Kaunas University of Technology

School of Economics and Business

Conceptual Model for Designing Synergetic Solutions Between Knowledge Management and Digital Transformation

Master's Final Degree Project

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Summary

This research project attempts to reveal the interplay dynamics between Knowledge Management (KM) and Digital Transformation (DT) and design solutions that would enable the synergistic value creation. DT involves levering various digital technologies, to fundamentally change how business operate, how, and what value they deliver to customer, while the goal of KM is to focus on the processes of creating, storing, sharing, and applying organizations collective knowledge, in order to make various organizational processes more efficient and help business reach its objectives. Integrating these processes, could open new avenues of value creation, speed up the DT implementation, increase the longevity of DT, its sustainability factors, while on the KM side, the use of DT technologies and concepts, could make all of the KM processes more efficient, reliable, which would in turn, make the knowledge workers of organizations more efficient, motivated and productive.

The aim of the research – to develop a conceptual model, enabling synergistic solutions of KM and DT interplay.

The object of the research – synergistic solutions of KM and DT interplay.

Research Objectives:

1. To justify the theoretical and practical premises for researching synergistic solutions in the interplay between Knowledge Management (KM) and Digital Transformation (DT).
2. Conduct a thorough literature review, focusing on separate elements of DT and KM, existing models and frameworks, as well as the synergy between KM and DT and propose a conceptual model of synergistic solutions of KM and DT interplay.
3. To develop the methodology for an empirical study.
4. To empirically validate the conceptual model of the synergistic solutions of KM and DT interplay, provide managerial recommendations for the model implementation and theoretical recommendations for future research directions.

Research methods:

A thorough literature review was conducted in order to better understand the current body of literature on the KM and DT interplay, identify the research gaps and develop a conceptual model that would show the various synergistic elements and foundations of KM and DT. Afterwards, the conceptual

model was empirically validated with a single-case study and a set of 21 semi-structured interviews in a global electronic component manufacturing company. The interview transcripts were coded with MAXQDA application, and coding results were interpreted in the context of the organization, conceptual model, and findings of the literature review.

Research findings:

The conceptual model was created based on the literature review of KM and DT as well as the available literature on their synergy, and covers the three required foundations of Organization, Technology, People & Culture, various risks and challenges that either affect both KM and DT equally, or are mode stronger in the context of their interplay, as well as possible synergistic solutions that can minimize or completely negate the identified risks. The conceptual model was empirically validated with a qualitative research approach and semi-structured interviews with 21 employees of a global, manufacturing company. With the help of the structured interviews, the elements of the conceptual model were ranked by their perceived importance and new elements were added, that were not found in the literature review. The updated conceptual model helps bridge the identified literature gaps, as well as provide a framework of KM and DT integration for practice.

Šarūnas Savickas. Sinerginių sprendimų tarp žinių valdymo ir skaitmeninės transformacijos formavimo modelis. Magistro baigiamasis projektas / vadovė Doc. Dr. Lina Užienė; Kauno technologijos universitetas, Ekonomikos ir Verslo fakultetas.

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Reikšminiai žodžiai: žinių valdymas, skaitmeninė transformacija, pramonė 4.0, sinergija

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Santrauka

Šiuo tyrimu bandoma atskleisti žinių valdymo (ŽV) ir skaitmeninės transformacijos (ST) sąveikos dinamiką ir sukurti sinerginių sprendimų formavimo modelį. ST apima įvairių skaitmeninių technologijų panaudojimą, siekiant iš esmės pakeisti tai, kaip verslas veikia, kaip ir kokią vertę jis kuria klientui, o ŽV tikslas yra sutelkti dėmesį į organizacijų kolektyvinių žinių kūrimo, saugojimo, dalijimosi ir taikymo procesus, siekiant efektyvinti įvairius organizacinius procesus ir padėti verslui pasiekti užsibrėžtų tikslų. Šių procesų integravimas galėtų atverti naujus vertės kūrimo kelius, paspartinti ST įgyvendinimą, padidinti ST ilgaamžiškumą, tvarumą, o iš ŽV pusės, ST technologijų panaudojimas galėtų paversti visus ŽV procesus efektyvesniais bei patikimesniais, o tai savo ruožtu paverstų organizacijų žinių darbuotojus veiksmingesnius, labiau motyvuotus ir produktyvesnius.

Tyrimo tikslas – argumentuoti konceptualų ŽV ir ST sąveikos modelį įgalinantį priimti sinerginius sprendimus

Tyrimo objektas – ŽV ir ST sąveikos sinerginiai sprendimai.

Tyrimo tikslai:

1. Pagrįsti teorines ir praktines prielaidas tirti sinerginius sprendimus ŽV ir ST sąveikoje.

2. Atlikti išsamią literatūros analizę, sutelkiant dėmesį į atskirus ST ir ŽV elementus, esamus modelius ir sistemas, taip pat ŽV ir ST sinergiją, bei pasiūlyti konceptualų ŽV ir ST sąveikos, sinerginių sprendimų modelį.

3. Parengti empirinio tyrimo metodologiją.

4. Empiriškai argumentuoti konceptualų modelį, atliekant pusiau struktūruotus interviu, bei pateikti vadybines rekomendacijas modelio įgyvendinimui ir teorines rekomendacijas galimų tolimesnių tyrimų kryptims.

Tyrimo metodai:

Tyrimo metu, buvo atlikta išsami literatūros apžvalga, siekiant geriau suprasti dabartinę literatūrą apie ŽV ir ST sąveiką, nustatyti tyrimo spragas ir sukurti konceptualų modelį, kuris parodytų įvairius ŽV ir ST sinerginius elementus ir pagrindus. Vėliau konceptualus modelis buvo empiriškai patvirtintas atliekant vieno atvejo tyrimą ir 21, pusiau struktūrizuotą interviu, pasaulinėje elektroninių

komponentų gamybos įmonėje. Interviu stenogramos buvo užkoduotos MAXQDA programa, o kodavimo rezultatai interpretuoti organizacijos, konceptualaus modelio ir literatūros apžvalgos išvadų kontekste.

Tyrimo išvados:

Konceptualus modelis buvo sukurtas remiantis ŽV ir ST literatūros apžvalga bei jau randama literatūra apie jų sinergiją ir apima tris būtinus organizacijos, technologijų, žmonių ir kultūros pagrindus, įvairias rizikas ir iššūkius, kurie turi įtakos ir ŽV, ir ST arba yra stipresni jų sąveikos kontekste, taip pat galimi sinerginiai sprendimai, galintys sumažinti arba visiškai paneigti nustatytas rizikas. Konceptualus modelis buvo empiriškai argumentuotas taikant kokybinio tyrimo metodiką ir pusiau struktūruotus interviu su 21 pasaulinės elektronikos gamybos įmonės darbuotoju. Struktūrizuotų interviu pagalba konceptualaus modelio elementai buvo surikiuoti pagal interviu respondentų suvokiamą svarbą ir pridedami nauji, literatūros apžvalgoje neaptikti elementai. Atnaujintas konceptualus modelis padeda užpildyti nustatytas literatūros spragas, taip pat suteikia ŽV ir ST integravimo praktikoje modelį.

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List of Abbreviations

Abbreviations:

AI – Artificial intelligence

AR – Augmented reality

BOK – Body of Knowledge

DT – Digital Transformation

I4.0 – Industry 4.0

I5.0 – Industry 5.0

IoT – Internet of Things

KBDC – Knowledge-Based Dynamic Capabilities

KIBS - Knowledge-Intensive Business Services

KM – Knowledge Management

KMS – Knowledge Management Systems

M&A – Mergers & Acquisitions

ML – machine learning

OL – Organizational Learning

PLM – Product Lifecycle Management

SME – Small and Medium-sized Enterprises

VR – Virtual Reality

List of Publications

Savickas, Š., Užienė, L., (2024) Žinių valdymo ir skaitmeninės transformacijos tarpusavio sąveikos: vertę kuriančių sprendimų projektavimas – Lietuvos Mokslo Taryba, Studentų mokslinė konferencija, Vilnius, Lithuania.

Užienė, L., Savickas, Š. (2024) The interplay between knowledge management and digital transformation: Issues that matter – IFKAD2024, Translating Knowledge into Innovation Dynamics, 12-14 June 2024, Madrid, Spain (accepted for publication).

Užienė, L., Savickas, Š. (2024) Interplay between knowledge management and digital transformation: designing solutions – ECKM, 25th European Conference on Knowledge Management, 5-6 September 2024, Veszprém, Hungary (submitted for review).

Introduction

Research relevance:

In an era marked by rapid technological advancements and evolving market dynamics, the interplay between Knowledge Management (KM) and Digital Transformation (DT) becomes a pivotal area of study and organizational priorities. DT, by itself, continues to be a critical focus area for organizations, industries and both local and international governmental bodies. Surveys by Deloitte (2023), Gartner (2023) and McKinsey (2023) highlight that investment into DT is driven by not only the organizational need to optimize it costs and value structure, but also by the need to adapt to crises and uncertainties, noting a significant increase in DT activities since the COVID-19 pandemic. On a governmental body level, development, deployment and application of technology and new, innovative solutions, is one of the foundational principles of Lithuania's vision for the future ("Lithuania's vision for the future 'Lithuania 2050'", 2023), which should guide the overall strategy and vision of the country, and make sure that the implementation of these innovations and technologies does not only cover the digital transformation of the businesses, but also addresses the societal challenges caused by it. Similar guiding principles are discussed in the vision of digital Europe, ("Europe 2030: A Digital Powerhouse", 2023), where DT is seen as one of the key foundations that would help create a more competitive, sustainable, resilient, and digitized Europe. Furthermore, these paradigms and vision are closely connected to the shift towards Industry 5.0, where the use of technology shifts focus from efficiency and value optimization, to more environmentally sustainable, human centric and resilient uses.

This renewed focus towards sustainability and human centricity of DT, as well as highly volatile environments, creates an urgency to adapt to new digital paradigms and prompts organizations to reevaluate and redesign their operational frameworks. In this context, KM emerges as a way to support the redesign of the operational frameworks, implementation of sustainable technologies, and serves as a foundational element towards the shift to the human centric use of technology, by enabling the Organizational Learning (OL), upskilling and reskilling initiatives (Lovrenčić, 2023), which in turn enhances the competitive advantage of businesses in a sustainable, long-term and people focused, manner (Anshari & Hamdan, 2022). KM focuses on optimizing the creation, sharing, and utilization of organizational knowledge, which creates a knowledge friendly and entrepreneurial culture of knowledge sharing, continuous learning, and is critical in maximizing the benefits of digital technologies. Studies by APQC (2024), Starmind (2022) and Gartner (2023) show that a significant portion of knowledge workers face challenges in information sharing due to disjointed tools and platforms, leading to inefficiencies and decision-making based on assumptions, but at the same time, the knowledge workers remain optimistic, as investments into KM capabilities are increasing, prioritizing AI integration, knowledge transfer activities and employee engagement. Standardized KM processes and systems, enabled by the technologies provided by DT, are crucial, especially in remote or hybrid work environments.

Continued investments in KM and DT can synergistically address challenges, support sustainable value creation, and prepare organizations for Industry 5.0's human-centric paradigms. Understanding their interaction and developing solutions from this interplay is essential for achieving long-term, sustainable organizational value. Integrating KM and DT unlocks new pathways for value creation, streamlines DT implementation, and enhances the sustainability and resilience of business operations. Therefore, there is a need for an integrated framework that blends KM and DT processes and

concepts, leverages their synergies, and addresses gaps in the current literature, which often treats KM and DT in isolation.

Research problem analysis:

This research project attempts to reveal the interplay dynamics between KM and DT, and design solutions that would enable the synergistic value creation. DT involves levering various digital technologies, to fundamentally change how business operate, how, and what value they deliver to customer, while the goal of KM is to focus on the processes of creating, storing, sharing, and applying organizations collective knowledge, in order to make various organizational processes more efficient and help business reach its objectives. Integrating these processes, could open new avenues of value creation, speed up the DT implementation, increase the longevity of DT, its sustainability factors, while on the KM side, the use of DT technologies and concepts, could make all of the KM processes more efficient, reliable, which would in turn, make the knowledge workers of organizations more efficient, motivated and productive.

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3. To develop the methodology for an empirical study.
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Thesis methodology and structure:

Chapter 1 provides a problem analysis of the KM and DT synergy based on a variety of academic and practical research, which indicates the need for a more in depth study of the synergistic solutions of KM and DT. Chapter 2 reviews the theoretical foundations of DT, its various definitions and scope, provides an overview of the technologies most used in the context of DT and I4.0, the risks, challenges, Critical Success Factors, and models and frameworks, associated with DT. A similar overview of the concepts of KM is also provided, with separate chapters reviewing the KMS and various knowledge management processes, models and frameworks. Then, the available literature focusing on the interplay of KM and DT is reviewed to provide an understanding of the current

literature and identify the gaps that should be covered with this research. Two major gaps were identified in the literature – lack of cross functional collaboration and lack of integrated, multi-faceted KM and DT interplay frameworks. A conceptual model of DT and KM interplay is created as the final output of Chapter 2, that is based on the problem analysis, literature review and identified gaps. The model covers the interplay between KM and DT, core foundations needed to facilitate it, common risks, challenges and possible synergistic solutions needed to minimize the risks. The thesis is based on a qualitative research methodology – chapter 3 describes the methodology and sampling strategy. In order to validate the conceptual model, a total of 21 semi-structured interviews, were conducted with employees directly involved with DT and KM processes of a global manufacturing corporation. The interview transcripts were then coded and grouped using MAXQDA application. Chapter 4 analyzes the findings of the semi-structured interviews by using the elements of the conceptual model, validates each one of them, then expands and updates the conceptual model with the finding from the empirical research. A set of theoretical and managerial implications as well as limitations and avenues for future research are identified.

1. Problem Analysis of Knowledge Management and Digital Transformation Interplay

In the current age of transition from technology and efficiency driven Industry 4.0, to a more sustainable and human centric Industry 5.0, (Mourtzis, Angelopoulos, & Panopoulos, 2022), marked by significant advances in various digital technologies, as a part of Digital Transformation (DT), Knowledge Management (KM), becomes and integral factor and enabler of the transition (Lovrenčić, 2023).

The European Commission (2021) identifies three major dimensions, where the Industry 4.0 paradigms need to transform, in order to achieve the sustainability and human centricity goals. First of all, the industrial digital transformation needs to follow and embrace circular economy principles across the supply and value chains, this needs to be combined with the environmental sustainability dimension, that would focus on environmentally responsible usage of technology, efficient and renewable energy usage. The third, social dimension, encourages companies to empower the employees, and instead of substituting their skills with technology, compliment them and their competencies, and reach a more sustainable human-machine interaction, with a human-centric approach.

This human-centricity is the dimension that is directly related to both KM and DT initiatives – with the use of technology, the Industry 5.0 workplace needs to become more diverse and secure, empower the employees with opportunities to upskill and reskill when needed (Lovrenčić, 2023). According to Saniuk and Grabowska (2023), there are multiple areas of skills and knowledge that needs to be developed in order to implement these Industry 5.0 dimensions. First of all, digital transformation related competencies and skills are required, in order to increase the overall performance and efficiency of organizational processes, also, organizations need to attract, hire and retain highly skilled employees that would be open to the DT environment of constant change, be willing and able to share their knowledge and work effectively in teams. The upskilling, reskilling, or Organizational Learning (OL) initiatives need to cover and integrate the technological and management learning areas, with a focus on skills and competencies of entrepreneurship, strategy, change management and leadership, collaboration and networking. The new learning initiatives needs to be accompanied by the promotion of a culture supportive of innovation, new talent management and ways of learning, which would create an environment of lifelong learning as well. And lastly, the future engineers will need to be able to combine their technical competencies, together with various social, methodological, and personal competencies.

KM, through the usage of new technologies supporting and triggering DT, can enable the processes of knowledge creation and acquisition, which are essential for the innovation cycle, to support organizations with creating and implementing new, sustainable technologies, business models and plays a central role in the OL, upskilling and reskilling initiatives as well (Lovrenčić, 2023). Therefore, researching and understanding both practical and theoretical implications and possibilities emerging from the synergy of DT and KM, is critical in the current ever-changing and evolving environment.

According to Digital Maturity Index Survey, conducted by Deloitte in 2023, this ever-changing, uncertain environment, is also one of the reasons for continued investment into DT activities – almost 30% out of about 800 C-level and business unit head level executives, said that the various crises, are the triggers for their increased investment into digitalization and even increases the rate of DT by

about 10%. Furthermore, in 2023, 98% of the surveyed companies indicated that they already started their digital transformation, where in 2019 the same was indicated by 78% of the surveyed companies, and according to the report, this increase can be attributed to the challenges and transformation triggers caused by the COVID-19 pandemic.

A similar survey, of CIO and technology executives by Gartner ("Digital Transformation Insights in Manufacturing | Gartner", 2023), in 2023, has shown that Digital Transformation remains one of the top 3 enterprise priorities, with 16% of respondents choosing it as a priority, next to Growth and Cost Optimization and Efficiency, both with 22% of respondents choosing them. Another similar survey conducted by McKinsey on organizational transformations ("How to Gain and Sustain a Competitive Edge Through Transformation," 2023), shows a slightly different view of DT, and indicates that 20% of financial benefit is lost during transformation goal setting phase, 25% - during planning, the biggest portion of value is lost during execution of the transformation – 37%, and another 19% is lost after the execution. A different McKinsey study ("How to Implement Transformations for Long-term Impact," 2023), expands upon this, stating that even though about 57% respondents are achieving most or all transformation goals, only 12% sustain those goals for more than 3 years.

According to a study conducted by KPMG in 2023 ("KPMG Survey: Majority of US Businesses Say They Have Not Seen an Increase in Performance or Profitability From Digital Transformation Investments," 2023), about 51% of digital transformation initiatives, in US companies with revenue of over $100 million, did not increase performance or profitability of the organization over the last two years, though at the same time, the survey reports that investment into emerging technologies, that have significant disruptive power, has tripled from 10% in year 2022 to 32% in 2023.

These surveys, from reputable business consultancies, show that DT is currently a major focus area for organizations, the investments into transformational technologies are just increasing, with a sizeable cause of that being triggered by various uncertainties, changes and crises, both global and industry level. Though the main identified challenge – is sustaining long term results that can be achieved during the implementation.

Academic literature expands upon these challenges - Mielli & Bulanda (2019) identified main roadblocks for successful long term digital transformation – lack of holistic approach, lack of understanding digitization, too technology-focused, no clear business case, wrong partnerships, wrong skills, customized applications, no plans for scale, legacy infrastructure. These roadblocks can be connected to the data seen in the surveys – due to wrong business partnerships, legacy and custom-built applications, the value will be lost during implementation because of higher technology integration costs, elevated risk of possible rework. While lack of understanding of what digital transformation is, as well as looking at it as a standalone strategy, might lead to choosing incorrect projects or technologies, loosing prioritization and funding in the later stages of the transformation projects as well (Mielli & Bulanda, 2019).

KM can support DT initiatives and help sustain their long-term impact, by first creating a knowledge friendly culture and agile organization, that addresses the Industry 5.0 needs for employee empowerment and upskilling, which in turn helps with identifying and retaining critical organizational knowledge, reduction of resource waste, implementation time and cost of DT projects (Gupta, Kr Singh, Kamble, & Mishra, 2022). These KM supported reductions of resource waste, cost and timelines, can reduce the identified value losses in different stages of DT, support the long-term

goals, as well as create an enabling environment needed for DT. However, KM processes and initiatives face a common set of challenges, especially in relation to the current global and industry situations, that can be addressed with the support of DT, and by integrating these continuous organizational processes, generate more sustainable business value.

A study commissioned by Starmind and done by Forrester in 2022, on the demands of modern workplace, found that 36% of 301 knowledge workers believe, that one of the main challenges with knowledge sharing in their organization, is too many tools and platforms used by different teams, which makes it hard to share information across the organization. This is a clear challenge of standardized processes and knowledge storage technologies, that creates a lot of unnecessary waste for the knowledge workers, and slows them down from creating business value.

