904

Kamble, S. S., Gunasekaran, A., & Sharma, R. (2018, 10). Analysis of the driving and dependence power of barriers to adopt industry 4.0 in indian manufacturing industry. *Computers in Industry*, *101*, 107-119. doi: 10.1016/J.COMPIND.2018.06.004

Kane, G. C., Palmer, D., & Phillips, A. N. (2017). *Achieving digital maturity* (Tech. Rep.). MIT Sloan Management Review.

Kane, G. C., Palmer, D., Phillips, A. N., & Kiron, D. (2015). *Is your business ready for a digital future?* (Vol. 56). Retrieved from http://mitsmr.com/1BkggSi

Kane, G. C., Palmer, D., Phillips, A. N., Kiron, D., & Buckley, N. (2018). Coming of age digitally. *MIT Sloan Management Review*.

Karimi, J., & Walter, Z. (2015). The role of dynamic capabilities in responding to digital disruption: A factor-based study of the newspaper industry. *Journal of Management Information Systems*, *32*(1), 39–81.

King, A. W., & Zeithaml, C. P. (2001). Competencies and firm performance: Examining the causal ambiguity paradox. *Strategic management journal*, *22*(1), 75–99.

Klein, M. (2020, 3). Leadership characteristics in the era of digital transformation. *Business & Management Studies: An International Journal*, *8*, 883-902. doi: 10.15295/bmij.v8i1.1441

Koch, T., & Windsperger, J. (2017). Seeing through the network: Competitive advantage in the digital economy [Article]. *Journal of Organization Design*, *6*(1). Retrieved from https://www.scopus.com/inward/record.uri?eid=2-s2.0-85048680612&doi=10.1186%2fs41469-017-0016-z&partnerID=40&md5=023ebd89e9b8c9f7e98974f170cb818d doi: 10.1186/s41469-017-0016-z

Kraus, S., Jones, P., Kailer, N., Weinmann, A., Chaparro-Banegas, N., & Roig-Tierno, N. (2021, 7). Digital transformation: An overview of the current state of the art of research. *SAGE Open*, *11*, 215824402110475. doi: 10.1177/21582440211047576

Kuratko, D. F., Ireland, R. D., Covin, J. G., & Hornsby, J. S. (2005, 11). A model of middle–level managers' entrepreneurial behavior. *Entrepreneurship Theory and Practice*, *29*, 699-716. doi: 10.1111/j.1540-6520.2005.00104.x

Lasi, H., Fettke, P., Kemper, H.-G., Feld, T., & Hoffmann, M. (2014, 8). Industry 4.0. *Business & Information Systems Engineering*, *6*, 239-242. doi: 10.1007/s12599-014-0334-4

Lavie, D. (2006). Capability reconfiguration: An analysis of incumbent responses to technological change. *Academy of management review*, *31*(1), 153–174.

Lee, O.-K., Sambamurthy, V., Lim, K. H., & Wei, K. K. (2015). How does it ambidexterity impact organizational agility? *Information Systems Research*, *26*(2), 398–417.

Li, L., Su, F., Zhang, W., & Mao, J. (2018, 11). Digital transformation by sme entrepreneurs: A capability perspective. *Information Systems Journal*, *28*, 1129-1157. doi: 10.1111/isj.12153

Libert, B., Beck, M., & Wind, J. (2016). *The network imperative: How to survive and grow in the age of digital business models*. Harvard Business Review Press.

Lleo, A., Viles, E., Jurburg, D., & Lomas, L. (2017). Strengthening employee participation and commitment to continuous improvement through middle manager trustworthy behaviours. *Total Quality Management & Business Excellence*, *28*(9-10), 974–988.

Lu, Y., & Ramamurthy, K. (2011). Understanding the link between information technology capability and organizational agility: An empirical examination. *MIS quarterly*, 931–954.

Mantere, S. (2008, 3). Role expectations and middle manager strategic agency. *Journal of Management Studies*, *45*, 294-316. doi: 10.1111/j.1467-6486.2007.00744.x

Martínez, J. M. G., Puertas, R., Martín, J. M. M., & Ribeiro-Soriano, D. (2022, 7). Digitalization, innovation and environmental policies aimed at achieving sustainable production. *Sustainable Production and Consumption*, *32*, 92-100. doi: 10.1016/J.SPC.2022.03.035

McIntyre, D. P., & Srinivasan, A. (2017). Networks, platforms, and strategy: Emerging views and next steps. *Strategic management journal*, *38*(1), 141–160.