Same Starmind and Forrester study found that 47% of knowledge workers thinks that required information is scattered across too many sources, and 63% say that they are spending too much time finding the right solutions to a problem. Out of this, 45% specifically stated, that they are spending too much time, looking for up-to-date information, and 39% of knowledge workers are spending too much time looking for specific people that have the required knowledge – knowledge silos. Because of this, 29% of employees said that they make decisions based on assumptions and their guesses. This does not only create waste, but is can also create potentially costly problems ("Knowledge Silos Cost Organizations Time and Resources", 2022). Comparable results can be seen in the Digital Worker Experience Survey, conducted in 2022 by Gartner, who surveyed 4861 respondents. The survey found that about 47% of digital workers are struggling to find information or knowledge that they need to do their jobs efficiently, furthermore, 32% made the wrong decisions because of the lack of information, 45% got irrelevant, distracting notifications, and 36% of the respondents attributed missed important updates or knowledge, to the high number of applications used or volume of information generated by them ("What Workers Want: Top 10 Insights From the Digital Worker Experience Survey", 2023). The standardized processes, knowledge repositories and availability of information becomes even more critical in the context of the shifts towards remote or hybrid work.

Matikainen, Kianto, & Olander (2023), in their qualitative study of higher education field of Finland also identified a set of key knowledge-related tensions, that occurred during the COVID-19 pandemic, in the context of remote work. The increase of explicit communication causes the risk of high information volume, which has a high impact on the productivity of workers as found in the Gartner research, but also helps with codifying a lot of tacit, implicit knowledge. Virtual meetings and collaboration tools can eliminate some of the usual barriers to knowledge sharing, but the isolation of remote work can also create knowledge silos, that makes the knowledge sharing across departments, teams or even individuals, much more complex, which in turn, has implication on the knowledge creation activities of the organization as well, as informal, innovative conversations cannot happen as easily.

A much more in-depth view, of the new KM dynamics, is provided in the survey of 226 global KM experts, conducted by APQC in 2024. As a more general finding, the study shows that while only 7% of the surveyed professionals, believes that KM in their organization is thriving, 56% believes their KM initiatives are making progress, and another 21% defines them being in a steady state. This creates an optimistic overview of the KM environment, especially as only 16% define their KM state as either declining or being in a freefall. KM, similarly to DT, in the surveyed organizations, remains

a critical investment area as well – only 4% of the respondents believed that the investments will decrease, while 28% expects it to remain stable and the remaining 68% believes that the investment in KM capabilities and projects will increase in the next 12 to 18 months. To 30% of the respondents, identifying and mapping critical knowledge is a top KM priority, while integration of AI and other related technologies, is now a priority to 27% of the respondents. Transferring of expert knowledge and increasing overall employee engagement with KM is a priority for 25% and 23% of the respondents respectively. This indicates that the changing workplace environment, together with the new enabling technologies, also changes the priorities of KM professionals, and gathering the knowledge from employees, enabling knowledge sharing and transfer processes, especially with the help of newest technologies, such as AI, is a key strategic objective, in order for KM to help generate the sustainable value and organizational resiliency. The survey also identifies key business priorities, that KM initiatives should focus on, and even though only 22% respondents specifically identified DT as the key area where KM should focus its impact, the biggest number of respondents, over 42% identified operational efficiency and process improvement as the main focus area of KM, which is also one of the objective areas for DT initiatives as well. The respondents of this survey, also agrees with the results of the previous ones, and 38% of the respondents find that the biggest challenge for KM, are the disjointed knowledge repositories, 36% believe that knowledge loss and employee attrition rates makes it critical to improve the knowledge sharing processes, 34% specifically name AI as the biggest opportunity for KM processes to scale and crate more value, 30% identify knowledge gaps and silos as the key risk, while 28% sees KM as the critical organizational capability, for employee upskilling and reskilling, which is, as already seen from DT related studies and literature, also a critical enabler and requirement for the transition to Industry 5.0.

The dimension of ever-evolving technologies creates more challenges – organizations need to accelerate the already complex process of DT, build flexibility into their business models and organizational structures, focus on human resource up-skilling and cross-training, implement agile approaches for continuous testing, learning and scaling (Gaurav & Kongar, 2021).

Based on the research and surveys, success of DT is a highly personalized measure, Barthel (2021), based on a literature review, categorized it into four main clusters:

- Overall company value and performance – includes the more traditional measurement dimensions, such as company value, sales performance, reputation, etc.
- Digital business performance – which consists of dimensions and measures of digital business success.
- Degree of realized external transformation – tries to measure digital products, business model innovation, transformation of customer interactions and partner network.
- Degree of realized internal transformation – measure success of internal DT activities of the organization, with the key ones being – strategy, structure, culture and leadership, competencies and knowledge.

One of the more widely accepted KM success measurement models by Jennex, Smolnik, & Croasdell (2014), divides it into four dimensions as well:

- Impact on business processes – measures in this dimension cover increased efficiency, reduced cost, positive ROI, improved decision making, effectiveness and resource allocation
- Impact on KM strategy – consists of changes or creation of KM goals, metrics, organizational incentives for knowledge management, knowledge capture, etc.

- Leadership/management support – increased support, both financial and political, awareness and use of KM.
- Knowledge content – changes in knowledge content, quality, increased demand, creation and identification of knowledge resources.

This helps further identify the synergies between KM and DT – both have a variety of complex success measurement frameworks, that cover more than one dimension. Both concepts also have interconnected success dimensions – literature and practice talk about the need of measuring the success not only in the traditional metrics of increased performance or efficiencies, but also changes in various culture, strategy and even leadership dimensions. The continued investments into KM and DT can create opportunities to synergistically address the challenges and opportunities created by the new working environment, constant change and various crises, as well as prepare the needed foundations for a more resilient organization, more sustainable, long term, value creation and the human-centricity paradigms of Industry 5.0. Therefore, it is beneficial to research how concepts and initiatives of KM and DT interact, what risks or solutions emerge from their interplay, how those can be advanced to create the long-term, sustainable and human-centric value.

2. Theoretical Presumptions for Digital Transformation and Knowledge Management Synergy

2.1. Digital Transformation Theoretical Foundations

This chapter will delve into the theoretical foundations of DT, reviewing its definitions, various technologies that trigger and support the transformation process, and lastly, it will explore two frameworks and models of DT, that are documented in the literature.

2.1.1. Digital Transformation Definition and Scope

DT is a broad and complex subject, with multiple different definitions and adjacent terms, such as "digitalization" or "digitization", and a standardized definition is critical, in order to advance the research further, and provide clear guidance for organizational leaders (Gong & Ribiere, 2021).

Table 1. Definitions of DT

Author, year	Research type	DT Definition
Schallmo, Williams, & Boardman, 2017	Literature review	"The DT framework includes the networking of actors, such as businesses and customers, across all value-added chain segments and the application of new technologies. <…> In order to increase the performance and reach of a company, DT involves companies, business models, processes, relationships, products, etc."
Reis, Amorim, Melão, & Matos, 2018	Literature review	"<…> we define Digital Transformation as the use of new digital technologies that enables major business improvements and influences all aspects of customers' life."
Vial, G., 2019	Literature review	"<…> a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies."
Gong & Ribiere, 2021	Literature review with survey	"A fundamental change process, enabled by the innovative use of digital technologies accompanied by the strategic leverage of key resources and capabilities, aiming to radically improve an entity and redefine its value proposition for its stakeholders."
Ahlskog, Badasjane, Granlund, Bruch, & Sauter, 2022	Case study	"In short can digital transformation be viewed as an organizational change enabled by usage of digital technologies and in this transformation, value is created for different stakeholders. Digital transformation implies cyclic development and change with the goal to create competitive advantages without an end goal for this journey."

Table 1 shows a selected list of DT definitions and according to Vial (2019), a good definition should have four major components – target, scope, means and expected outcome.

Target of the definitions vary from specifically talking about a business or organization (Schallmo, Williams, & Boardman, 2017; Reis, Amorim, Melão, & Matos, 2018; Ahlskog, Badasjane, Granlund, Bruch, & Sauter, 2022), to being much more vague, implying that DT can be differently understood and on multiple different levels of an organization (Vial, G., 2019; Gong & Ribiere, 2021).

Scope of the definitions is wide in all of them – "across value chain <…> DT involves companies, business models, processes, relationships, products, etc." (Schallmo, Williams, & Boardman, 2017), "<…> influences all aspects of customers' life" (Reis, Amorim, Melão, & Matos, 2018), <…> properties <…>" (Vial, G., 2019), "<…> redefine its value proposition for its stakeholders" (Gong & Ribiere, 2021), " <…>organizational change <…>" (Ahlskog, Badasjane, Granlund, Bruch, & Sauter, 2022).

Third, is the means of the change, which all the definitions very clearly identify as digital technologies, which emphasizes the critical role that technology plays in this process as a trigger, enabler and support.

And lastly, it's the expected outcome or overall goal of the transformation, and in the definitions, we can see that Vial (2019) is defining the goal as a very vague "improvement", while others are focusing on efficiency and customer value improvements – "<…> increase the performance and reach of a company <…>" (Schallmo, Williams, & Boardman, 2017), "<…> major business improvements and influences all aspects of customers' life." (Reis, Amorim, Melão, & Matos, 2018), "<…> radically improve an entity and redefine its value proposition for its stakeholders." (Gong & Ribiere, 2021), "<…> value is created for different stakeholders. <…> with the goal to create competitive advantages <…>" (Ahlskog, Badasjane, Granlund, Bruch, & Sauter, 2022). The latest selected definition, by Ahlskog, Badasjane, Granlund, Bruch, & Sauter (2022), also emphasizes that digital transformation process is more of a cyclical process, without an end goal.

From the definitions alone, it is possible to extract key elements of digital transformation, that all of the authors agree on – it is a radical, continuous change, on any and all levels of an organization, that is triggered and supported by digital technologies, with the goal of creating new efficiencies, customer and stakeholder value, across the whole value chain.

The organizational change mentioned in the definitions, covers more than just its processes, but also can, and should, affect the overall structure of the organization. Though not explicitly mentioned in the definition, Vial (2019), breaks these structural changes into four categories:

- Organizational structure – it covers cross-functional collaboration, agility and ambidexterity.
- Organizational culture – agile development practices, innovative culture, "failing fast", are few of the cultural criteria required to increase the value generation in the context of DT.
- Leadership – leaders are responsible for developing a DT mindset within the organization and should be able to respond to the disruptions caused by it.
- Employee roles and skills – changes to the structure, culture and technology, also changes the way employees work – they often assume non-traditional roles, require upskilling or reskilling, in order to be successful in the new environment.

2.1.2. Digital Technology Overview

As already proven by the prevalence of digital technology in DT definitions, their importance requires a separate review of most common technologies that trigger, enable and support DT of organizations. Sauter, Bruch, Badasjane, Granlund, & Ahlskog (2024) states that the terms DT, digitization, digitalization and Industry 4.0 (I4.0) are often used interchangeably, as there are a lot of variability in both literature and practice, on the scope of these terms, but as already discussed, DT refers to a

change enabled by digital technology to create value and competitive advantage, the end goal and means of I4.0 is exactly the same – create competitive advantage through digital technologies, but the scope of it is focused on the manufacturing industry. Therefore, as I4.0 definition reflects the DT definitions in its goal, means and results, but with a more limited scope, technologies that enable I4.0 can be considered as the enablers for overall DT as well.

Table 2. Digital technologies used in DT and I4.0

Author, year	Technologies identified
Lu, 2017	Mobile computing, cloud computing, big data, IoT
Frank, Dalenogare, & Ayala, 2019	Internet of Things, Cloud, Big Data, Analytics
Bai, Dallasega, Orzes, & Sarkis, 2020	3D printing, AR, VR, Cloud computing, cloud manufacturing, IoT, blockchain, digital twin
Abdallah, Shehab, & Al-Ashaab, 2021	AI and ML, IoT, Cyber Security, Cloud computing, big data analytics, digital twin, robotic automation, enterprise resource planning ERP
Ghobakhloo et al., 2023	Additive manufacturing, networking and communication technologies, embedded system, enterprise systems, internet of everything, industrial control systems, Machine learning and cognitive computing, distributed ledger (blockchain), Smart Product Lifecycle Management (SPLM), Cloud and edge computing, big data analytics
Zhong & Ren, 2023	Artificial intelligence technology, blockchain technology, cloud computing technology, big data technology, digital technology applications

Table 2 shows a selected list of DT and I4.0 enabling technologies, that are researched in literature in various contexts. From this list, Ghobakhloo et al. (2023), stands out as one research that focuses on two sets of technologies – facilitating, that were commercialized during I4.0 and are related to the research done by other selected authors, and emerging technologies, such as Cognitive Cyber-Physical Systems, Intelligent or Adaptive Robots or Intelligent Energy Management systems. Most of these emergent technologies, build upon the facilitating ones, and should be more thoroughly reviewed in the future, but for the purpose of this research, the focus stays with the facilitating technologies only.

The most commonly mentioned technologies are:

- 3D printing or additive manufacturing – technology that allows to innovate and iterate 3D object designs quickly, by creating 3D solid objects via a layering method (Bai, Dallasega, Orzes, & Sarkis, 2020).
- Artificial intelligence (AI) and machine learning (ML) – compliments all other systems, can enable more advanced and efficient planning and autonomous optimization, equipment predictive maintenance or identify patterns for digital businesses (Frank, Dalenogare, & Ayala, 2019).
- Augmented (AR) and virtual reality (VR) – AR and VR can be analyzed under a single term, and emerging technology, of Extended Reality – it can improve employee training, help facilitate real time events, such as industrial fault diagnostics, with teams from different regions and functions (Ghobakhloo et al., 2023)

- Big Data and Analytics – used to store and process large volumes of data, usually complimented with data r process mining (Bai, Dallasega, Orzes, & Sarkis, 2020), in some cases, more intelligent analytic approaches, such as ML, are also grouped under this category.
- Blockchain or distributed ledger – a distributed database of a list of records that grow continuously and are dependent on a network-wide authentication and encryption algorithms (Bai, Dallasega, Orzes, & Sarkis, 2020)
- Cloud computing – cloud technologies are usually one of the first ones to implement and can enable other technologies as well (Frank, Dalenogare, & Ayala, 2019), and can refer to any system that is provisioned and accessed in a cloud environment (Bai, Dallasega, Orzes, & Sarkis, 2020)
- Internet of Things (IoT) – aims to provide technology and processes for communication of all the assets and systems within manufacturing (Frank, Dalenogare, & Ayala, 2019).

All of these technologies, both create a disruption that requires organizations to response, and are used to alter their value creation processes (Vial, 2019).

2.1.3. Digital Transformation Risks and Challenges

When analyzing majority model of leveraging DT in manufacturing, Sjödin, Parida, Leksell, & Petrovic (2018) categorized the identified challenges into three main categories – People, Technology and Process. This categorization covers more than just the technological aspect of transformation, but also the structural changes and dimension mentioned earlier and identified by Vial (2019). Similar categorization was done by Schnasse, Menzefricke, & Dumitrescu (2021), where the authors divided the risks into technology, human and organization, a similar categorization will be used, as it more closely relates to the research done by Vial (2019), with an added element of an external category – environment, to help better summarize internal and external influences on the organization.
Further division into sub-categories is based on empirical findings of Sauter, Bruch, Badasjane, Granlund, & Ahlskog (2024), then expanded with risks and challenges identified by other authors. Table 3 shows the summary of selected DT risks and challenges.

Table 3. DT risks and challenges

Category	Sub-category	Risks and Challenges	References
People	Skills and knowledge gap	Wrong or no skills; lack of understanding of DT; shortage of specialists;	Mielli & Bulanda (2019); Sauter, Bruch, Badasjane, Granlund, & Ahlskog (2024); Schnasse, Menzefricke, & Dumitrescu (2021); Oludapo, Carroll, & Helfert (2024); Brink, Packmohr, & Paul (2022)
	Culture	Cultural differences; lack of entrepreneurial culture;	Sauter, Bruch, Badasjane, Granlund, & Ahlskog (2024); Abdallah, Shehab, & Al-Ashaab (2021); Brink, Packmohr, & Paul (2022)

Technology	Infrastructure	Difficult integration of legacy systems and infrastructure; Too many custom in-house applications; local deviations in applications;	Abdallah, Shehab, & Al-Ashaab (2021); Mielli & Bulanda (2019); Sauter, Bruch, Badasjane, Granlund, & Ahlskog (2024); Brink, Packmohr, & Paul (2022)
	Cyber Security	Lack of security awareness;	Schnasse, Menzefricke, & Dumitrescu (2021); Oludapo, Carroll, & Helfert (2024); Abdallah, Shehab, & Al-Ashaab (2021); Brink, Packmohr, & Paul (2022)
	Resources	High up-front cost; Lack of financial incentives to change; Lack of clear ROI and metrics; Bad investments;	Sjödin, Parida, Leksell, & Petrovic (2018); Abdallah, Shehab, & Al-Ashaab (2021); Mielli & Bulanda (2019); Oludapo, Carroll, & Helfert (2024)
	Technological maturity	Poor data quality; fragile systems;	Schnasse, Menzefricke, & Dumitrescu (2021)
Organization	Change Management	Difficult to change traditional routines; Supply chain resistance to change; Lack of Change Management;	Sjödin, Parida, Leksell, & Petrovic (2018); Abdallahbu, Shehab, & Al-Ashaab (2021); Oludapo, Carroll, & Helfert (2024); Brink, Packmohr, & Paul (2022)
	Structure	Inefficient organizational structure; lack of cross functional teams;	Abdallah, Shehab, & Al-Ashaab (2021); Oludapo, Carroll, & Helfert (2024)
	Strategy & Leadership	Lack of DT strategy; DT strategy not integrated with overall organization strategy; No plan for scale; Lack of common vision; lack of coordination;	Abdallah, Shehab, & Al-Ashaab (2021); Mielli & Bulanda (2019); Sjödin, Parida, Leksell, & Petrovic (2018); Schnasse, Menzefricke, & Dumitrescu (2021); Oludapo, Carroll, & Helfert (2024); Brink, Packmohr, & Paul (2022)
Environment	Partnerships	Lack of standards between partners; local deviations in processes; wrong partnerships; lack of partnerships;	Schnasse, Menzefricke, & Dumitrescu (2021); Mielli & Bulanda (2019); Abdallah, Shehab, & Al-Ashaab (2021); Sauter, Bruch, Badasjane, Granlund, & Ahlskog (2024);

	DT awareness	Lack of DT trend awareness; lack of DT understanding	Mielli & Bulanda (2019); Oludapo, Carroll, & Helfert (2024); Brink, Packmohr, & Paul (2022)
	Regulations	Regulation uncertainty; lack of DT policies;	Abdallah, Shehab, & Al-Ashaab (2021); Oludapo, Carroll, & Helfert (2024); Brink, Packmohr, & Paul (2022)

Main risks under the People category can be divided into two subgroups: skills and knowledge gap, representing such challenges as lack of DT specific skills and specialists, which is further amplified if there is also a lack of proper DT training initiatives (Mielli & Bulanda (2019); Sauter, Bruch, Badasjane, Granlund, & Ahlskog (2024); Schnasse, Menzefricke, & Dumitrescu (2021); Oludapo, Carroll, & Helfert (2024)). Culture can be understood directly, as the challenges that comes with working in a multicultural environment, especially in global organizations, and indirectly, as an extension of the internal organizational culture, where lack of entrepreneurship skills or supportive environment, can cause DT initiatives to fail (Sauter, Bruch, Badasjane, Granlund, & Ahlskog (2024); Abdallah, Shehab, & Al-Ashaab (2021); Brink, Packmohr, & Paul (2022)).