Müller, J. M., Kiel, D., & Voigt, K.-I. (2018, 1). What drives the implementation of industry 4.0? the role of opportunities and challenges in the context of sustainability. *Sustainability*, *10*, 247. doi: 10.3390/su10010247

Nadkarni, S., & Prügl, R. (2021, 4). Digital transformation: a review, synthesis and opportunities for future research. *Management Review Quarterly*, *71*, 233-341. doi: 10.1007/s11301-020-00185-7

Netland, T. H., Powell, D. J., & Hines, P. (2020, 5). Demystifying lean leadership. *International Journal of Lean Six Sigma*, *11*, 543-554. doi: 10.1108/IJLSS-07-2019-0076

Nonaka, I. (1994, 2). A dynamic theory of organizational knowledge creation. *Organization Science*, *5*, 14-37. doi: 10.1287/orsc.5.1.14

Nyagadza, B. (2022, 9). Sustainable digital transformation for ambidextrous digital firms: systematic literature review, meta-analysis and agenda for future research directions. *Sustainable Technology and Entrepreneurship*, *1*, 100020. doi: 10.1016/J.STAE.2022.100020

Oberer, B., & Erkollar, A. (2018). Leadership 4.0: Digital leaders in the age of industry 4.0. *International journal of organizational leadership*.

Paavola, R., Hallikainen, P., Elbanna, A., & Holloway, R. (2017). Role of middle managers in modular digital transformation: The case of servu. , 887-903. Retrieved from http://aisel.aisnet.org/ecis2017_rphttp://aisel.aisnet.org/ecis2017_rp/58

Pagani, M., & Pardo, C. (2017, 11). The impact of digital technology on relationships in a business network. *Industrial Marketing Management*, *67*, 185-192. doi: 10.1016/J.INDMARMAN.2017.08.009

Pearce, C. L., Hoch, J. E., Jeppesen, H. J., & Wegge, J. (2010, 1). New forms of management. *Journal of Personnel Psychology*, *9*, 151-153. doi: 10.1027/1866-5888/a000022

Petrillo, A., Felice, F. D., Cioffi, R., & Zomparelli, F. (2018, 2). Fourth industrial revolution: Current practices, challenges, and opportunities. InTech. doi: 10.5772/intechopen.72304

Porter, & Heppelmann. (2015). How smart, connected products are transforming companies. *Harvard Business Review*, *93*, 96-114.

Prince, K., Barrett, M., & Oborn, E. (2014, 4). Dialogical strategies for orchestrating strategic innovation networks: The case of the internet of things. *Information and Organization*, *24*, 106-127. doi: 10.1016/J.INFOANDORG.2014.05.001

Raelin, J. D., & Cataldo, C. G. (2011, 12). Whither middle management? empowering interface and the failure of organizational change. *Journal of Change Management*, *11*, 481-507. doi: 10.1080/14697017.2011.630509

Reis, J., Amorim, M., Melão, N., & Matos, P. (2018). Digital transformation: A literature review and guidelines for future research. In (p. 411-421). doi: 10.1007/978-3-319-77703-0_41

Reynders, P., Kumar, M., & Found, P. (2022, 2). ' lean on me': an integrative literature review on the middle management role in lean. *Total Quality Management & Business Excellence*, *33*, 318-354. doi: 10.1080/14783363.2020.1842729

Rowe, W. G. (2001, 2). Creating wealth in organizations: The role of strategic leadership. *Academy of Management Perspectives*, *15*, 81-94. doi: 10.5465/ame.2001.4251395

Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., & Harnisch, M. (2015). *Industry 4.0: The future of productivity and growth in manufacturing industries.*

Saunders, M., & Lewis, P. (2017). *Doing research in business and management*. Pearson.

Sayer, K. (1998). Denying the technology: middle management resistance in business process re-engineering. *Journal of information technology*, *13*(4), 247–257.

Schallmo, D., Williams, C., & Bordman, L. (2017, 12). Digital transformation of business models — best practice, enablers, and roadmap. *International Journal of Innovation Management*, *21*, 1740014. doi: 10.1142/S136391961740014X

Schneider, P. (2018, 7). *Managerial challenges of industry 4.0: an empirically backed research agenda for a nascent field* (Vol. 12). doi: 10.1007/s11846-018-0283-2

Schwab, K. (2016). *The fourth industrial revolution*.

Schwarzmüller, T., Brosi, P., Duman, D., & Welpe, I. M. (2018). How does the digital transformation affect organizations? key themes of change in work design and leadership. *management revu*, *29*, 114-138. doi: 10.5771/0935-9915-2018-2-114

Schwertner, K. (2017). Digital transformation of business. *Trakia Journal of Science*, *15*, 388-393. doi: 10.15547/tjs.2017.s.01.065

Sekaran R., . B. U. (2019). Research methods for business: A skill building approach. *John wiley & sons.*.

Shamim, S., Cang, S., Yu, H., & Li, Y. (2016, 7). Management approaches for industry 4.0: A human resource management perspective. In *2016 ieee congress on evolutionary computation (cec)* (p. 5309-5316). IEEE. doi: 10.1109/CEC.2016.7748365

Staffen, S., & Schoenwald, L. (2016). Leading in the context of the industrial revolution: The key role of the leader 4.0. *Capgemini Group: Paris, France*.

Stentoft, J., & Rajkumar, C. (2020). The relevance of industry 4.0 and its relationship with moving manufacturing out, back and staying at home. *International Journal of Production Research*, *58*(10), 2953–2973.

Stoker, J. I. (2006, 9). Leading middle management: Consequences of organisational changes for tasks and behaviours of middle managers. *Journal of General Management*, *32*, 31-42. doi: 10.1177/030630700603200103

Tagscherer, F., & Carbon, C. C. (2023, 5). *Leadership for successful digitalization: A literature review on companies' internal and external aspects of digitalization* (Vol. 2). Elsevier B.V. doi: 10.1016/j.stae.2023.100039

Tallon, P. P., & Pinsonneault, A. (2011). Competing perspectives on the link between strategic information technology alignment and organizational agility: insights from a mediation model. *MIS quarterly*, 463–486.

Torres, D., Pimentel, C., & Matias, J. C. (2023, 4). Characterization of tasks and skills of workers, middle and top managers in the industry 4.0 context. *Sustainability (Switzerland)*, *15*. doi: 10.3390/su15086981

Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Dong, J. Q., Fabian, N., & Haenlein, M. (2021, 1). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research*, *122*, 889-901. doi: 10.1016/J.JBUSRES.2019.09.022

Vial, G. (2019, 6). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems*, *28*, 118-144. doi: 10.1016/J.JSIS.2019.01.003

Vrana, J., & Singh, R. (2021). Nde 4.0—a design thinking perspective. *Journal of nondestructive evaluation*, *40*(1), 8.

Vukšić, V. B., Ivančić, L., & Vugec, D. S. (2018). A preliminary literature review of digital transformation case studies. *International Journal of Computer and Information Engineering*, *12*(9), 737–742.

Warner, K. S., & Wäger, M. (2019). Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal. *Long range planning*, *52*(3), 326–349.

Wooldridge, B., Schmid, T., & Floyd, S. W. (2008). *The middle management perspective on strategy process: Contributions, synthesis, and future research* (Vol. 34). doi: 10.1177/0149206308324326

Wrede, M., Velamuri, V. K., & Dauth, T. (2020). Top managers in the digital age: Exploring the role and practices of top managers in firms' digital transformation. *Managerial and Decision Economics*, *41*(8), 1549–1567.

Zott, C., Amit, R., & Massa, L. (2011). The business model: recent developments and future research. *Journal of management*, *37*(4), 1019–1042.

7. Appendix

7.1. Interview Guide

Middle Managers

Introduction: Hi! Welcome, and thank you for joining this interview today. Our discussion will focus on your involvement in Industry 4.0 technologies in organisations, specifically from managerial perspectives. The study focuses on how middle managers can support the adoption of Industry 4.0 technology. I am particularly interested in learning about your experience in Industry 4.0 projects and uncovering organisational dynamics. This interview will take approximately 45 minutes. Please feel free to be as detailed as possible in your responses. Sharing specific stories or examples will be particularly helpful. There is no rush, so take your time to articulate your thoughts clearly.