In the category of Technology, we find more sub-groups – infrastructure, cyber-security, resources and overall technological maturity level. Some of the more specific risks that are commonly expressed by authors in this group, is an unprepared infrastructure, fragile systems, poor data quality (Abdallah, Shehab, & Al-Ashaab, 2021; Mielli & Bulanda, 2019; Sauter, Bruch, Badasjane, Granlund, & Ahlskog, 2024; Schnasse, Menzefricke, & Dumitrescu, 2021). DT is a process that requires high up-front investment and funding, inability to provide the necessary resources is seen as one of the biggest risks as well, which can stem from unclear ROI or inability to track transformation metrics (Sjödin, Parida, Leksell, & Petrovic (2018); Abdallah, Shehab, & Al-Ashaab (2021); Mielli & Bulanda (2019); Oludapo, Carroll, & Helfert (2024)). Cyber-security, as a risk to DT, was identified by Schnasse, Menzefricke, & Dumitrescu (2021), and the authors raise a challenge of overall lack of security awareness in organizations, even if data and security breaches are well known. Oludapo, Carroll, & Helfert (2024) expands upon this, by adding that DT can be impacted by other economic, social and regulatory risks, and organizations should prepare and manage the potential security breaches.

Organization category is divided into Change Management, Structure and Strategy & Leadership. Main challenges, being various difficulties and overall reluctance to implement external and internal changes, inefficient organizational structure, lack of overall strategy, common vision, leadership and coordination (Abdallah, Shehab, & Al-Ashaab (2021); Mielli & Bulanda (2019); Sjödin, Parida, Leksell, & Petrovic (2018); Schnasse, Menzefricke, & Dumitrescu (2021) Oludapo, Carroll, & Helfert (2024); Brink, Packmohr, & Paul (2022)). Because DT encompasses the whole organization and is a continuous process, not having a common vision and strategy, that aligns with overall business goals, can cause multiple other tensions and challenges (Mielli & Bulanda, 2019). When a DT strategy exists, but is not adequately supported by management, it leads to unwillingness to change, which in turn can lead to the failure of the strategy as well (Schnasse, Menzefricke, & Dumitrescu, 2021).

Last group of challenges, consists mostly of various external challenges that organizations need to deal with when going through their DT. The most widely researched subgroup is partnerships. Sauter, Bruch, Badasjane, Granlund, & Ahlskog (2024) focuses on internal partnerships between units of the same organization and the challenges visible mostly in global corporations, where there needs to be a balance between global standards and local deviations in technology and processes. Though external partnerships are equally important, and not having partnerships with other organizations, can be as risky as having incorrect partnerships (Schnasse, Menzefricke, & Dumitrescu (2021); Mielli & Bulanda (2019); Abdallah, Shehab, & Al-Ashaab (2021); Sauter, Bruch, Badasjane, Granlund, & Ahlskog (2024)). Two other external risks are considered to be the lack of understanding of DT and awareness of it trends, as well as the uncertainties that comes from various regulatory environments Mielli & Bulanda (2019); Abdallah, Shehab, & Al-Ashaab (2021); Oludapo, Carroll, & Helfert (2024).

2.1.4. Digital Transformation Critical Success Factors

Reviewing the challenges and risks, only shows one side of the complex and multi-faceted nature of DT of an organization, focusing on how to overcome these challenges – on what are the Critical Success Factors (CSF), can help both with identifying the highest priority risks, as well as giving guidance on how the risks can be managed.

CSF is a well researched concept in management studies, and can be defined as "limited number of areas in which satisfactory results will ensure successful competitive performance for the individual, department or organization" (Bullen & Rockart, 1981). In the context of DT, few of the biggest challenges are not providing enough resources and unclear ROI, therefore identifying the CSFs is especially important, to make sure that enough resources can be focused on the areas that matter the most and areas that can create the most competitive advantage.

For the sake of consistency, the CSFs identified by researchers are grouped into the same groups of People, Technology, Organization and Environment, summary is provided in Table 4.

Table 4. DT Critical Success Factors

Category	Success Factor	References
People	Employee qualification and knowledge	Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)
	Talent acquisition and retention potential	Ubiparipović, Matković, Marić, & Tumbas (2020)
	Employee engagement	Osmundsen, Iden, & Bygstad (2018)
Technology	Flexible infrastructure	Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Osmundsen, Iden, & Bygstad (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)
	IT Security	Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)
	Reliability	Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)

	Flexibility	Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Osmundsen, Iden, & Bygstad (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)
	Data analytics system	Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)
	Bimodal IT operations	Osmundsen, Iden, & Bygstad (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)
Organization	DT vision, strategy and alignment	Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Osmundsen, Iden, & Bygstad (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)
	Leadership support and funding	Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Osmundsen, Iden, & Bygstad (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)
	Organizational culture	Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)
	Organizational agility	Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Osmundsen, Iden, & Bygstad (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)
	Cross-functional teams	Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)
Environment	DT context and contents awareness	Ubiparipović, Matković, Marić, & Tumbas (2020)
	Collaboration with external partners	Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Osmundsen, Iden, & Bygstad (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)
	Standardization	Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018)
	Transparency and connectivity	Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018)

In the category of People, the three success factors reflects the challenges and risks very well. Firstly, it is critical to focus on employee qualifications and knowledge (Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)), furthermore, in order to make the change management aspect of DT easier, employees should be actively engaged in the activities of DT (Osmundsen, Iden, & Bygstad (2018)), and there should be a focus by Human Resource Management team to acquire and retain talent that already have necessary skills (Ubiparipović, Matković, Marić, & Tumbas (2020)).

Technology category focuses on the need for the IT infrastructure and applications of the organization to be flexible, so that they can better and faster adjust to the new technologies DT brings, and the systems need to reliable – stable and provide correct data (Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Osmundsen, Iden, & Bygstad (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)). Data analytics systems are specifically mentioned as a foundational CSF, because of the amount of data technologies such as IoT can create, and to process and harness it for new service or product creation, a specific set of technologies and competencies are needed (Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)). Bimodal

IT operations, refers to the ability of IT department to be both proactive, flexible and deliver results quickly, as well focus on the long term value creation and governance (Osmundsen, Iden, & Bygstad (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)).

Organizational CSFs are also similar to the challenges summarized earlier, where the key factors are overall vision and strategy of DT, commitment to the strategy of the leadership, overall organizational culture of not only accepting, but promoting change in the context of DT, as well as the organizational agility and cross-functional DT teams (Vogelsang, Liere-Netheler, Packmohr, & Hoppe (2018); Osmundsen, Iden, & Bygstad (2018); Ubiparipović, Matković, Marić, & Tumbas (2020)). Organizational agility can be interpreted in different ways, but it usually refers to the ability of the organization to quickly identify and react to changes that DT brings, adapt to the new organizational needs (Ubiparipović, Matković, Marić, & Tumbas, 2020), which can be achieved through developing pilot DT projects, that allow to quickly learn from mistakes and implement successful changes much faster (Vogelsang, Liere-Netheler, Packmohr, & Hoppe, 2018). Because DT affects all functions of an organization and requires a combination of different skills and knowledge, organizations also need to enable cross-functional teams, where employees with different skills and knowledge can work towards successful DT together (Vogelsang, Liere-Netheler, Packmohr, & Hoppe, 2018).

In the environment category, the CSF that is repeated in research the most, is collaboration with external partners, which enables the organization to quickly find and cooperate with specialized experts on DT activities (Ubiparipović, Matković, Marić, & Tumbas, 2020). These partners can be any member of the supply chain, including both customers and vendors, that is why it also requires a high level of mutual trust, transparency and standardization of processes and data exchange (Vogelsang, Liere-Netheler, Packmohr, & Hoppe, 2018). Another CSF, is overall grasp and awareness of various DT concepts and trends, which includes understanding both external – economical, industry and technology, and internal – individual, functional, organizational, environments (Ubiparipović, Matković, Marić, & Tumbas, 2020).

Overcoming these challenges and focusing on the CSF, allows DT to create a set of efficiencies and new value for the organization. Abdallah, Shehab, & Al-Ashaab (2021) aggregated benefits found in literature, into a cross-dependent list of benefits. Firstly, increase in overall profitability, is driven by DT allowing organizations to be more customer focused and fostering an innovation culture. Both of these elements increases sales channels, makes manufacturing processes more productive. Yonghong, Jie, Ge, & Ru (2023) also found that DT has a direct and positive impact on financial performance of manufacturing companies in China – the more prepared for DT the company is technologically, the higher the impact on inventory and asset turnover rate, but there is a noticeable lag of profitability performance, as the start of DT requires more investments. Second benefit is the Continuous Growth ability, which is driven by more productive manufacturing operations, and a higher competitive advantage created by DT (Abdallah, Shehab, & Al-Ashaab, 2021). Sjödin, Parida, Leksell, & Petrovic (2018) strengthens this benefit, by identifying increased overall process efficiencies, as well as lower operating costs and increased employee safety and organizational sustainability, that can be attributed to DT as well. Wang, Jiao, Bu, Wang, & Wang (2023) further expands on the sustainability benefits, by analyzing how DT affects the ESG (Environment, Social, Governance) performance of manufacturing companies in China. It was found, that DT strategy has the highest positive impact on ESG performance, with total productivity, information transparency and investor stickiness having moderating effects.

2.1.5. Digital Transformation Models and Frameworks

There have been various DT frameworks and models suggested in the academic literature through the years, because the purpose of this work is to suggest a model that integrates DT and KM, it is worthwhile to analyze examples of DT and KM frameworks separately.

The first framework, depicted in Figure 1, is created by Vial (2019), and shows the major building block of DT based on an extensive literature review. In this framework, just like in the definition of DT provided in the same paper, digital technologies play one of the central roles – it both creates the disruptions, such as changes in consumer behavior, overall competitive landscape, and availability of data, and it also enables the various changes in value creation of businesses. In turn, the disruptions forces organizations to reevaluate their strategies, by creating digital transformation, or overall digital business strategies, and those relies on the use of digital technologies as well (Vial, 2019).
Enabled by the technology, organizations can also create new value propositions to their customers, or change how the value is delivered to them, by creating and using new value networks and digital channels, and these changes can also happen more rapidly, as organizations become more agile and better suited to respond to shifts in the market. The value creation paths are affected by both the organizational changes that are triggered by DT, as well as the organizational barriers, that resist these changes. DT has the potential to disrupt the organizational structure and culture, as it requires a high level of agility and a more flexible organizational structure, and sometimes even different organizational values, which need to be supported by the leadership and will lead to new roles and skills that employees will need to acquire and fulfil, in order to make DT successful (Vial, 2019). This change process is slowed down by the two barriers – resistance to change, and inertia of the organization, which refers to a situation where even if there is no resistance from the leadership, but the structure, processes, culture and other internal and external parts of the organization become rigid and cannot be easily modified (Vial, 2019).
If the changes enabled by DT are successful, it can generate both positive and negative impacts. The negative is the security and privacy, which can refer to a wide array of areas – from data security and privacy, to a higher level impact on job security and employee safety. On the positive side of the impacts, DT can have an impact on the level of overall industry and society, by increasing the quality of life and starting transformational shifts, and it directly affects the organizational performance and efficiency of the organization that is going through the transformation (Vial 2019).

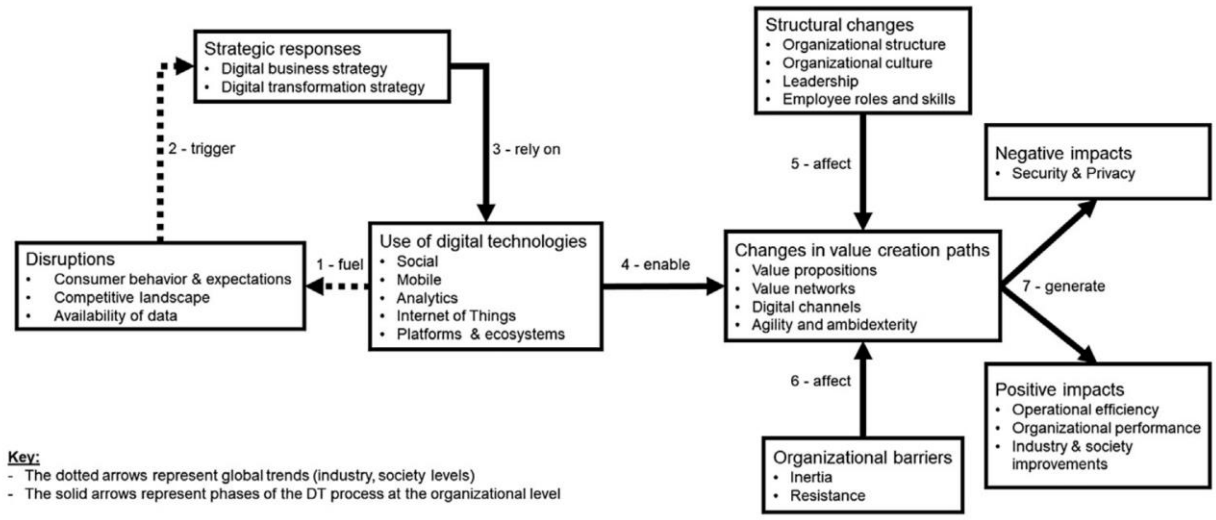


Figure 1. DT building blocks (Vial, 2019)

This framework expands upon the definition of DT, by providing a structured approach on how the changes in technology triggers a response from organizations, and how that response can change the strategy and very structure of the organization and eventually the industry and even the society overall.

Second framework, which is broadly accepted and referenced, is created by Warner & Wäger (2019) from multiple case studies, and focused on dynamic capability building for successful DT. The framework is depicted in Figure 1.

This framework is based on the concept of dynamic capabilities, which are a set of capabilities that allows organizations to build competitive advantage, especially during times of technological change, by integrating, reconfiguring and learning organizational skills, competencies and resources (Teece, 2007). This definition, closely resembles the selected definition of DT by Vial (2019), thus dynamic capabilities are widely researched in the context of DT.

Model is represented as a process, from external triggers, such as disruptive digital competitors, customer behaviors and technologies, to the strategic renewal of business model, collaborative approach and organizational culture. Three core internal enablers are cross-functional teams, fast decision making and executive support. The internal barriers to digital transformation are rigid strategic planning, resistance to change, and a high level of hierarchy in the organization. Lack or proper planning, internal and external resistance to change and inefficient hierarchy structure, are all identified challenges in the previous section as well (Abdallah, Shehab, & Al-Ashaab, 2021; Mielli & Bulanda, 2019; Sjödin, Parida, Leksell, & Petrovic, 2018; Schnasse, Menzefricke, & Dumitrescu, 2021). Each of the three steps of Digital Sensing, Digital Seizing and Digital Transforming, also have their own distinct dynamic capabilities, which are required for that step to be successful.
The capability of sensing consists of following and understanding DT trends, analyzing and interpreting those trends, then formalizing strategies and establishing and promoting a long-term DT vision and entrepreneurial mindset in the organization.

Seizing refers to the ability of rapidly prototype new products and services through creation of minimum viable products, working as a start-up and using digital innovation labs. Then these prototypes and innovations should be scaled up, balanced and executed by reallocating any needed resources, making strategic decisions and embracing the change that comes with it.
Lastly, transformation capability consists of joining and exploiting new partnerships and ecosystems that DT creates, transforming the organization by innovating its business model, structure and improving the digital maturity by upskilling, reskilling or hiring employees when needed.

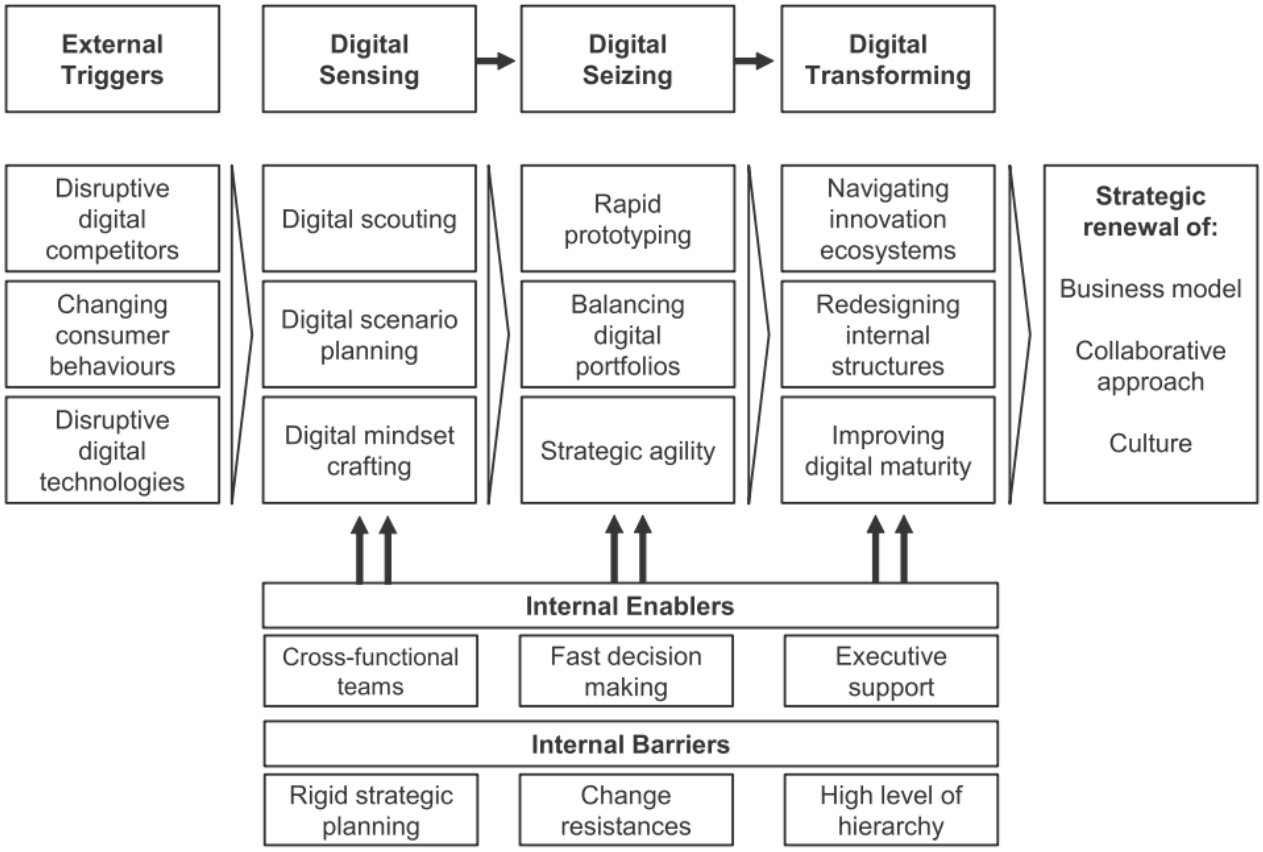


Figure 2. Dynamic capability framework for successful DT (Warner & Wäger, 2019)

The two frameworks offer a similar, yet slightly different view of the process of DT and what organizational shifts it is enabled by and creates. The framework by Vial (2019) focuses on the circular nature of DT, as well as the strategic response of an organization, whereas framework by Warner & Wäger (2019) is more process-oriented and offers a more granular view into what organizations need to successfully implement DT. Both frameworks offer valuable insights, can be seen as complimentary to each other, and can be seen as a valuable foundation for future research of DT.

2.2. Knowledge Management Theoretical Foundations

This chapter will delve into the theoretical foundations of KM, reviewing its definitions, KM processes, KM systems, and lastly, it will also explore a few frameworks and models of KM.

2.2.1. Knowledge Management Definition and Dimensions

Table 5. Definitions of KM

Author, year	Research type	DT Definition
Quintas, Lefrere, & Jones, 1997	Literature review	"Knowledge management is the process of continually managing knowledge of all kinds to meet existing and emerging needs, to identify and exploit existing and acquired knowledge assets and to develop new opportunities."
Inkinen, 2016	Literature review	"Conscious organizational and managerial practices intended to achieve organizational goals through efficient and effective management of the firm's knowledge resources"
ISO, 2018	Standard	"Knowledge management is a discipline focused on ways that organizations create and use knowledge <…> It uses a systemic and holistic approach to improve results and learning. <…> it Includes optimizing the identification, creation, analysis, representation, distribution and application of knowledge to create organizational value"
Corrêa, Paula, Carvalho, & Anastácio, 2021	Literature review	"<…> KM consists of management that relates mutually to other themes and organizational areas to promote processes and activities based on knowledge, aiming to achieve the objectives desired by the organization."
Hilger & Wahl, 2022	Book	"Knowledge management involves the people, process, content, culture, and enabling technologies—necessary to Capture, Manage, Share, and Find information."