Introduction Questions:

- Can you briefly describe your role and responsibilities in the organisation?
- How many people are in your team, and how many report directly to you?

Project Initiation for Industry 4.0 Projects:

1. Is your organization familiar with Industry 4.0 technologies? (such as ERP, MES, and IoT devices)
2. Can you provide a recent example of an Industry 4.0 project implemented in your organisation and which had a direct impact on shop floor activities?
   - What were the primary objectives of this project?
3. How did the implementation of this project begin? Was it part of a broader digital strategy/roadmap?
   - What is your role in this I4.0 project?
   - Who were the key stakeholders involved during the initial stages?

Identifying Improvement Projects within Industry 4.0:

4. How do you identify potential problems or opportunities for improvement before they become critical issues in operations, specifically in terms of digital projects? (Can you give examples)
   - What methods do you use to proactively identify potential problems or opportunities for improvement in your area of responsibility?
5. What kind of small-scale digital projects have you initiated on your own, and what motivated you to do so?
6. How do you convince the top managers to provide resources for implementing digital projects?

Interaction and Support from Top Managers:

7. Do you receive support from top management for your digital initiatives? Are there any specific strategies or guidelines provided to you?
8. Do you feel the support from top management impacts your ability to implement Industry 4.0/digital projects? (If yes how?)

Implementing Projects Driven by Top Managers:

9. Do you also implement digital projects that were initiated from top managers? (If yes, can you give examples?)
   - What was your role in implementing these projects?
   - How do you align operational level employees with such initiatives?
   - Have you faced any challenges in implementing such initiatives? (how have you addressed it?)
   - In what ways do you support the team in implementing these initiatives on the shop floor?

Mediators and Role in Change Management:

10. Do you see your role as that of a mediator between senior management and the operational level? If not, why?
    - What challenges have you faced in this mediator role?
    - How did you overcome these challenges?
11. Do you think you as a middle manager has to juggle between facilitating change and leading change within your team or department? (If yes what are the upsides and downsides of it?)

Leadership and Creating a Collaborative Environment:

12. Did you face any resistance to change within the organization, particularly from team managers and operational staff for adopting new technologies?
    - What strategies have been effective in gaining buy-in from the team and employees for adopting new digital technologies? (Can you share an example?)
13. Does your organization have a change management champion or team to ensure smooth transitions? (Do you think having change champions is important? Why?)
14. Do you think employees react differently if they are aware of digital changes from the start?
    - Is it necessary to keep local team managers and members informed about the digital roadmap of the company?
15. Was there any instance when an Industry 4.0 initiative failed?
    - If yes what were reasons behind it?
    - In your opinion what could have been done differently for making it successful?
    - Was there any instance or project where you did not see the value in implementing it on shopfloor,

but had to because of management direction? How did you handle the implementation? Was it successful?

Measuring Effectiveness of Adoption:

16. How do you measure the success of technology adoption projects in your team or department?
    - What adoption metrics or indicators do you use, particularly from a people perspective?
17. Balancing ongoing operations with the introduction of disruptive digital projects can be challenging. How do you manage the responsibilities of maintaining daily operations while also pushing forward with digital transformation initiatives? Can you provide specific strategies or examples of how you have handled this balance effectively?

Senior Managers

Introduction:

- Can you briefly describe your role and responsibilities in the organization? (be clear he is more into strategy)
- In what ways does your expertise contribute to the organization's digital transformation initiatives?
- How many people are on your team or report directly to you?

Project Initiation for Industry 4.0 Projects:

1. Is your organization familiar with Industry 4.0?
2. Can you give me an example of an Industry 4.0 project or digitalization project that was implemented in your organization, which had a direct impact on shopfloor activities?
    - What were the primary goals of this project?
3. How did the implementation of this project start? Was it part of a broader digital strategy?
    - Who were the key stakeholders involved in the initial stages?
4. After identifying the Industry 4.0 project, what is the next step? Who is responsible for the execution on the shop floor?