Table 4 summarizes few of the definitions available in academic literature, and also compares them to a definition provided in International Organization for Standardization Standard No. 30401:2018, that standardizes some of the requirements for KM systems. The definitions for KM can be analyzed according to the same definition framework suggested for DT by Vial (2019).

Firstly, the target of all of majority of the KM definitions refers to an organization, either directly (Inkinen, 2016; ISO, 2018; Corrêa, Paula, Carvalho, & Anastácio, 2021), or indirectly – definitions by Quintas, Lefrere, & Jones (1997) and Hilger & Wahl (2022) does not specifically state the target entity in the definitions themselves, but their research and work, where the definitions are taken from, focuses solely on the organizational KM.

Second, is the scope of the definition, or where KM occurs, which is more undefined in KM definitions. For Quintas, Lefrere, & Jones (1997), the scope of KM covers all existing and acquired knowledge assets, Inkinen (2016) definition scope can be implied to be the "organizational and managerial practices", the ISO standard (2018) states that KM is focused on how knowledge is created and used, definition of Corrêa, Paula, Carvalho, & Anastácio (2021) is much more vague and scope is not stated directly, but can be implied to be various related processes of KM, scope of Hilger & Wahl (2022) is also very vague, intentionally, as the goal of the definition is to "ensure it covers everything necessary for an organization to be truly successful in designing, implementing, and maintaining a KM program or office that adds real business value" (Hilger & Wahl, 2022).

Third are the means of KM, which for all the authors, are focused on the process itself of KM, which is different from the DT definitions, where the focus was on technology. Quintas, Lefrere, & Jones (1997) specifically say, that the means are identifying and exploiting knowledge, Inkinen (2016) writes that KM is done through efficient and effective knowledge resource management. ISO standard (2018) is much more specific, and firstly mentions a "systemic and holistic approach", then goes into detail listing all the KM activities and processes. Similarly, works of Corrêa, Paula, Carvalho, & Anastácio (2021) and Hilger & Wahl (2022) both focus on the activities of KM, but Hilger & Wahl (2022) also adds people, culture and enabling technology dimensions, which were not seen in the previous definitions.

Last important part of the definitions, are the expected outcomes or goals of KM. In this area, the identified outcomes of KM, are similar to the outcomes identified in the DT definitions as well. Quintas, Lefrere, & Jones (1997) outcome is twofold – first, is meet any existing and emerging needs, and then, to develop new opportunities. KM objectives according the ISO Standard (2018) are also twofold – improve results, learning and create organizational value. Inkinen (2016) and Corrêa, Paula, Carvalho, & Anastácio (2021) state their KM outcomes very similarly – achieving overall goals and objectives of the organization, whatever they might be. Hilger & Wahl (2022) do not mention the end objective at all, but in their book, authors say that "Knowledge Management Systems, by definition, are meant to add value to how an organization does business" Hilger & Wahl (2022).

Based on these definitions, it is also possible to extract the key elements that should be included in a KM framework – it is a continuous process, that encompasses all organizational activities and dimensions, used to capture, store, manage and apply knowledge assets of the organization, with the goal of creating new organizational value and reach the objectives of an organization. Analyzed definitions are picked from a wide range of years and academic works, but the basic elements remain the same, which could mean that KM by itself, is a relatively standardized concept, but it is rarely defined together with other organizational concepts or processes, such as DT.

2.2.2. Knowledge Management Systems

Knowledge Management Systems (KMS), are information systems and technologies, that support the KM processes analyzed before, three main application are – coding and sharing of knowledge, creation or corporate knowledge directory and creation of internal and external knowledge networks (Alavi & Leidner, 2001). Authors also give examples of how KMS can support all of the major KM processes, first of all, platform technologies, such as communication technologies and intranets, support the whole KM process. Knowledge creation is supported by various learning tools and data or process mining technologies. Knowledge storage – knowledge repositories, databases, document management systems. The storage systems, together with communication platforms can support knowledge transfer as well, while expert and workflow systems support the knowledge application.

Maramba & Smuts (2020), based on KMS implementation case studies, created a comprehensive KMS implementation framework, consisting of 4 KMS focus areas and multiple success factors for each:

- Operational KMS implementation – depends on appropriate software, infrastructure and other technology aspects, as well as defining KMS processes and activities.

- Leadership – key factors in this group are strategy alignment between business and KMS, governance and control, developing KMS metrics, effective change management.
- Tactical – focused more on adoption of KMS as a culture, defined roles and responsibilities, improved business processes to include KMS.
- Organizational – covers overall KMS integration to the procedures and operations of organization, as well as societal and technological environmental context, customer needs, available resources and relevance.

An implementation framework by Purwadi & Sardjono (2024) focuses on similar areas, though grouped slightly differently.

- Organizational agility – organizations need to engage employees, motivate and connect their contributions to the usage of KMS, allow decentralized decision-making, ensure leadership buy-in and support to foster collaboration culture.
- Knowledge infrastructure – prepare a flexible and reliable IT infrastructure that will support KMS.
- Knowledge empowerment – organizations should align KMS strategy to the overall business goals, onboard new talent or empower existing employees, provide incentives for contributing and using KMS, employee upskilling and training initiatives, create an environment that encourages trust among employees.

It is evident, that implementation of such systems covers more than just technological or knowledge dimensions, but also depends on the culture, leadership and even external factors that the organization faces (Maramba & Smuts, 2020). Successful implementation of KMS can facilitate open innovation, which also increases the overall innovation performance of an organization – it can help create an environment, for a more effective knowledge exploitation and exploration processes (Santoro, Vrontis, Thrassou, & Dezi, 2018)

In the context of tacit knowledge, correct implementation and use of various KMS, supports the knowledge conversion processes of the SECI model (Lesjak & Natek, 2021), that will be more thoroughly analyzed in the next chapter. During the step of Socialization, various collaboration tools can provide opportunities for both synchronous and asynchronous sharing of tacit knowledge quickly and efficiently; Externalization step is supported by knowledge codification and storage technologies and applications such as wikis, best practices, FAQs, data warehouses, etc.; knowledge Combination is made more efficient through the same technologies and their use for easier knowledge discovery, maintenance, sharing and combination of different data and knowledge sources to form a single knowledge base; and lastly, these technologies provide easy access to explicit knowledge, that then can be easily Internalized and converted to tacit (Lesjak & Natek, 2021).

To summarize, KMS can support all the processes of KM and utilize various digital technologies like wikis, collaboration tools and data warehouses, to enable more efficient knowledge sharing, storage and application processes. KMS implementation requires a comprehensive approach of aligning and preparing organizational strategy, culture, IT infrastructure, ensuring employee empowerment and leadership support, while a successful implementation can greatly affect the innovation capabilities of an organization.

2.2.3. Knowledge Management Risks and Challenges

Hammoda, B., & Durst, S. (2022) in their research of knowledge risks in healthcare organizations, grouped the risks together into 3 main categories – human, technology and operational, while according to Igbinovia & Ikenwe (2018), KM must consist of effective management of people, processes and technology, where people is the most important category, as they are the conveyors of knowledge. These two views, covers the dimensions and categories of KM and KMS mentioned in the previous chapters, and is similar to the categorization of challenges used in the DT chapter, therefore the categorizations were aligned, for easier review and comparisons. External factors were not as prominent in KM risks and challenges research, thus that category is excluded from the summary. The challenges and risks are summarized in Table 6.

Table 6. KM challenges and risks

Category	Sub-category	Risks and Challenges	Reference
People	Skills and knowledge gap	Lack of training; loss of critical knowledge; missing competencies;	Zia & Asgher (2022); Nakash & Bouhnik (2020); Durst & Zieba (2018); Mazorodze & Buckley (2019)
	Personal	Big workload, poor communication skills, lack of motivation, seeking own benefit; hiding knowledge; forgetting and unlearning; incorrect habits; lack of trust;	Zia & Asgher (2022); Durst & Zieba (2018); Hammoda, B., & Durst, S. (2022); Mazorodze & Buckley (2019)
Technology	Infrastructure	Lack of integrated infrastructure;	Zia & Asgher (2022); Mazorodze & Buckley (2019)
	Cost	Costly and lengthy implementation of KMS; lack of budget ;	Zia & Asgher (2022); Mazorodze & Buckley (2019)
	Technological maturity	Obsolete technology, deficient IT resources; poor knowledge curation;	Zia & Asgher (2022); Durst & Zieba (2018); Hammoda, B., & Durst, S. (2022)
	Cybersecurity	Lack of awareness; external knowledge sharing; using personal accounts for work; espionage;	Hammoda, B., & Durst, S. (2022)
Organization	Standardization	Lack of standardization; lack of knowledge re-use;	Nakash & Bouhnik (2020)
	Structure	Inefficient organizational structure; Restructuring;	Zia & Asgher (2022); Hammoda, B., & Durst, S. (2022)

	Culture	Inefficient corporate culture; lack of knowledge sharing culture;	Zia & Asgher (2022); Mazorodze & Buckley (2019)
	Strategy & Leadership	Lack of KM strategy; lack of leadership; internal and external competitiveness; leadership change; lack of executive support;	Zia & Asgher (2022); Hammoda, B., & Durst, S. (2022); Mazorodze & Buckley (2019)
	Process	Improper applying of knowledge; unreliable information and knowledge; lack of appropriate methodologies;	Durst & Zieba (2018); Hammoda, B., & Durst, S. (2022); Mazorodze & Buckley (2019)

People category is broken down into skill and knowledge gaps, that happens because of missing competencies, lack of training and might create a risk of loss of critical knowledge (Zia & Asgher, 2022; Nakash & Bouhnik, 2020; Durst & Zieba, 2018; Mazorodze & Buckley, 2019)
Personal dimension has challenges such as employee overload, lack of motivation, unintentional forgetting of knowledge or intentional unlearning, incorrect and long-standing habits, lack of trust in the organization, and sometimes, malicious hiding of knowledge to seek personal benefit (Zia & Asgher, 2022; Durst & Zieba, 2018; Hammoda, B., & Durst, S., 2022; Mazorodze & Buckley, 2019).

Technology category has four main sub-categories – infrastructure, cost of resources, technological maturity level, and cybersecurity. Though only one Hammoda, B., & Durst, S. (2022) mentioned the cyber-security group of risks in the healthcare industry, which occurs through employees using their own personal accounts in a work environment, lack of general awareness of security practices even when data breaches are well known, and in some cases, espionage can be a risk as well. Other technological challenges are lack of integrated or outdated infrastructure and technology, long and expensive KMS implementation process, poor knowledge quality and curation (Zia & Asgher, 2022; Durst & Zieba, 2018; Hammoda, B., & Durst, S., 2022).

Organizational category is also similar to the same category in the DT challenge analysis, where the main sub-categories are standardization, organizational culture, structure, strategy and leadership, and processes. Common standardization related challenges are lack of process and KMS standardization, and lack of knowledge re-use (Nakash & Bouhnik, 2020), structural challenges can be overall inefficient organizational structure, or changes that happen because of restructuring (Zia & Asgher, 2022; Hammoda, B., & Durst, S., 2022). Second sub-category is culture, which consists of risks such as overall inefficient corporate culture and more specifically, lack of knowledge sharing culture (Zia & Asgher, 2022); Mazorodze & Buckley, 2019). Strategy and leadership challenges consists of lack of KM strategy, lack of leadership and executive support, and can also occur as an internal or external competitiveness, when employees are not incentivized to share their knowledge (Zia & Asgher, 2022; Hammoda, B., & Durst, S., 2022; Mazorodze & Buckley, 2019). Process related challenges can be improper application or unreliable knowledge, as well as a lack of appropriate methodologies, that would cover all or majority of KM processes and systems (Zia & Asgher, 2022; Hammoda, B., & Durst, S., 2022; Mazorodze & Buckley, 2019).

2.2.4. Knowledge Management Critical Success Factors

CSFs of KM, can also provide a different perspective of what is important for the organization, and where the focus of managers should be, in order to maximize the value from KM activities (Sedighi & Zand, 2012). A summary is provided in Table 7.

Table 7. KM Critical Success Factors

Category	Success Factor	References
People	Employee engagement	Mathew & Rodrigues (2019); Sedighi & Zand (2012); Sensuse, Qodarsih, Lusa, & Prima (2018); Onofre & Teixeira (2022);
	Incentives and motivation	Mathew & Rodrigues (2019); Sedighi & Zand (2012); Sensuse, Qodarsih, Lusa, & Prima (2018); Onofre & Teixeira (2022);
	Training	Mathew & Rodrigues (2019); Sedighi & Zand (2012); Sensuse, Qodarsih, Lusa, & Prima (2018); Onofre & Teixeira (2022);
Technology	Integrated KMS	Mathew & Rodrigues (2019); Sedighi & Zand (2012); Sensuse, Qodarsih, Lusa, & Prima (2018); Onofre & Teixeira (2022);
Organization	KM process capability	Mathew & Rodrigues (2019); Sedighi & Zand (2012);
	KM measurement	Mathew & Rodrigues (2019); Sedighi & Zand (2012); Onofre & Teixeira (2022);
	KM Strategy	Mathew & Rodrigues (2019); Sedighi & Zand (2012); Sensuse, Qodarsih, Lusa, & Prima (2018); Onofre & Teixeira (2022);
	KM Culture	Mathew & Rodrigues (2019); Sedighi & Zand (2012); Sensuse, Qodarsih, Lusa, & Prima (2018); Onofre & Teixeira (2022)
	Leadership support and funding	Mathew & Rodrigues (2019); Sedighi & Zand (2012); Sensuse, Qodarsih, Lusa, & Prima (2018); Onofre & Teixeira (2022);
	Organizational agility	Onofre & Teixeira (2022);
Environment	KM context and contents awareness	Sedighi & Zand (2012); Sensuse, Qodarsih, Lusa, & Prima (2018); Onofre & Teixeira (2022);
	Collaboration with external partners	Sedighi & Zand (2012); Onofre & Teixeira (2022);

All analyzed research finds similar CSFs in the people category – employee engagement, incentives and motivation, as well as training. To maximize the benefits of KM, employees of the organization must be involved with the process of KM (Mathew & Rodrigues, 2019), and to make sure the involvement is fruitful, organizations should focus on employee training, which develops the needed skills to enable and facilitate KM activities, such as creation and sharing, while also providing a standardized framework to do it (Sedighi & Zand, 2012), monetary and non-monetary incentives can

provide motivation to accelerate knowledge sharing and minimize such risks as knowledge hiding (Mathew & Rodrigues, 2019).

Technology category consists of a single and broad CSF – an integrated KMS. An effective, stable, accessible and trusted KMS is one of the foundational factors for a successful KM strategy, especially in the context of DT (Mathew & Rodrigues (2019); Sedighi & Zand (2012); Sensuse, Qodarsih, Lusa, & Prima (2018); Onofre & Teixeira (2022)).

The two process related factors in organizational CSFs, are the capability to execute KM processes, having the technology, structure and culture to do it effectively (Mathew & Rodrigues (2019); Sedighi & Zand (2012); Onofre & Teixeira (2022)), and measuring the effectiveness of these process and overall KM strategy, in order to adjust it effectively and measure its success (Mathew & Rodrigues (2019); Sedighi & Zand (2012); Onofre & Teixeira (2022)). Similar to DT, KM strategy, enabling organizational culture, leadership support, funding and agility are all also identified as CSFs for KM (Mathew & Rodrigues (2019); Sedighi & Zand (2012); Sensuse, Qodarsih, Lusa, & Prima (2018); Onofre & Teixeira (2022)).

Effective KM can create a multitude of benefits for the organization. One of the most comprehensive and oldest researches into the benefits by Alavi & Leidner (1999) splits it into two categories similar to the groups of challenges analyzed before:

- Process – KM allows for faster more efficient communication and creates an environment for increased employee participation in knowledge processes. This in turn reduces problem solving times, faster time-to-market of new products and solutions, and increases overall efficiency of the organization.
- Organization – KM can increase profitability of the organization, by reducing operational costs and increase of sales,, because of more customer focused processes and better customer service, it can also help with creating more targeted and proactive marketing campaigns, through the effective combination of external and internal knowledge about customers. This also improves project management processes, allows for more multinational client base, and can reduce personnel, such as document management employees, to further save costs.

Mazorodze & Buckley (2019), based on a qualitative study, finds that more than half of the respondents believes, that KM can improve overall knowledge flow in the organization and enhances the change management capabilities. Second most popular benefit is acceleration and stronger organizational commitment to innovation. Next to it, are the benefits of knowledge reuse, that helps with elimination of repetitive tasks, then better collaboration among employees, and a possibility to create a competitive advantage for the company.
Liu, Tsui, Kianto, & Zhao (2023) did a literature review of 24,663 articles on knowledge management and performance, and found, that knowledge codification strategy had a direct relationship with overall business and financial performance, while personalization was directly correlated with overall business performance as well. Codification, is a KM strategy, where organizational knowledge is codified, meaning transformed into explicit, and stored in databases for easier access, while personalization leans on person-to-person and tacit knowledge sharing, instead of storage (Hansen, Nohria & Tierney, 1999).

2.2.5. Knowledge Management Processes, Models and Frameworks

Before analyzing KM models or frameworks, it is also worth reviewing the activities the models and frameworks are built on.

Table 5 shows KM processes or activities, picked from the literature and already mentioned ISO standard.

Table 8. KM processes

Author, year	Research type	KM Processes
Alavi & Leidner, 2001	Literature review, conceptual study	Creation, storage, transfer, application
Gold, Malhotra, & Segars, 2001	Quantitative study	Acquisition, conversion, application, protection
ISO, 2018	Standard	identification, creation, analysis, representation, distribution, application
Igbinovia & Ikenwe, 2018	Conceptual study	Acquisition, capture, organization, storage, sharing, application
Ode & Ayavoo, 2020	Quantitative study	Generation, storage, diffusion, application
Sahibzada, Jianfeng, Latif, Shah, & Sahibzada, 2020	Quantitative study	Creation, acquisition, storage, sharing, utilization
Hilger & Wahl, 2022	Book	create, capture, manage, enhance, find, connect

First process that can be identified from the summary, is knowledge creation, which is mentioned by most of the authors directly (Alavi & Leidner, 2001; ISO, 2018; Sahibzada, Jianfeng, Latif, Shah, & Sahibzada, 2020; Hilger & Wahl, 2022), or is named differently, but means the same process of a continuous creation of new knowledge, an example of that is “acquisition” process, identified by Gold, Malhotra, & Segars (2001), Sahibzada, Jianfeng, Latif, Shah, & Sahibzada (2020) and Igbinovia & Ikenwe (2018), while not mentioning it in the main processes, Alavi & Leidner (2001) considers creation and acquisition two activities of the process, where creation is internal, and acquisition is acquiring external knowledge.

Second activity is knowledge storage. In the works of Alavi & Leidner (2001) and Ode & Ayavoo (2020) it is mentioned as a single process, Gold, Malhotra, & Segars (2001) analyses a synonymous process of knowledge conversion, but other authors divide it into sub-activities. Analysis and representation mentioned in ISO Standard (2018), are usually sub-processes of effective knowledge storage, Igbinovia & Ikenwe (2018) mention storage separately, but also say that capture consists of technology that facilitates knowledge creation and sharing as well as mapping of knowledge assets, while knowledge organization is a process to organize the knowledge so that it can be stored and retrieved efficiently, which means that capture and organization can both be sub-processes of

knowledge creation or storage. Hilger & Wahl (2022) also mention knowledge management and enhancement as activities, which consists of continuous maintenance of stored knowledge, enhancing with new metadata and linking it together, and can be grouped as an sub-processes under knowledge storage process. Goal of knowledge conversion, mentioned by Gold, Malhotra, & Segars (2001), is to effectively structure, organize, integrate, coordinate and distribute the knowledge, which also fits with both the knowledge storage and knowledge sharing activities analyzed by other authors.

In the selected processes, there is very little debate or differences in the definition of the process of knowledge sharing, transfer, distribution, or diffusion – which are all used as synonyms, for the process of sharing or transferring knowledge between functions, individuals, groups or internal and external partners (Alavi & Leidner, 2001; ISO, 2018; Igbinovia & Ikenwe, 2018; Sahibzada, Jianfeng, Latif, Shah, & Sahibzada, 2020; Ode & Ayavoo, 2020). Though Hilger & Wahl (2022) define it as "connect", and say that the goal of this process, is to connect the people or systems that have or store the knowledge, to the individuals who need the knowledge, which also can be

Last process, is the knowledge application or utilization, mentioned by all works, except Hilger & Wahl (2022). Knowledge application is where the source of created competitive advantage resides (Alavi & Leidner, 2001), it is when knowledge is utilized to solve problems (Igbinovia & Ikenwe, 2018), furthermore, knowledge application both directly, and indirectly as a mediator for other processes, affects organizations innovation performance (Ode & Ayavoo, 2020), and overall organizational performance (Sahibzada, Jianfeng, Latif, Shah, & Sahibzada, 2020).

These findings can be synthesized into four main KM processes:

- Knowledge Creation – referring to both internal and external knowledge identification, creation and acquisition sub-processes.
- Knowledge Storage – refers to effective knowledge categorization, enhancement, storage and continuous maintenance.
- Knowledge Transfer or Sharing – this is the dissemination of collected knowledge throughout the organization and with partners.
- Knowledge Application – is using knowledge to create a competitive advantage, solve specific organizational challenges, increase innovation performance and create new business value in general.

In addition to these processes, there also certain strategies of how the processes can be applied to reach different organizational goals. First set of such strategies, are the codification and personalization, first mentioned in the fundamental research by Hansen, Nohria & Tierney (1999), where with the codification strategy, knowledge is codified, written down and stored for future reuse, such strategy requires a large investment into IT infrastructure, the overall goal is for that codified knowledge to be reused as much as possible and increase the overall generated revenue of the organization. The knowledge personalization strategy is the opposite of that – goal is to maintain high profit margins, offer highly customized and personalized solutions, focus more on sharing of tacit knowledge.

Second set of strategies were first mentioned, in the context of KM and organizational learning, by March (1991) – exploration and exploitation, and are also the polar opposites of each other. Exploration of knowledge is the focus on experiments, innovation discovery and flexibility – can be summarized as creation of new knowledge, while exploitation deals with refinement, efficiency and

application, or in the context of KM – reusing and updating knowledge that organization already possess. According to the author, there needs to be a balance between using the exploitation and exploration strategies, as too much focus on exploitation can give quick, short-term results, but exploration will build long-term capabilities and value for the organization

The most widely used, and basic framework of a lot of academic research, for knowledge creation and sharing is created by Ikujiro Nonaka (1994), and is called the SECI (Socialization, Externalization, Combination, Internalization) model of knowledge creation, goal of which, is to continuously integrate and convert knowledge between the tacit and explicit forms.
Explicit knowledge, is a knowledge type that can be easily written down and shared between individuals or groups (manuals, best practices, documentation, data, etc.), while tacit knowledge is much more intangible, personal and hard to formalize or communicate with others (personal experiences, know-how, subjective insights, feelings, etc.) (Nonaka & Konno, 1998).

First mode of the SECI model is Socialization, which is the process of sharing tacit knowledge of individuals, or creating it through shared experiences. Second mode, which is on the other side of knowledge spectrum, is Combination – "reconfiguring of existing information through the sorting, adding, recategorizing, and recontextualizing of explicit knowledge can lead to new knowledge." (Nonaka, 1994). Third mode is the conversion of tacit knowledge into explicit – Externalization, and the fourth one, is reusing the available explicit knowledge and transforming it back into individual tacit knowledge – Internalization. The original model is expanded in the later work by Nonaka & Konno (1998). First addition was the representation of individual, group and organizational scopes on the model, as well as showing it as a continuous process. This makes the model easier to understand and showcases how the conversion happens on different layers of the organization. Next addition was the concept of "ba" (Nonaka & Konno, 1998), which is a platform or an environment where knowledge is created or shared. This model is shown in Figure 3.

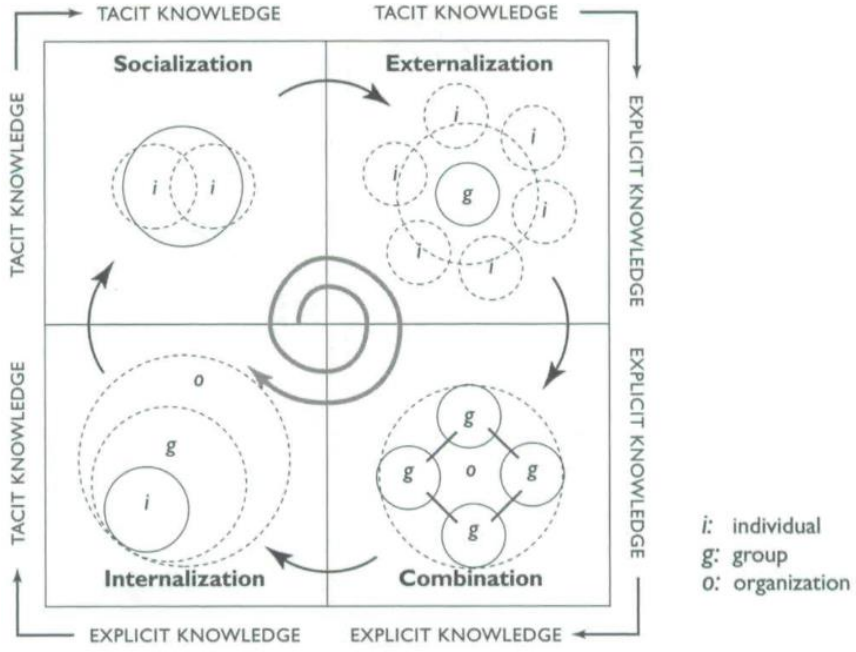


Figure 3. SECI knowledge creation model (Nonaka & Konno, 1998)

Later, the SECI model was used as a basis for a KM framework by Alavi & Leidner (2001), which is shown in the Figure 4. This depicts more of the knowledge transfer processes and activities, between distinct groups and organization as a whole. This model also introduces two new concepts of knowledge – semantic and episodic memory. Semantic memory is the general and explicit knowledge of groups, while episodic, is the tacit and context-specific knowledge of groups and organizations, such as specific decisions, circumstances and environmental factors).

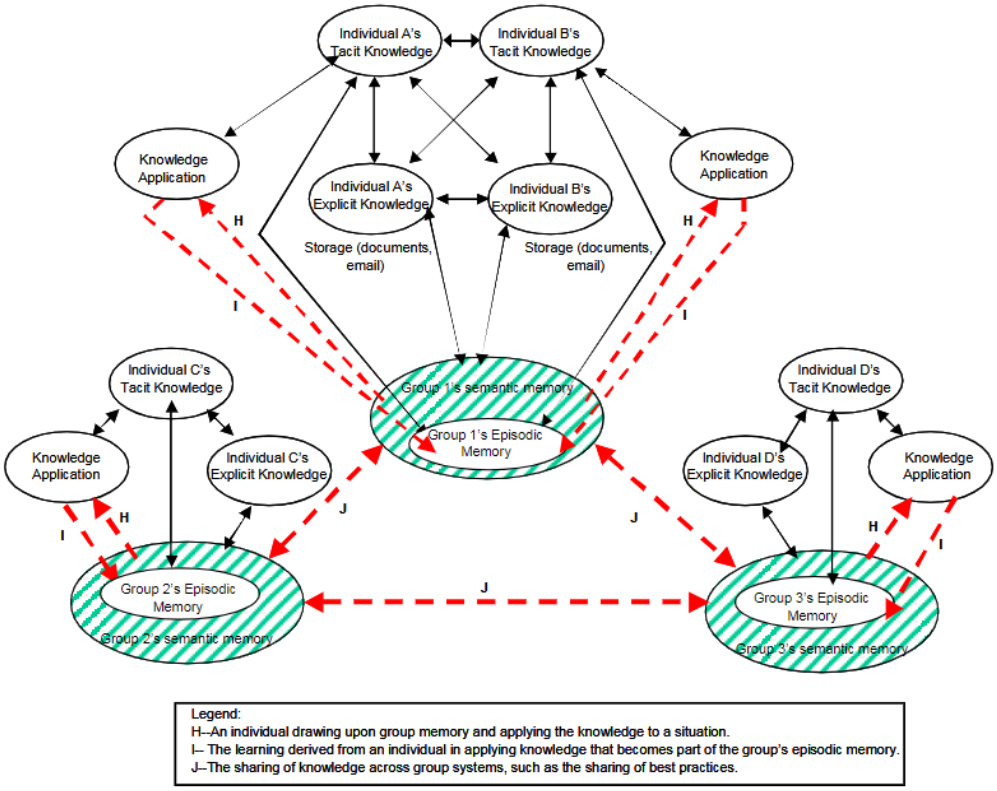


Figure 4. KM framework (Alavi & Leidner, 2001)

SECI model has seen a lot of different applications throughout the years. Bider & Jalali (2014) combined the SECI model with agile business process development principles, and applied it for a traditional process development project, with an expansion of two extra modes of knowledge conversion – embedment and adoption. While Soares, Pereira, Baldam, & de Francisco (2022), applied the model in a paper industry, with the context of process standardization, and found that it is still valid in practical scenarios, though depend heavily on the commitment of the organization. These applications and modifications, decades after the SECI model was initially constructed, proves that the SECI model remains at the core of KM research, and that it is usable even today, in the context of DT, as long as the required support and resources are provided for its implementation and maintenance.

A different framework, that uses the same KM processes of creation, storage sharing and application, but is not based on the SECI model, was recently developed by Shrestha & Saratchandra (2023), and it can be more closely associated to the process of DT, as the key enabler in the suggested model is

Information Systems and technologies. The knowledge exploration process is made more efficient with the help of information systems – employees can quickly access, generate, combine and analyze different information and datasets to generate new knowledge.

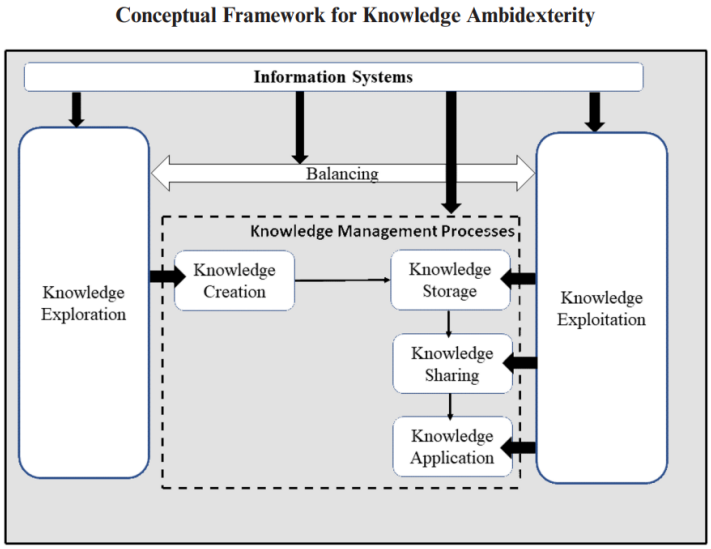


Figure 5. Conceptual Framework for Knowledge Ambidexterity (Shrestha & Saratchandra, 2023)

The authors suggest that Information Systems, support the knowledge exploration process and enables creation of new knowledge from internal and external data sources, with the use of latest technology, such as Big Data, cloud based KMS, AI and NLP. While knowledge exploitation is facilitated using knowledge repositories, databases and enables the KM processes of storage, sharing and application. Then Information Systems can help balance the knowledge exploration and exploitation activities through automation, real-time analytics and insights into knowledge processes, which would allow organizations to achieve knowledge ambidexterity and better adapt their knowledge activities to the ever-changing environment of DT.

The three reviewed KM frameworks and models, shows three different scales of KM, and can illustrate the evolution of KM as well. The SECI model of Nonaka (1994) and its later expansion by Nonaka & Konno (1998), focuses only on the knowledge creation and conversion between tacit and explicit, model by Alavi & Leidner (2001), scales the SECI model to an organizational level and expands it further by adding knowledge sharing, application and storage processes, first elements of technology can also be seen here, as facilitators of the KM processes. The latest analyzed framework by Shrestha & Saratchandra (2023), adds Information Systems and KMS as an enabler and facilitator of different KM strategies and processes, that also helps balance the exploration and exploitation strategies. The requirement, that for the models to be effective, organizations need to commit their resources and support, calls for a different view and a framework of how exactly these KM processes and models can be supported and what capabilities are needed to do that.

2.3. Interplay of Knowledge Management and Digital Transformation

The following chapter will review the theoretical and practical premises of the KM and DT interplay.

2.3.1. Literature Review of Digital Transformation and Knowledge Management Interplay

DT, by its nature, creates a highly dynamic environment for organizations, and when dealing with it, knowledge and information creation becomes as important, as its efficient processing (Nonaka, 1994), this creates the need to efficiently manage all processes of knowledge within the organization. KM, similar to DT, is a continuous, personalized and ever-evolving process of an organization and involves several key KM activities – creating knowledge, storing it, retrieving when it is needed, sharing internally and externally, and lastly – applying it to generate value. (Alavi & Leidner, 2001). Therefore, researching and understanding the interactions between these two processes is a worthy endeavor, that can create both practical and academic value.

Because of the multi-faceted concepts of DT and KM, and even wider array of their interplay options, an in-depth literature review to identify both the gaps in literature and future research areas is required.

A wide search of literature was done in the SCOPUS, Web of Science databases, as well as Google Scholar, with the following keywords and their different combinations – "knowledge management", "industry 4.0", "industry 5.0", "digital transformation", "digitization", "digital innovation". Summary of the results is presented in the Table 7.

Table 9. Summary of literature review on KM and DT synergy

Author, Year	Research type, context, goal	Findings	Limitations and future research
Wolf & Erfurth, 2019	Literature review – identify how KM supports DT, identify research questions for the future	DT has an impact how KM is applied – KM is being upgraded technologically, access improved, more personalized. KM with DT requires new strategies and rules in the organization. Lack of conceptual model adaptability in practice	Future research – KM practices in companies, more cross-functional research
Tinz, Tinz, & Zander, 2019	Comparative analysis of KM models in the context of DT and I4.0.	I4.0 introduces new challenges such as human-machine, machine-machine interactions and data protection. Current KM models do not widely address these challenges.	Future KM models need to include the new challenges and interactions in I4.0.
Capestro & Kinkel, 2020	Literature review of empirical studies – how I4.0 and KM are linked in knowledge creation and help with sustaining competitive advantage	I4.0 is a knowledge based approach, with knowledge coming from internal and external sources. Most important variable in I4.0 and KM relationship and achieving business goals – digital skills and competencies.	Future research – include the role of organizations' strategy on KM, more research from different disciplines.

Schniederjans, Curado, & Khalajhedayati, 2020	Content analysis of practitioner and scholar articles on supply chain digitization and how KM can be applied in the supply chain field.	IoT, cloud and big data identified as the most prevalent technologies in research, with practitioners focusing more on AI, blockchain and augmented reality. Developed research questions on supply chain DT and KM synergy.	Future research areas and questions identified.
Smith & Beretta, 2020	Case study to investigate how organizations respond to the paradoxes of DT	KM was found to be one of the three paradoxes created by DT, and requires organizations to balance between informal knowledge sharing of more ambiguous knowledge and formal alignment and sharing of knowledge once the DT scales up.	More case studies in different environments, focus more on external influences and factors.
Wang, Zhang, Xiong, & de Pablos, 2020	Conceptual study – from KM 1.0 to KM 2.0 and future KM 3.0	In the context of DT, very concept of knowledge needs to be reviewed. KM question is changing from "How to facilitate knowledge transfer from two fixed partners" to "how to find high potential and valuable partners from numerous emerging SMEs and individuals" and "how to establish an agile and dynamic knowledge sharing model with numerous and temporal partners"	
Zoppelletto, Orlandi, Zardini, & Rossignoli, 2020	Qualitative study with 35 SMEs from various business sectors, to find the critical knowledge factors in DT of SMEs	KM both affects and is affected by digital strategy of SMEs, within their DT projects. KM technology, infrastructure, knowledge sharing culture and formal processes builds a robust organizational knowledge infrastructure, required by DT.	Future research – change the scope to different regions, nations, sectors or company sizes.
de Bem Machado, Secinaro, Calandra, & Lanzalonga, 2021	Literature review – how is DT and KM and I4.0 researched in the literature, what are the key concepts and future research	Research clusters identified – KM and DT, KM and modern technologies, KM and I4.0.	Future research – case studies in different sectors, more engagement between academics and practitioners.
Fakhar Manesh, Pellegrini, Marzi, & Dabic, 2021	Literature review – how does KM literature address changes occurring during I4.0, and how will it impact KM in the future	Current research areas reviewed, current research clusters identified and future research questions raised	Future research – how can different technologies enable KM, knowledge leakage management, how DT and KM lead to company success
Silva, Santos & Souza, 2021	Systematic literature review to identify how SECI model applies to DT and principles of I4.0.	Developed a theoretical relationship and diagnostic model between I4.0 principles, tacit and explicit knowledge, as well as the	Deeper understanding of other I4.0 principles, KM dimensions and its impact on management practices

		SECI modes of knowledge conversion.	during DT, is needed. Model needs to be tested in practice.
Anshari & Hamdan, 2022	Literature review and focus group to identify critical new skills and capabilities that KM can build for success in I4.0	KM can improve organizations learning strategy, allow to build a sustainable competitive advantage quicker, upskill and re-skill employees, and in the context of I4.0, focuses on three dimensions – people, process, and technology.	Larger scope for literature analysis, test proposed models to develop KM strategies, use a case study approach
Erceg & Zoranović, 2022	Literature review – relationship between KM, DT and cultural change of the organization	DT processes promote exchange of knowledge, which leads to cultural change – a necessary first step in both KM and DT. DT is an ongoing process, and KM helps with identifying priorities, connecting people who need knowledge, to people who have it.	
Gupta, Kr Singh, Kamble, & Mishra, 2022	Quantitative study – survey of manufacturing and IT consultancy employees, to find CSF of KM in I4.0	CSF for KM system in I4.0 environment are top management support, KM strategy, KM culture, digital infrastructure, employee training	Expand findings with case studies, longitudinal data, new regions and industries
Miao, Zaman, Zafar, Rodriguez, & Ali Zaman, 2022	Qualitative study – questionnaire with experts of airline industry, discover critical I4.0 factors that increase human resource resilience through KM	Top critical factors – knowledge sharing, joint knowledge creation, E-learning – assists in management and efficiency performance	Limited to aviation sector of emerging nation, more variables can be included, scope expanded with more respondents. Results can be used for comparison with other research
Cardoso et al., 2023	Quantitative survey of 291 respondents, to understand DT, digital culture, technology adoption and its impact on performance, as well as role of KM in DT	There is a significant relationship between knowledge management and digital culture, adoption of digital technologies and competitiveness. Multiple other significant interconnected relationships discovered between knowledge of DT, commitment, productivity, digital cultures and competitiveness.	Qualitative studies should be conducted, evaluate maturity levels of companies, compare across sizes, regions and sectors.
Sánchez Ramírez, Guadamillas Gómez, González Ramos, & Grieva, 2022	Quantitative study of 78 companies to analyze how relationships between DT and KM affect business results	Digitization has a direct positive impact on performance, innovation capabilities and KM – confirming that DT can improve KM results. KMS has a mediating effect between DT and innovation capabilities	Future research could focus on one sector, "<…> analysis of the strategic and organizational factors that determine the implementation of the DT in an effective way and how these could foster the importance of KM in improving the company´s results."