Middle Managers in the Organization:

5. What does middle management (particularly Operations Manager) mean to you in the context of your organization?
    - What are their main tasks and responsibilities?
    - Middle managers are people who implement strategy or new initiatives on the shop floor, they usually have titles like department heads and plant managers like operations heads.
6. How do you involve department heads or managers in the digital initiatives?
    - How are they usually involved in the discussions when introducing new systems or tools on the

shop floor? (What kind of discussion they are involved in?)

- Did their input influence the final decision? How?

7. What are your expectations from department heads while implementing digital initiatives on the floor? Does your team need to get buy-in from them? (What support do you give to middle managers?)
   - Do they face any challenges? As they also have to manage daily operational activities?
8. Do factory teams also come up with new ideas and problems which can be improved? Who do they contact?
9. Are department heads aware of the digital roadmap?

Deployment of Industry 4.0 Project:

10. Do you think middle managers have an influence on the operational level and employees that can help them embrace new technologies/tools? (If yes how?)
    - Can you provide examples of how their influence has facilitated or hindered the adoption process?

Leadership and Creating a Collaborative Environment:

11. Did you face any resistance to change within the organization, especially from middle managers and operational staff?
    - What strategies did you employ that have been effective in overcoming the resistance? How to get their buy-in?
12. How do you encourage employees to embrace the changes that new digital technologies bring to your organization?
13. Is it easy to sustain digital change within the organization? If not, what are the ways to sustain it?
14. Was there any instance when an Industry 4.0 initiative failed?
    - If yes, what were the reasons behind it?
    - In your opinion, what could have been done differently to make it successful?

Measuring Effectiveness of Adoption:

15. How would you measure the success of technology adoption projects in your team or department?
    - What adoption metrics or indicators do you use, particularly from a people perspective?

Consultants – Change Management and Business Management

Introduction:

- Can you describe your role and experience in consulting for implementing Industry 4.0 projects?

Project Initiation:

1. How do you typically get involved in a digital transformation project?
   - At what stage do you usually join the project?
2. Can you provide an example of a project where you helped an organization implement an I4.0 digital transformation project?

Interaction with Middle Managers

3. What is your understanding of middle managers? How would you describe their role in manufacturing organizations?
   - Middle managers are people who implement strategy or new initiatives on the shop floor, they usually have titles like department heads and plant managers like operations heads.
4. In your experience as an OCM consultant what is middle management's involvement in digital transformation projects?
   - Does the involvement of middle managers impact the implementation process? If yes how?
   - If there is no involvement, what is the reason? Should they be involved in such projects?
   - In what ways should organizations involve middle managers in the process? What (ideal) role should they play in the success of the digital project?
5. What difficulties do middle managers face when digital initiatives are being implemented on the shop floor? Can you provide an example? (As there is often a difference between projects on paper and executing them in reality)
6. In your opinion, what obstacles can arise when Industry 4.0 projects are implemented using a top-down approach? (How can vision be conveyed, and resources mobilized effectively?)
7. Currently, in manufacturing organizations, particularly on the shop floor, changes are incremental rather than radical. How should a head of the department approach this change?

Leadership and Collaboration

8. How do you try to extract the needs and concerns of operational staff during the change phase? Do you involve (their) managers in this phase?
   - Can you give an example of how these needs and concerns were addressed in the project?
9. What methods would you suggest to managers for creating a safe and collaborative environment within teams during a digital transition?

Change Management

10. What key change management practices do you use or recommend to organizations going through digital transitions? (incremental)
    - How do you approach each stage (creating awareness, desire, knowledge, ability, and reinforcement)?

- What methods do you use to create awareness about digital change?
- How can an organization sustain digital change? What practices have you implemented that ensured changes were integrated into the organisational culture?

11. Do you think change champions are necessary for digital transformation projects?
    - What role do these champions play in the success of a project?
12. How do you identify and work with change champions within an organization?

Training and Development

13. What training and development programs do you typically recommend for middle managers during the digital transition journey?
    - How do you assess the effectiveness of these programs?

Measuring Success and Impact

14. From your experience, do organizations have metrics in place to understand the adoption of new technologies?
    - What adoption metrics or indicators should organizations use, particularly from a people perspective rather than a process perspective?