Songkajorn, Aujirapongpan, Jiraphanumes, & Pattanasing, 2022	Quantitative survey of auto parts industry SMEs in Thailand, to identify relationships between DT, KBDC, and organizational strategic intuition and high performance organizations	KBDC has a positive effect on DT, and together they have a positive effect on organizational strategic intuition and high performance organizations, therefore, to increase the organizational importance, it is worth to invest into KBDC and DT both.	Expand into other industries, regions, investigate impact of COVID-19 and other cultural factors, change the strategic intuition variable with other outcomes.
Tortorella et al., 2022	Quantitative survey of 153 practitioners in India and Brazil, role of I4.0 on the relationship between KM and innovation performance	I4.0 principals and technologies contribute to higher potential of KM and innovation performance.	Expand to other regions and industries, determine an implementation framework, investigate tacit versus explicit knowledge nuances.
Mele, Capaldo, Secundo, & Corvello, 2023	Structured literature review to analyze evolution of dynamic capabilities and KBDC in DT	Areas and trends of research on dynamic capabilities identified, definition of KDBC revisited, future research areas suggested.	Focus on different company sizes and scales, interaction of regular capabilities with dynamic ones in the long-term.
Cheng et al., 2023	Qualitative survey of 267 managers in furniture industry of China, to investigate the impact of knowledge digitization on innovation performance	Combination of technology and KM creates competitive advantages, boosts innovation performance. Knowledge digitization can help drive DT by enabling the creation of new products and services.	Scope should be expanded to other industries, and more emphasis and research needed for other knowledge digitization and KM aspects, such as knowledge creation.
Lovrenčić S., 2023	Conceptual paper on how KM can help in achieving I5.0	KM is an integral part of transition to I5.0, knowledge creation, storage and supporting AI technologies are important for fulfilling I5.0 action plan.	
Siuko, Myllärniemi, & Hellsten, 2023	Qualitative – interviews with 26 employees in public sector, to show how to enable DT from perspective of KM, what are the challenges.	Knowledge sharing, learning from mistakes and knowledge creation, are critical for DT. Information, data and knowledge has to be identified as critical resources, and the practices of identification, acquisition and storage has to be well organized and communicated.	More research on DT in the lifecycle of both private and public organizations.
Khedr & Gohar, 2023	Qualitative survey with Egyptian manufacturing and service companies, how KM can embrace I4.0	All KM activities have a positive and significant effects on I4.0, most essential – knowledge application. By implementing KM, organization can become more agile, respond to market shifts faster, allocate resources more efficiently	Increase scope, focus on longitudinal study, integrate other success factors besides KM, include other market orientation features

Wessam & Nermin, 2023	Quantitative survey of 666 respondents in Egypt manufacturing and service sectors, to understand the impacts of KM activities on I4.0 adoption	All KM activities have significant and positive effects in I4.0 adoption, most important – knowledge application. KM activities, level of I4.0 adoption and market orientation differs according size, maturity, industry and organization type.	A longitudinal study is needed, add other success factors, expand research to other countries and market orientation types, compare manufacturing and service sectors independently.
Wu & Wang, 2023	Qualitative – interviews with managers of healthcare organizations and how to implement DT by taking advantage of KM	Effective KM is one way to achieve success in DT, it develops data-driven business models, harnesses full potential of DT	"<…>few studies have explored DT from the perspective of KM.", scope should be expanded from healthcare and other dimensions (risk management, assessment of DT)
Yan, Xiong, Gu, Lu, & Zhang, 2023	Literature review, to understand the research trends of digital technology application in KM	KM is significantly improved by the use of digital technologies. Four main research topics - digital technology and customer KM; application dilemma and problems of digital technology in KM; DT of organizational KM; influence of digital technology on KM.	Proposed future research directions – digital KM and sustainable development, digital KM and innovation, digital technology and knowledge creation and sharing.
Abu-AlSondos, Alkhwaldi, Shehadeh, Ali, & Al Nasar, 2024	Literature review to discuss the impact of I4.0 technology on KM in UAE.	I4.0 technologies increase efficiency of KM by making the KM processes more efficient, reliable and faster.	More case studies in a variety of business contexts are needed, knowledge enhancers and various security and scalability challenges of I4.0.
Khilji, Nicolic, & Ikram-ur-Rehman, 2024	Systematic literature review to investigate the role of KM in DT and how organizations manage change and innovation to improve performance	KM plays a critical role in the execution of DT through the creation and sharing of innovative ideas and knowledge.	

From the results, we can identify a couple of key trends in the research literature of KM and DT interplay.

First, even though the field of KM and DT synergy research is very active, and all the authors agree that both concepts are interconnected – success of DT depends on KM, while DT can promote and improve KM, majority of the articles call for a more in-depth review into more specific areas of KM and DT interaction. Wolf & Erfurth (2019), identified that KM and DT requires completely new organizational strategies, as DT is one of the main reasons behind increased KM importance in organizations, at the same time, the authors also called for more cross-functional research between academics and practitioners, with more case studies of KM within companies. De Bem Machado, Secinaro, Calandra, & Lanzalonga (2021), emphasized the importance of DT in KM development, identified various research clusters of DT and KM, and seconded the call for more interactions

between practice and academia, as vast majority of the available research on interactions between KM and DT, is written by academics, and an exchange of ideas and knowledge is especially important in this area. The call for more practical studies is further reinforced by Anshari & Hamdan (2022), who did a literature review and a focus group, with the goal to build an organizational learning model for I4.0 focusing on dimensions of people, technology and processes, and suggested conducting more case studies, in order to test the proposed models in practice. Employee skills, competencies and the need for focus on organizational learning, were also described as key variables in the relationship between KM and I4.0, by Capestro & Kinkel (2020), who similarly, suggested conducting more research from different disciplines and include strategy of the organization on KM, as another key dimension.

Research is spread across various different regions, nations and industries, but, at the same time, there is a lot of focus on more specific scenarios or elements of DT. Miao, Zaman, Zafar, Rodriguez, & Ali Zaman (2022) found that critical I4.0 factors in the context of KM, such as knowledge sharing, joint knowledge creation and e-learning, assists in management efficiency and overall performance, but their research was focused on the aviation sector of an emerging nation. Wu & Wang (2023) research on DT implementation by taking advantage of KM, was done in healthcare industry, and found that effective KM is one of the ways to achieve a successful DT, as it helps make data-driven decisions, and harness full potential of DT. Fakhar Manesh, Pellegrini, Marzi, & Dabic (2021) analyzed I4.0 and KM related literature, to identify new research areas and clusters, and one of the main ones, was researching how different digital technologies can enable successful KM. DT and KM interaction in the public sector was analyzed by Siuko, Myllärniemi, & Hellsten (2023), their findings show the data, information and knowledge, has to be identified as critical resources for an organization, while the various processes of knowledge acquisition, storage and sharing have to be well organized and communicated throughout the organization.

From the selected articles, it is evident, that even though KM and DT synergy research field is active, it remains relatively underexplored. Wu & Wang (2023) says that there are still few studies that explore DT from the perspective of KM, Sánchez Ramírez, Guadamillas Gómez, González Ramos, & Grieva (2022) calls for more analysis of how DT can be done in an effective way together with KM, and how that synergy can improve company's results. Wang, Zhang, Xiong, & de Pablos (2020) suggests that the very concept of knowledge needs to change, because of the context of DT, and future research should focus more on how to make KM more agile and dynamic. Yan, Xiong, Gu, Lu, & Zhang (2023), argues that the current research is scattered, lacks the review of trends and topics, and identified, that future research could focus on digital KM and how it promotes innovation, sustainable development, how digital technology affects KM processes of creation and sharing, and what digital technology solutions could be offered to organizations, in order to facilitate effective knowledge sharing and creation.

Synergy of DT and KM also has both direct and indirect impact on organizational performance, namely, sustainable competitive advantage and increased innovation performance. Competitiveness of an organization is directly impacted by usage of digital technology, overall commitment to digital transformation and knowledge management (Cardoso et al., 2023). Committing to KM and having strong practices, also enables, and is enabled by, Organizational Learning (OL), which in turn can help businesses increase their competitive advantage in a sustainable, long-term and people focused, way (Anshari & Hamdan, 2022). This combination of digital technology, KM and OL practices, not

only boosts competitiveness, but in a circular way, can also help drive DT by boosting the innovation performance of an organization, enable creation of new products and services (Cheng et al., 2023). Developing adaptable KMS, can also be one of the ways for companies to capture the opportunities provided by DT and technology. This way, KMS and KM acts as a mediator between DT and innovation capabilities of a company, strengthening that relationship (Sánchez Ramírez, Guadamillas Gómez, González Ramos, & Grieva, 2022). More specifically, the changes that I4.0 adoption brings, enhances overall potential of KM, and the process of knowledge acquisition, from both internal and external partners, promotes both process and product innovation (Tortorella et al., 2022).

One quantitative study by Gupta, Kr Singh, Kamble, & Mishra, (2022), surveyed employees of manufacturing and IT consultancy companies, to identify the critical factors of successful KM system in I4.0 environment, and three main groups of CSF were identified. First group, are the dependent factors, that have high dependance on other factors but also have low driving power, meaning that they are more important for the long-term success of organizational strategy and are more of an outcome of the KM integration in I4.0 environment, these are the identification and retention of knowledge, waste, cost, lead time reduction, and sustainable competitive advantage. Second group, linkage factors, have high dependance and also high driving power, and according to the authors, any change in these, both depends on, and affects other factors. The linkage factors are the organizational flexibility, employee empowerment, agile IT and KM systems. Final group, that have low dependence and high driving power, are called the drivers, these are leadership commitment to both I4.0 and KM, as well as their support, employee training on I4.0, KM strategy, organization culture that enables KM, and lastly – technology infrastructure. These are the critical drivers for successful KM and I4.0, thus DT, integration, and should be considered with top priority.

2.3.2. Knowledge-Based Dynamic Capabilities

The DT framework by Warner & Wäger (2019) reviewed in previous chapter, is based on the three groups of dynamic capabilities suggested by Teece (2007) – sensing, seizing and transforming. In the same research by Teece (2007), KM, specifically the processes of knowledge sharing, creation, and application, is considered as one of the micro foundations critical for the continuous alignment, realignment and integration of knowledge and resources in the transformation dynamic capability.
This connects the definitions and frameworks of all three concepts – DT, KM and dynamic capabilities, as all of them are focused on continuous new value creation for the organization, through similar processes of sensing, creating, seizing, applying and transforming organizational assets and both tangible and intangible resources.

Concept of dynamic capabilities within knowledge management, is elevated and made even more relevant to KM and DT interplay, by the research of KM by Zheng, Zhang, & Du (2011), who introduced the framework of knowledge-based dynamic capabilities (KBDC), and states that "<…> dynamic capabilities are the ability to acquire, generate and combine knowledge resources to sense, explore and address environment dynamics.". Three such KBDCs are identified, that are closely connected with each other – knowledge acquisition capabilities, knowledge generation capabilities and knowledge combination capabilities.
Knowledge acquisition and generation capabilities are closely connected to the KM process of knowledge creation, but acquisition specifically refers to identification and acquisition of knowledge from both external and internal resources, while generation focuses more on the internal capabilities

to generate completely new knowledge, the third capability of knowledge combination covers the process of knowledge application and integration. All three of these capabilities are closely connected – acquisition and combination of newly acquired knowledge with existing one, will also influence creation of new knowledge internally (Zheng, Zhang, & Du, 2011). Kaur (2019) identifies the same two KBDCs of knowledge acquisition and combination, but joins the knowledge generation with the knowledge acquisition capability, and identifies a new one – knowledge protection, which includes the processes of restricting access to critical, proprietary or sensitive knowledge, protection from misuse, loss or theft.

A modified definition of KBDC, in the context of DT, states that "<…> knowledge-based dynamic capabilities in a digitally transformed era are context- dependent and higher-order capabilities that enable a firm to integrate, build, and reconfigure internal and external knowledge and digital or material resources, as well as lower-order capabilities, in order to rapidly address changes related to the digital transition." (Mele, Capaldo, Secundo, & Corvello, 2023). These higher-order dynamic capabilities, are usually identified as the Adaptive Capability of organizations to address market shifts quickly, upgrade its technology and upskill the people; Absorptive Capability to acquire the needed knowledge and use it efficiently, as well as the Innovative Capability to use the acquired technologies, skills and knowledge, to create a competitive advantage and new value to its customers (Kaur, 2019).

A more in-depth examination of the KBDCs and a detailed analysis of their components can be found in the work of Bhardwaj, Srivastava, Mishra, & Sangwan (2022), who analyzed the KBDCs in a social purpose organization context, using a multiple-case study approach. The authors identified the following micro foundations of KBDCs:

- Knowledge Acquisition capability consists of two components. First, is the ability create knew knowledge and ideas from participating in various knowledge sharing events, learning and upskilling initiatives. Second one is the acquisition of strategic assets, tangible resources and knowledge.
- Knowledge Generation capability consists of more components that are specific to social purpose organizations, such as various commitments the organization establishes, but also have identified more generic components such as creation of new technological and marketing knowledge through experiments, prototypes and development or acquisition of new technologies, as well as co-creation of knowledge with volunteers, or in the case of regular organizations – its partners.
- Knowledge Combination capability involves decentralizing and restructuring of the company to be more agile and specialized; integrating and combining knowledge from different functions and teams; collaboration and co-innovation with other organizations.

To summarize, KBDCs is a more structured representation of the intersection between DT, KM and dynamic capabilities suggested by Teece (2007) and Warner & Wäger (2019). They highlight how KM processes of knowledge creation, sharing and application, are also foundational for the dynamic capabilities necessary for successful DT. KBDCs supports DT by providing the correct knowledge and KM practices required for the success of the transformation, and also supports the KM processes and activities themselves – capabilities to acquire external knowledge, integrate it and create new internal knowledge, store and maintain it securely and efficiently, then apply, reuse and augment, are the critical capabilities needed for both successful KM and DT processes.

2.3.3. Knowledge Management and Digital Transformation Integration Challenges and Critical Success Factors

Based on the literature review that analyzes DT and KM interplay, it is evident that the main focus of researchers are the compounding benefits of these processes, but there is little notable research on the challenges and their interactions. However, after reviewing the challenges and CSFs related to KM and DT individually, it becomes feasible to establish a common understanding of their synergy as well. This understanding highlights the challenges and CSFs common to both concepts, how they interact to amplify these challenges, and the essential factors for successfully addressing them.

Table 10. Identified KM and DT synergistic challenges, enablers and interplay in People category

Category	Challenge	Enabler	Interplay
People	Knowledge and skill gaps	Organizational learning, technology	DT can offer technology for e-learning and skill development, KM ensures retention and dissemination of DT critical knowledge through organizational learning initiatives
	Knowledge loss and hoarding	KM practices and culture, technology	Robust KM, powered by digital technology, can make capture and conversion of critical explicit and tacit knowledge easier, provide a structure to preserve knowledge generated in DT and knowledge sharing culture to disseminate the knowledge across the knowledge silos
	Lack of employee engagement and motivation	Active employee involvement, leadership support, incentives and rewards	Involving employees in DT and KM, by using incentives and rewards, can create a greater buy-in into DT initiatives, encourage knowledge sharing culture and overall engagement in the organization

The first two shared challenges are very closely connected – the skills and knowledge gaps of employees that organizations face during DT and KM implementations, as well as the two seemingly opposite, but very connected risks of knowledge loss and knowledge hoarding. DT is a knowledge intensive process, and development of knowledge around DT, is a major challenge for organizations (Sauter, Bruch, Badasjane, Granlund, & Ahlskog, 2024) – adopting DT and using digital technologies, requires new technical and soft skills, such as knowledge specific to the technologies, problem solving and communication skills (Mielli & Bulanda, 2019), because in the context of I4.0, employees often must take on more creative and strategic activities than before (Gupta, Kr Singh, Kamble, & Mishra, 2022). Organizations should identify the missing skills and competencies, then focus on closing this gap by providing diverse levels of training – technical and soft skill, DT specific and KM specific training (Gupta, Kr Singh, Kamble, & Mishra, 2022). Loss of critical knowledge,

when experienced and trained workers leave the organization, can be damaging to operational efficiency and even business continuity, and it creates a space for knowledge hoarding – or a dependance on tacit knowledge that the experienced employees keep to themselves (Nakash & Bouhnik, 2020). Because of the intensity and amounts of knowledge created and transferred during DT projects, it is critical that it is retained in the organization, and technologies such as AI or ML can help with capturing and retaining this critical tacit knowledge (Gupta, Kr Singh, Kamble, & Mishra, 2022). Creating a knowledge sharing culture, regarded as one of the most important components of KM, not only enhances collaboration among employees, but also helps with knowledge retention – knowledge that is shared, will not be lost when an employee leaves (Mazorodze & Buckley, 2019). Furthermore, building a culture of trust among employees, will enable both the knowledge sharing culture and organizational learning (Mathew & Rodrigues, 2019). To summarize, DT can provide the needed technologies for more effective training, knowledge capture and dissemination, while robust KM practices will ensure the new acquired knowledge is retained and effectively disseminated across different company levels, with the help of various organizational learning activities and KM practices.

Third challenge in the category of People, is the lack of employee engagement. Because DT processes heavily depend on the human resources of organizations, it is also critical that the employees are engaged in the ongoing changes and DT activities, which will increase the DT adoption rate in the organization and reduce employee resistance to the changes (Osmundsen, Iden, & Bygstad, 2018). Employee involvement is just as critical for the success of KM processes, and leadership should create all the needed conditions for employees to get involved with KM processes, incentivize and reward sharing their tacit knowledge (Mathew & Rodrigues, 2019), if employees are not motivated and there is no knowledge sharing culture, KM initiatives will not succeed (Onofre & Teixeira, 2022). Therefore, empowering employees, motivating them to share knowledge, allowing them to be a part of decision-making process, will also incentivize the use of digital technologies and help with knowledge retention (Gupta, Kr Singh, Kamble, & Mishra, 2022), which can also increase the overall employee engagement in the organization.

Table 11. Identified KM and DT synergistic challenges, enablers, and interplay in Technology category

Category	Challenge	Enabler	Interplay
Technology	Rigid and outdated IT infrastructure	Modern, reliable, flexible IT infrastructure	Investment in infrastructure for DT can also create and improve the needed technologies for KMS, which will facilitate better knowledge flow and accessibility.
	Poor data, information, and knowledge quality	Robust KMS and analytic systems	Implementing data storage and management technologies is one of the foundational prerequisites for DT, which would also serve KM by providing reliable data storage solutions as well as data sources
	Cybersecurity and compliance risks	Strong cybersecurity practices and measures	Making the cybersecurity practices stronger, protects data and technology involved with DT, reduces the risk of losing or leaking critical knowledge assets, especially when sharing the

			knowledge with external partners, which is a requirement for successful DT

First challenge in the Technology group, is the barrier of rigid and often outdated IT infrastructure and legacy systems. Creation and maintenance of digital technology infrastructure, is one of the major factors in the success of KM and I4.0 technology integration – it can upgrade the KMS, and enable more efficient knowledge storage and sharing, provide access to and upgrade the organizational knowledge with more actionable, real-time data (Gupta, Kr Singh, Kamble, & Mishra, 2022). IT infrastructure must be ready to facilitate these upgrades, data integration, analytics, and process orchestration (Ubiparipović, Matković, Marić, & Tumbas, 2020), which means that it needs to be flexible, scalable and be able to adjust to new technologies, information, and knowledge needs (Vogelsang, Liere-Netheler, Packmohr, & Hoppe, 2018). Applications and infrastructure that is either in-house built, heavily customized, or legacy, are usually hard to integrate with modern technologies, hard to update and maintain, or connect with new applications (Mielli & Bulanda, 2019). In the context of KM, obsolete and legacy technologies not being able to communicate and implement the efficiencies of modern technologies brought by DT, reduces the efficiency and productivity of KM, as well as the satisfaction of employees (Hammoda & Durst 2022). IT infrastructure, that is connected and integrated with other enterprise systems and KMS built on such infrastructure, which is easy to use, access and share knowledge with, is one of the critical KM success factors (Sensuse, Qodarsih, Lusa, & Prima, 2018). High, and often unclear, implementation costs are a challenge for both KMS (Zia & Asgher, 2022) and DT (Oludapo, Carroll, & Helfert, 2024) thus, investment into modern, reliable and flexible IT infrastructure and applications would create a synergy and have a positive impact on both the DT processes, as well as KM, through the upgrades and creation of efficient and flexible KMS.

In order to fully utilize the effect that new technologies and modern infrastructure can bring, quality of organizational data, information and knowledge, also needs to be addressed. For a successful DT, correct data needs to be provided to the right user, available real-time and cover many different aspects and alternatives (Vogelsang, Liere-Netheler, Packmohr, & Hoppe, 2018). Knowledge also needs to be kept up to date, validated and refreshed to make sure that the knowledge that is applied by the employees is not outdated and of high quality (Durst & Zieba, 2018). Knowledge that comes from a variety of sources, is structured, mapped, and high quality, are some of the KM CSFs identified by Onofre & Teixeira (2022) and analytics systems, that are able to process both structured and unstructured, real-time, big data, information from external and internal sources, create insights by using predictive analytics, creates a competitive advantage for organizations (Ubiparipović, Matković, Marić, & Tumbas, 2020). Implementing efficient data, information and knowledge storage and analytics systems, is a foundational requirement for DT, and when implemented, they can also serve KM processes by providing the information and data required to create new knowledge, store, structure and update it, then support the decision making by providing both up to date knowledge and real-time data.

Third common challenge in the technology group, are the various cybersecurity related risks. While building systems that allows for more flexible and easier access to data, organizations also need to be aware of the increasing risk of cyber-attacks, potential data leaks or losses, and make sure to address

security of systems and privacy of data, especially customer's data (Abdallah, Shehab, & Al-Ashaab, 2021). Knowledge leaks can happen both intentionally, during cyber-attacks, and unintentionally, but the risk is especially high when dealing and sharing the knowledge with external partners (Hammoda & Durst 2022), which is a critical practice for both KM and DT success. KMS upgraded and integrated with DT and I4.0 technologies, processes large amount of data and information, which creates data privacy and security risks, in order to minimize them, organizations need to invest in cyber security systems, raise employee awareness (Gupta, Kr Singh, Kamble, & Mishra, 2022), create robust security practices by adapting compliance rules to DT and KM, creating guidelines, risk management systems, strategies (Ubiparipović, Matković, Marić, & Tumbas, 2020), strict control of information access roles (Vogelsang, Liere-Netheler, Packmohr, & Hoppe, 2018). The combination of technological, awareness and process related solutions, would improve the security of data and knowledge stored, reduce the risk of losing or leaking it and improve the security of knowledge sharing with external partners.

Table 12. Identified KM and DT synergistic challenges, enablers and interplay in Organization category

Category	Challenge	Enabler	Interplay
Organization	Lack of strategy and its alignment	Aligned DT and KM strategy with overall organizational goals	DT and KM need to be integrated in all levels of organizational strategy planning processes, to make sure they can support overall business goals and are seen as a synergistic processes.
	Lack of leadership support and funding	Active leadership engagement, endorsement and resource provision	Cultivating a supportive culture for either DT or KM, will also affect the other. Resources provided for DT, can create needed synergies for KM and KMS implementation as well
	Poor organizational culture	Fostering an entrepreneurial culture of trust, knowledge sharing and continuous learning	Cultivating a culture that learns from mistakes, can innovate fast, has high level of trust and openness, can lead to knowledge-rich environments, where that knowledge will need to be managed effectively
	Lack of organizational agility	Organizational flexibility and agility	KMS and KM can ensure that DT teams and initiatives have the required knowledge to adapt to the rapidly evolving conditions and requirements, while DT technologies enables KBDCs, specifically quick and efficient recombination of knowledge. A flexible, organizational structure, with minimal hierarchy, will empower its overall agility and both KM and DT.
	Poor cross-functional collaboration	Cross-functional collaboration and team enablement	DT requires knowledge from different functions and departments, effective KM practices can facilitate the knowledge exchange, while DT tools can provide the medium to do it. A knowledge sharing friendly culture will

			help adopt new tools, techniques and encourage participation in cross-functional teams
	Non-existent or poor external collaboration	Active external partnerships and collaboration networks	DT requires external collaboration, especially in the supply chain, and can provide technologies and standards to collaborate effectively, while KM can make sure the external knowledge is captured, stored and applied in the organization.

The Organization category has the most identified common challenges between KM and DT. First one, is the importance of strategic alignment, not only between KM and DT, but also with overall organizational goals and strategies. Importance of KM strategy is identified as one of the CSF by Gupta, Kr Singh, Kamble, & Mishra (2022), who wrote that organizations need to develop KM strategies, that would fit their unique set of external and internal variables, identify the needed capabilities, resources, set timelines and decide on the success criteria, and formulating such strategies is especially important when implementing I4.0 technologies with KM. In order to be successful, formulated KM strategy needs to be connected to the overall business strategy, objectives and performance, be clear and communicated to all levels of the organization (Mathew & Rodrigues, 2019). Similarly, DT strategy also need to be developed in tandem of the overall business strategy, reflect the market organization is operating in, its needs, and be clearly communicated (Mielli & Bulanda, 2019). KM can even help in formulating the digital strategy of organizations – successfully and efficiently applied knowledge, can help create DT strategy and even redefine the business model of the organization (Zoppelletto, Orlandi, Zardini, & Rossignoli, 2020). Therefore, working on interconnected KM and DT strategies, that are also connected to the business objectives, needs, and are communicated across organization as synergistic processes, is a critical factor in this interplay.

Formulation of strategy, leads to the second challenge of leadership support, which comes in two forms – overall engagement and endorsement, as well as provision of resources. Both lack of executive support, and allocation of budget needed for KM practices to work efficiently are seen as two biggest negative factors in KM success (Mazorodze & Buckley, 2019). In an unstable environment that DT creates, leadership should commit to the KM projects, create environments that would allow efficient knowledge creation and sharing, and then focus on change management of KM, by creating, communicating and seeing through a vision, that takes the KM processes to the desired future state (Sedighi & Zand, 2012), this requires funding and resources, and the leadership is responsible to provide it (Mathew & Rodrigues, 2019). Financial resources are also critical for DT, as the lack of stable and secure budget, can severely limit the impact of DT (Ubiparipović, Matković, Marić, & Tumbas, 2020), but it should not stop with the provision of financial resources, provision of required time and knowledge are also critical to the success of DT projects (Vogelsang, Liere-Netheler, Packmohr, & Hoppe, 2018). KMS can help with ensuring the provided resources are optimized and knowledge is applied and exploited efficiently by creating optimal knowledge sharing avenues and facilitating knowledge-based decision making (Di Vaio, Palladino, Pezzi, & Kalisz, 2021). Similarly to the IT infrastructure risks, resources that are provided to DT initiatives, can also impact KM, while leaders who actively engage with and commit to enabling organizational culture that fosters change during DT, will also indirectly or directly support a culture that is beneficial for KM as well.

Poor organizational culture, that manifests itself in the lack of trust between employees, lack of knowledge sharing and entrepreneurial culture, is a critical barrier for success of both KM and DT. First of all, DT and embracing new digital technologies, calls for an organizational culture, that is willing to take risk, invest in high-risk projects focused on long-term return (Abdallah, Shehab, & Al-Ashaab, 2021), though this strong entrepreneurial culture enables DT through potentially allowing the organization to develop its own technical solutions, it can also contribute to the technological challenge of having a non-standard IT infrastructure (Sauter, Bruch, Badasjane, Granlund, & Ahlskog, 2024). Also, a culture of allowing failures with proof-of-concept or pilot projects, would alleviate some of the risks involved with investment into these high-risk projects (Vogelsang, Liere-Netheler, Packmohr, & Hoppe, 2018). This leads to knowledge-rich environment, that also requires a knowledge-friendly culture, that promotes knowledge sharing, adoption of new technologies, processes and techniques (Gupta, Kr Singh, Kamble, & Mishra, 2022), while a lack of trust among employees, will impact their willingness to share knowledge (Sedighi & Zand, 2012), and building an organizational culture that allows for knowledge sharing is critical to alleviate the aforementioned risks from the People category as well.

An organization that can quickly adapt, and learn from its mistakes, needs to be supported not only by its culture, but by the overall structure as well – lack of organizational agility and flexibility is a challenge that affects the impact of KM and DT. Organizations need to shift their focus from emphasizing control of its processes, to emphasizing agility, dynamic capabilities to respond to market disruptions, reorganize its resources and structure (Osmundsen, Iden, & Bygstad, 2018), focus on the hierarchical structure of the organization and identify how it needs to change, in order to facilitate DT initiatives better (Oludapo, Carroll, & Helfert, 2024). A flexible and agile organizational structure also enables different KM processes – organizations that have less hierarchical levels and can be easily restructured, can also quickly restructure and reconfigure its knowledge resources and align with the disruptions in the market (Gupta, Kr Singh, Kamble, & Mishra, 2022). Through the use of KBDCs of knowledge acquisition, generation, combination and protection, as well as a flexible and agile organizational structure, companies will also boost the effectiveness of KM and DT processes.

Last two challenges are closely related to each other, organizational structure and culture, and refers to the internal collaboration through cross-functional teams and external collaboration through external partnerships and collaboration networks. As mentioned before, DT is a knowledge intensive process, which requires employees from different functions and possessing different knowledge to collaborate on complex projects (Vogelsang, Liere-Netheler, Packmohr, & Hoppe, 2018), this collaboration can stimulate the generation of new ideas, drive innovation, eliminate knowledge silos (Ubiparipović, Matković, Marić, & Tumbas, 2020) and in the context of KM, it supports, and is supported by, knowledge sharing culture which also depends on trust and teamwork, which are essential for creation of new ideas, solutions and organizational innovation overall (Mathew & Rodrigues, 2019). This internal teamwork and collaboration, needs to be supported by external partnerships as well. Collaboration, extending beyond the organizational boundaries, allows the partners to work together as experts and focus more efficiently on specific areas of innovation and DT (Ubiparipović, Matković, Marić, & Tumbas, 2020), furthermore, collaboration with external knowledge experts, using and integrating their knowledge, is a requirement for effective DT, especially in small and medium size enterprises (Tung, 2023). Integration of these two knowledge types, was found to be one of the key knowledge-based dynamic capabilities as well – it improves knowledge worker productivity, and organizations should build robust networks and mechanisms to

absorb external knowledge (Khaksar, Chu, Rozario, & Slade, 2020). Acquisition, internalization and application of external knowledge, either through mergers and acquisitions or levering the customer and supplier networks, helps organizations with their own DT initiatives, change management and creation of new value propositions (Osmundsen, Iden, & Bygstad, 2018). Same is true in healthcare industry, where bi-directional knowledge transfer and sharing, was found to increase the pace and reduce the costs of digital transformation (Hinder et al., 2021). The dependency on inter-organizational knowledge is evident not only in the bi-directional knowledge sharing, but also in the knowledge creation process, as due to the complexity and variety of technologies adopted during I4.0 transformation, organizations require both internal and external collaboration, especially with Knowledge-Intensive Business Services companies (KIBS), to create new knowledge and achieve its innovation goals (Bettiol, Capestro, Di Maria, & Grandinetti, 2023).
But these external partnerships also comes with a set of risks. Firstly, it is critical to select partners that have the required knowledge and expertise in DT, failing to do so, can lead to incorrect decisions and waste of resources (Mielli & Bulanda, 2019), secondly, external knowledge sharing creates various knowledge loss and cybersecurity related risks (Hammoda & Durst, 2022) that are reviewed in the Technology category as well, and lastly, external partnerships might also required standardized infrastructure or ways to integrate with the partners (Abdallah, Shehab, & Al-Ashaab, 2021). To summarize, according to Duarte Alonso et al. (2024) in the context of DT and I4.0, the organization becomes a "nexus between internal and external knowledge and expertise acquisition", and it needs to facilitate internal learning through various events and employee upskilling, but also involve external partners, where the internal knowledge does not suffice. This combination of cross-functional internal collaboration and strategic external partnerships, with the help of knowledge sharing culture facilitated by secure KMS, can synergistically improve the efficiency of DT, by providing the heterogenous knowledge it needs to succeed, and KM by providing the systems and expertise needed to upgrade KM in the era of DT.

To summarize, the combination of KM and DT presents several challenges, CSFs and common potential solutions, that are critical for achieving synergistic value creation. The analysis highlights the importance of three main groups of challenges – People, Technology and Organization. In the People category, it is critical to address the employee skill gaps, knowledge retention, employee engagement with the processes of DT and KM. Technology challenges are mostly related to outdated IT infrastructure, data, information and knowledge quality issues, and cybersecurity risks. Organizational challenges are the biggest group, and includes strategy misalignments of KM and DT as separate processes, their combination and alignment with overall business goals, lack of agility, leadership support, enabling culture and internal or external collaboration are also found to be critical common challenges. Therefore, fostering a collaborative knowledge sharing culture, upgrading technology and IT infrastructure, and engaging employees and providing full leadership support, resources and incentives are a few of the strategies that can be vital for leveraging the synergistic capabilities of KM and DT.

2.4. Development of the Conceptual Model of Digital Transformation and Knowledge Management Interplay

The following chapter will discuss the research gaps identified after literature review, and present the conceptual model of DT and KM interplay.

2.4.1. Gaps in Knowledge Management and Digital Transformation Research

The overall analysis of definitions, benefits and risks, available frameworks and models, shows that the concepts and processes of DT and KM support each other and are interconnected. Their critical success factors are supported not only by technology, but also by dimensions of the organization, people and processes, furthermore, both concepts have a direct and positive impact on business performance – from overall efficiency to innovation performance and even sustainability goals. The synergy of DT and KM, would allow to efficiently use the soft and hard competencies and resources of an organization, open new potential of growth and innovative solutions. Nevertheless, there are also critical gaps in the research of DT and KM interplay, that can be identified based on the literature review summarized in chapter 2.3.1.

Even though both KM and DT are being actively researched, and there are cases and studies on the interactions of their elements, there is not enough, in-depth, and decision-oriented studies revealing a full picture of the interplay between these processes. So far, digital transformation has been approached mostly from the technology perspective, and the people side of it, which is an important source for competitive advantage in the context of KM, has been addressed less frequently (Fakhar Manesh, Pellegrini, Marzi, & Dabic, 2021). More specifically, sharing of tacit knowledge, while also extensively studied, is an almost unknown field, when it comes its interaction with software, particularly Industry 4.0 and Web 2.0 technologies (Cerchione, R., Centobelli, P., Oropallo, E., Magni, D., & Borin, E., 2023). Integration of tacit knowledge is called out specifically in the SECI-based model by Silva, Santos & Souza (2021), but the model lacks more in-depth understanding of other I4.0 principles and the technology application or KMS dimensions. Tinz, Tinz, & Zander (2019) conducted a review of five KM frameworks encountered in smart factories, including processes of knowledge identification, development, exchange, use, preservation, evaluation, data protection and human-machine and machine-machine interactions. The authors discovered, that the models only selectively represent the human-machine and machine-machine interactions, data privacy and security challenges, and recommend for future models to include organizational learning culture as well as other missing I4.0 challenges. Li, Landström, Fast-Berglund, & Almström (2019) – found that I4.0 technologies is one of the focus topics in KM research, though KM is not a focus topic in I4.0, which does not allow for creation of simplified, connected, frameworks that would allow for quicker adoption of the technology with a human centric approach.

There is also a lack of cross disciplinary and case studies, that would join theoretical and practical approaches to the interplay of KM and DT. Firstly, there is a difference between what technologies practitioners and academics focus on, which indicates that there is a concerning gap in literature of how technologies are applied in practice (Schniederjans, Curado, & Khalajhedayati, 2020). Wolf & Erfurth (2019) highlights the necessity to involve KM concepts and models from various scientific disciplines, but also suggests that these models must be empirically tested in organizations. In the context of DT, there is also a clear need for researchers and practitioners to work together, as DT creates a new knowledge environment of rapid change, that needs to be further analyzed, as suggested by Wang, Zhang, Xiong, & de Pablos (2020). The literature review conducted by de Bem Machado, Secinaro, Calandra, & Lanzalonga (2021) confirms the existence of a significant gap in the viewpoints – out of 2065 authors, only 327 are practitioners, and another 149 have a mixed background. More in-depth case studies are also needed, that would address different business

contexts and challenges of I4.0 (Abu-AlSondos, Alkhwaldi, Shehadeh, Ali, & Al Nasar, 2024), test the models that are created by the academic research (Silva, Santos & Souza, 2021), and provide organizations with comprehensive tools and processes to address those challenges (Anshari & Hamdan, 2022).

These gaps create a need for a standardized framework and a set of recommendations, that integrates the various concepts and processes of both KM and DT, cover the common challenges, risks, created opportunities and needed organizational, technological and people-related capabilities, that would connect the concepts found in academic research, but would also be grounded and validated in practice.

2.4.2. Essence of the Conceptual Model

The conceptual model presented in the following chapter, was created based on the notion that KM and DT are complimentary processes, that are both continuous, encompasses all levels of an organization, all its activities and dimensions and has a common goal of creating new organizational value, based on the specific objectives of the organization. This cyclical and complimentary relationship is the first element of the conceptual model. Due to the identified research gaps, the model also incorporates the common core foundations, common challenges and risks, as well as the possible solutions. The risks and synergistic solutions are not depicted having a one-to-one relationship, due to the processes being closely interconnected, and one solution can potentially affect multiple risks or dimensions of the KM and DT synergy. This creates an integrated, cyclical, conceptual model, that reviews multiple dimensions of interaction between KM and DT, their impact on an organization, and suggests a concrete list of possible synergistic solutions that would drive the interplay of KM and DT forward.

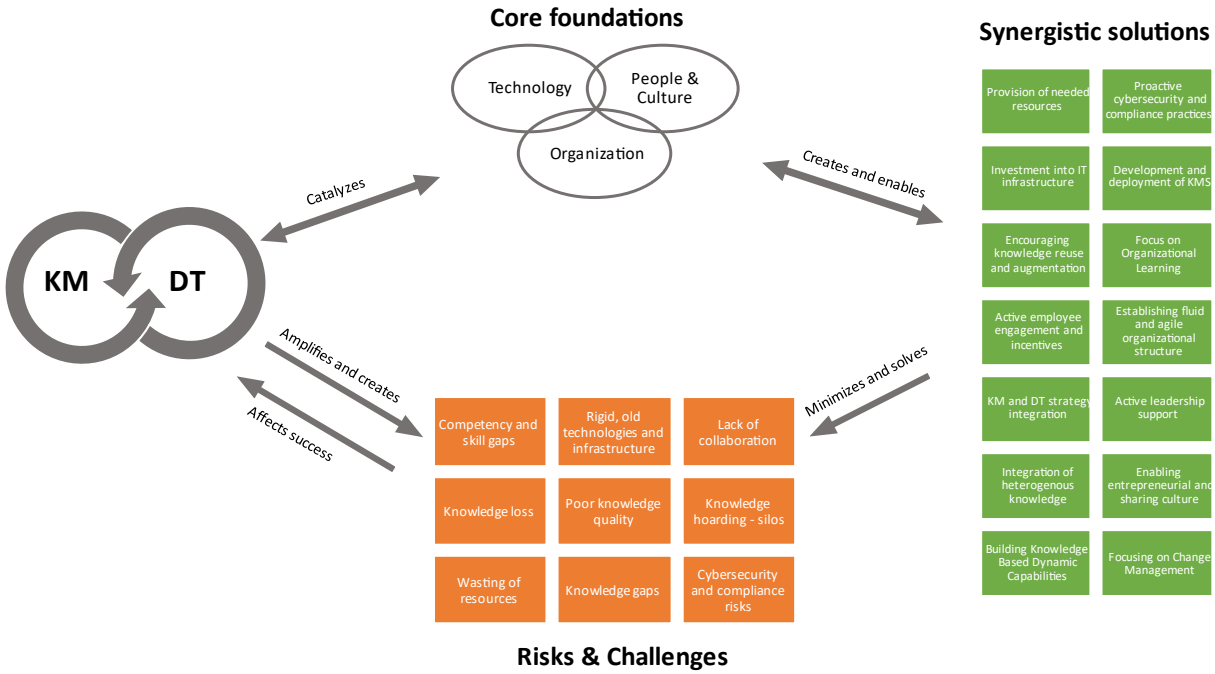


Figure 6. Conceptual model of KM and DT interplay

Core Foundations

Second group of elements in the conceptual model, are the core foundations that are common between KM and DT processes, and in their intersection become even more critical – Technology, People & Culture and Organization.

The first capability is the Technology, which is extensively covered in the context of DT, in chapter 2.1.2 and in the context of KM, in chapter 2.2.2. Technology is a key element of DT as evident from the various definitions presented in the literature – it can be both a trigger for DT, and its enabler (Vial, 2019; Warner & Wäger, 2019). In the context of KM, the key technological enablers can be summarized under the term KMS, which can be viewed as an extension of other various technologies used in DT, it can also help transform gathered information into knowledge, especially when used together with IoT technologies (Santoro, Vrontis, Thrassou, & Dezi, 2018). Implementing a KMS, similarly to implementing any other digital technology, becomes a DT project and requires focus on the key areas of implementation of the actual technology, leadership and strategy alignment, cultural and process changes, as well as organizational context, needs and available resources (Maramba & Smuts, 2020). Therefore, Technology becomes a core concept in both DT and KM fields, which can be a trigger and an enabler at the same time.

Second required core foundation, are the People and Culture, namely – the culture of knowledge sharing, entrepreneurship and human centricity. As discussed in the section 2.3.2, DT requires a culture, that embraces change, takes on risks, allows learning through failures and pilot projects (Abdallah, Shehab, & Al-Ashaab, 2021; Vogelsang, Liere-Netheler, Packmohr, & Hoppe, 2018). This constant innovation and experimentation, creates a knowledge-rich environment, in order to reap all its benefits and use the generated knowledge effectively, a knowledge friendly culture of sharing and trust is also required, which will in turn empower more learning, pilot projects and technology adoption (Gupta, Kr Singh, Kamble, & Mishra, 2022). People, their skills and knowledge, are the critical resource in the success of DT initiatives, and organizations should start their transformation from the changes of the people, culture and organization, instead of technology (Kane, 2019). This creates a human-centric approach, which is also an important factor in the transition to I5.0, and companies that can combine human resource management with KM, through diversity, inclusion and people empowerment policies can improve their organizational performance as well (Cillo, Gregori, Daniele, Caputo, & Bitbol-Saba, 2021).

Third overarching core foundation is the Organization, with its strategy, processes, leadership, structure and environment that the organization operates in. First, DT needs to be recognized as a critical part of the overall business strategy and the strategy of DT itself, needs to be closely integrated with the strategy of the business (Ubiparipović, Matković, Marić, & Tumbas, 2020), which means that it needs to align with the unique situation, environment and set of capabilities of the organization. Similar approach needs to be taken with KM, where its strategy also needs to be developed in a way that aligns with the business goals and fits their unique internal and external environment (Gupta, Kr Singh, Kamble, & Mishra, 2022). Due to the complexity of technologies, new dependencies, and relationships in the organization that DT creates, organizations wanting to remain in control of these processes, need to create a more common understanding and strategy of KM that integrates with DT

strategy as well (Wolf & Erfurth, 2019). It is the main task of senior management or leadership of an organization to develop these strategies, provide resources, engage and empower employees to use them, and increase the flexibility of organizational structures (Gupta, Kr Singh, Kamble, & Mishra, 2022). Small and Medium Enterprises (SMEs), are a good example of such organizations – their leadership is usually more actively involved, they posses relatively flat or flexible organizational hierarchy with a high level of personal authority, which favor innovation and DT initiatives, though they need to be balanced with more formal initiative coordination and controls (Lokuge & Duan, 2022), large organizations are usually on the other side of this spectrum, thus a balanced approach is needed for both types of organization. Another important additive of the Organization foundation, is the environment the organization operates in, and how well it adapts to the changes in that environment. Organizations that can that implement strategically integrated KM, can apply dynamic capabilities and compete by foreseeing and adapting to shifts in the market, build effective relationships with suppliers and customers, as well as allocate its resources more efficiently (Khedr & Gohar, 2023). To summarize, the foundation of Organization, covers a broad array of elements ranging from the strategy and structure of an organization, to its leadership, processes, and how it is able to interact and adapt to the internal and external environment. Collection of these elements, is a driving and enabling foundation in both KM and DT processes, and it becomes critically important in its intersection.

Risk & Challenges

Third group of elements are the various risks and challenges, that are either common to KM and DT, or is more pronounced in one of the processes, but their interplay amplifies and highlights these issues. These risks affect the success of the interplay between KM and DT, as well as the implementation of the required capabilities and their efficiency. All the identified risks in the model are also covered in the chapters 2.1.3, 2.2.3 and 2.3.3. Most of the risks have a stronger or lesser impact on all of the core foundations, yet certain risks are more pronounced than the others. Following challenges were identified in the conceptual model:

- Competency and skill gaps cover the risks of not having required training, competencies or skills to effectively participate in KM and DT activities and use the new digital technologies or KMS. Having employees who have the required skills and competencies is a critical success factor for DT (Ubiparipović, Matković, Marić, & Tumbas, 2020) and for KM
- Rigid, outdated technology and IT infrastructure – outdated and rigid IT infrastructure is one of the critical barriers of new technology integration and DT, which can also stop development of effective KMS.
- Lack of collaboration – covers the risk of both internal and external collaboration. Internal knowledge should be one of the first knowledge resources to tap into when implementing new technologies or going through a DT initiative, but, if there is a lack of collaboration, achieving common goals, or a high level of knowledge sharing and integration, will not be possible. On the other hand, due to complexity of the DT processes, not all knowledge might be available internally or be easy to acquire, therefore strong partnerships are required to acquire external knowledge and integrate it successfully with the internal knowledge.
- Knowledge loss – retention of critical knowledge, is a big focus area in KM research – loss of such, mostly tacit, knowledge, can even lead to business continuity risks (Nakash & Bouhnik, 2020). Knowledge loss can happen due to multiple different reason – employee

attrition, intentional and unintentional forgetting or unlearning due to being too set in the "old ways" or being unengaged, and organizations need to be able to formulate strategies on how to deal with all of these risks, in order to make sure that their transformation processes are efficient and successful.

- Knowledge hoarding or silos – is a risk closely related to the risk of knowledge loss, as trying to avoid loss, can create a dependency on knowledge hoarded and held by these employees as knowledge silos (Nakash & Bouhnik, 2020). Creation of knowledge silos is also caused by the lack of collaboration and cross-functional cooperation, which can create a culture of competition and mistrust, which is a critical challenge of DT efforts as well (Brink, Packmohr, & Paul, 2022).
- Poor data, information, and knowledge quality – reduces the overall efficiency of the organization and transformation processes, increases the risk of data, knowledge and work duplication, can also reduce the trust in KMS, if it is implemented without knowledge clean-up activities.
- Wasting of resources – inefficient usage of knowledge, technology or knowledge gaps, can also lead to duplication of work, and thus – wastage of resources, such as labor, machine, time or monetary resources (Gupta, Kr Singh, Kamble, & Mishra, 2022).
- Knowledge gaps – because DT is a transformational process for the whole organization, it also requires vast organizational knowledge to support it – if an IT department has the knowledge on digitization, but does not have the knowledge about processes and needs of other functions, it creates a knowledge gap, that does not allow for effective DT implementation (Brink, Packmohr, & Paul, 2022).
- Poor cybersecurity and compliance – due to the integration of new technologies, external partnerships, intentional and unintentional knowledge loss risks, creation of new intellectual property fueled by DT, cybersecurity and overall compliance to standards and policies becomes a critical organizational risk.

Synergistic Solutions

All of these risks, can be either minimized or completely solved by the last element of the conceptual model – Synergistic Solutions. These are the more specific solutions and focus areas, that can also be a part of or enable the needed capabilities, and in the interplay of KM and DT, these solutions can gain even more importance, thereby simplifying the decisions to implement them. The solutions are covered in chapter 2.3.3, and are summarized as:

- Provision of needed resources – for both KM and DT processes, organizations need to first identify and then provide the required time, material and human resources. This would help ensure an adequate level of employee engagement using rewards, allocating time and people required to effectively manage knowledge.
- Proactive cybersecurity and compliance requirements – implementing concrete cybersecurity and compliance requirements, policies and guardrails, while staying proactive in addressing emerging risks, would help organizations ensure that the various cybersecurity related risks, knowledge loss and leaks, can be controlled, minimized or made highly improbable.

- Investment into IT infrastructure – if enough material resources can be provided, investments into IT infrastructure and refresh of outdated systems, would create the needed technological foundations for both DT and KMS.
- Development and deployment of KMS – KMS and KM processes can be expanded by the integration of more advance digital technologies and IT solutions – both tacit and explicit knowledge creation, sharing, application, replication and reuse processes can be enhanced by advanced AI and automation solutions (Gupta, Kr Singh, Kamble, & Mishra, 2022). KMS can facilitate every KM process, though the success of knowledge application, reuse and augmentation depends on the employees and their engagement with the system (Shrestha & Saratchandra, 2023).
- Encouraging knowledge reuse and augmentation – organizations need to make sure, that knowledge workers do not need to repeat an operation or recreate something that was previously achieved in the organization, only because of lack of knowledge and duplication of existing knowledge (Nakash & Bouhnik, 2020). Improving knowledge quality, encouraging reuse and active augmentation could at the same time solve knowledge quality challenge and improve KBDC.
- Facilitating Organizational Learning initiatives and culture, can help solve the skill and knowledge gap challenges, make employees and the organization more effective, prepare them to respond to changes better. Organizations that foster Organizational Learning and knowledge sharing cultures, can reach higher value from implementing I4.0 technologies (Tortorella et al., 2022).
- Fluid and agile organizational structure – organizations cannot successfully manage DT with the old, static hierarchical structures, and should become more flexible, open and quickly adapt to changes by adapting their organizational model as well (Smith & Beretta, 2020). A less hierarchical organizational structure can help enable the knowledge sharing culture needed for the DT and KM interplay, as well as facilitate easier knowledge transfers, more collaboration and experimentation.
- Active leadership promotion – leaders should be actively involved in both KM and DT transformation initiatives, promote them and the needed changes. Leaders that can inspire, support and facilitate the culture of trust and learning are critical to the success of an organization (Inkinen, 2016). Active involvement of such leaders will help create more robust, integrated strategies and lay the required foundations for organizational and cultural changes required (Mazorodze & Buckley, 2019)
- KM and DT strategy integration – concrete steps must be taken to integrate the KM and DT together and into the organizational strategy, then cascade it down to functional leaders and strategies, to make sure there is a common vison in the organization.
- Active employee engagement and incentives – employees need to be engaged and made a part of the DT processes, and encouraged to actively participate in KM. This would help solve not only the engagement risk, but could also encourage knowledge sharing practices and improve KBDCs of the organization. A properly motivated employee, through incentives or gamification of KMS, can help ensure a high quality of knowledge within the KMS, and help build the knowledge sharing culture (Friedrich, Becker, Kramer, Wirth, & Schneider, 2020).
- Enabling entrepreneurial and sharing culture – leaders should also focus to make sure that they are taking steps to enable the entrepreneurial and knowledge sharing culture in the

organization, which can be done through increasing collaboration, engaging employees, building mutual trust, as well as providing resources needed for experiments.

- Integration of heterogeneous knowledge – DT increases the heterogeneity of knowledge that is required for a successful transformation, and at the same time, it creates a highly heterogenous knowledge (Yoo, Boland, Lyytinen, & Majchrzak, 2012). Therefore, working on methods, practices, systems and strategies to implement a wide array of different knowledge assets, will help solve the internal and external collaboration, knowledge loss and hoarding challenges.
- KMDC, group of capabilities covered in chapter 2.3.2, refers to the ability of an organization to quickly adapt to changes and acquire, generate and combine knowledge (Zheng, Zhang, & Du, 2011). KMDCs have a direct and positive impact on DT through the support of KM processes, the better the KMDCs of an organization, the better are its capabilities to create, acquire, integrate and apply internal and external knowledge, which also allows to quickly use it and adapt to new market situations (Songkajorn, Aujirapongpan, Jiraphanumes, & Pattanasing, 2022).
- Focusing on Change Management – in the intersection of KM and DT, change management becomes another area for leadership to focus on, as a lack of change management practices will lead to failure of DT projects (Brink, Packmohr, & Paul, 2022). KM strategies of personalization, codification and Organizational Learning, can help implement these projects, by increasing the organizations readiness for change and reducing its cynicism (Imran, Rehman, Aslam, & Bilal, 2016).

The conceptual model is built on thorough analysis of the literature of KM, DT and their interplay. To address the first identified gap, the lack of integrated and standardized frameworks, the conceptual model is built on the notion that KM and DT are circular, highly inter-connected processes, and includes risks and solutions not only from the technology-focused side of the interplay, but also covers the People and Organizational dimensions through the identified capabilities, risks and solutions needed. In order to address the second literature gap, which calls for more collaboration between interplay and practice, an empirical research is required.

3. Empirical Research Methodology of Knowledge Management and Digital Transformation Interplay

In order to address the identified research gaps, especially the lack of cross disciplinary studies, and in order to validate the conceptual model of DT and KM interplay, the following research methodology was developed. It is expected, that the conceptual model can be validated and grounded in practice, with key risks, challenges and solutions highlighted or expanded.

3.1. Research Goal and Objectives

The goal of the empirical research, is to empirically validate the conceptual model of DT and KM synergy, provide managerial recommendations on building synergistic solutions and possible directions for future research.

Objectives of the empirical research are as follows:

1. Prepare the methodology for semi-structured interviews, that would allow for a deeper, practical, understanding of the synergy between KM and DT in the context of selected case study.
2. Validate and ground the conceptual model, by validating the practical implications of KM and DT interplay.
3. Disclose the challenges, risks and opportunities seen in practice that are created, or made stronger, by the synergy of KM and DT.
4. Provide managerial recommendations, on designing synergistic solutions between KM and DT, that would enable both processes and highlight future academic research directions that would drive the field forward.

The empirical research objectives will help with filling in the two academic research gaps identified – it will help build an integrated, multi-faceted KM and DT interplay model, by combining the insights collected from a thorough academic research, with a practical perspective and examples.

3.2. Research Design

The research utilizes a qualitative, single case study design with semi-structured interviews, in order to gain a deeper, more comprehensive, understanding of the concepts and interactions being studied.

Similar, qualitative type research, utilizing semi-structured interviews, were already conducted in the KM and DT interplay research field, as evident from the literature review summarized in chapter 2.3.1. Semi-structured interviews were used by Zoppelletto, Orlandi, Zardini, & Rossignoli (2020) to analyze the critical knowledge factors in DT, across different industries, also by Wu & Wang (2023), who focused on managers from different healthcare organizations, and analyzed how can DT be implemented by taking advantage of KM. A single case study method was employed by Siuko, Myllärniemi, & Hellsten (2023), to understand how to enable DT from the perspective of KM in the public, but the authors also interviewed other organizations, that were collaborating with the organization being researched. All three of the research papers identified similar limitations and future research agendas – scope should be changed to different regions, company sizes and industries. All other reviewed, empirical papers, were employing either quantitative research methods, or instead

of semi-structured interviews, were utilizing surveys to gather answers from their respondents. The lack of qualitative research, and especially lack of case studies is evident from the bibliographic analysis of Journal of Knowledge Management, conducted by Donthu, Kumar, Sureka, Lim, & Pereira (2022) – from the year 1977 to 2021, 65% of research was empirical, but only 15% employing qualitative research methods, of that, 21% of the studies were interviews and 13% – case studies.

Because the goal of this research is to validate the conceptual model, by gaining more in-depth, practical insights into the KM and DT synergy, a single case study can help produce this in-depth, multi-faceted, understanding and findings that could also have more broad applicability (Boddy, 2016). The semi-structured interview is a flexible method of qualitative data collection, where highly specific topics can be addressed, also leaving the possibility for the interviewee to offer new insights and experience through a combination of closed and open ended questions (Galletta, 2013). This approach is recommended when the goal of the research is to analyze complex topics, based on the perceptions and opinions of respondents, when respondents possess limited awareness of the research subject, or when there is a need to gain more insight about practical issues through the experiences of the interviewee (Kallio, Pietilä, Johnson, & Kangasniemi, 2016). Because the goal and objectives of the research is to validate the conceptual model, by expanding it with practical perspectives and then offer both academic and managerial recommendations, the semi-structured interview with a single case study can provide the required depth with a focus on the specifics of the chosen case study.

3.3. Research Sampling

The qualitative studies of KM and DT interplay research field, reviewed in the previous chapters, suggests to expand the scope of the research into different markets, regions and functions, and the research field itself calls for a case study with an organization that would have experience with both DT and KM processes, therefore, a large, global manufacturing company (hereinafter Company), with multiple manufacturing locations in different geographical regions, working in different industries, was chosen as the organization for the single case study. The Company generates about 2.4 Billion yearly revenue, employes over 17,000 employees in 20 countries and has a diversified portfolio of markets and industries it works in – from producing electronical components to consumer electronics, to semiconductors for industrial applications or sensors for the automotive industry. Major manufacturing locations, research and shared-services centers of the Company are established in China, Philippines, Mexico, Germany, Lithuania, France, among others. The Company attributes half of its yearly growth to inorganic growth through M&A activities, and sees DT as a critical driver of organizational efficiency and value creation.

Hennink & Kaiser (2022) found, that in order to reach saturation, which is one of the most important metrics to consider when selecting a sample size for qualitative research and indicates that all of the possible insights are collected from the data, a relatively narrow range of interviews are needed – from 9 to 17. The respondents for the interview were selected using a purposive and heterogenous sampling strategy, as described by Etikan (2016) – all the respondents are directly involved in DT projects and initiatives, have experience with KM processes, but in order to review a wider spectrum of experiences and perspectives, a more heterogeneous sample of interviewees was selected. First of all, to cover the multi-national aspect of the Company and potential cultural differences, respondents from three general regions were selected – North America, Europe and Asia, which also covers different industries that the Company operates in, furthermore, in order to gain perspectives of different roles, functions, experience and seniority levels, respondents were purposefully selected, to

fit under three different levels of the organization – management, team leaders or supervisors and team members or individual contributors as well as fitting into two different functions – Business and IT, and lastly, in order to make sure that all of the respondents would be able to participate in the interviews and answer the questions to the best of their ability, the selected respondents were informed in advance about the research topic, ensuring confidentiality, with an invitation to participate in the research, only the respondents who agreed to participate, were invited to the interview sessions. In total, 21 semi-structured interviews were conducted, summary of the respondents can be seen in the Table 13. For data confidentiality and privacy, all respondents are coded with IDs from R1 to R21.

Table 13. Summary of semi-structured interviews and respondents

Respondent ID	Region	Function	Role	Organizational level	Years in the Company	Interview duration (minutes)
R1	North America	IT	Director of Innovation	Management	21	60
R2	North America	IT	Lead Data Engineer	Team Lead	3	50
R3	Europe	Business	Business Intelligence Supervisor	Team Lead	6	55
R4	Europe	IT	Programming Supervisor	Team Lead	5	45
R5	Europe	Business	Business Analyst	Team Member	3	60
R6	Europe	Business	Senior Lean Manager	Management	4	70
R7	Asia	IT	Applications Architecture Manager	Management	15	60
R8	Asia	IT	Senior IT Manager	Management	8	50
R9	North America	IT	IT Product Owner	Team Lead	9	60
R10	North America	IT	Business Systems Lead	Team Lead	6	60
R11	Asia	Business	Supply Chain Manager	Management	15	60
R12	Europe	Business	Project Manager	Team Member	3	60
R13	Europe	Business	PLM Architect	Team Member	5	45
R14	Europe	Business	Automation Engineer	Team Member	1	60
R15	Asia	IT	Business Systems Analyst	Team Member	6	60
R16	Asia	IT	Digitization Engineer	Team Member	2	45
R17	Asia	IT	Digitization Engineer	Team Member	3	45
R18	Asia	IT	Manufacturing Applications Manager	Management	6	45
R19	North America	IT	Cloud Engineer	Team Member	3	50
R20	Europe	IT	IT Business Partner	Management	18	60
R21	North America	IT	Helpdesk Supervisor	Team Lead	2	50

To avoid biases, similar sized groups of respondents were selected across the region, function and organizational level dimensions. There are 6 respondents from North America, 8 from Europe and 7 from Asia, which covers the main regions Company operates in. Based on the organizational level there are also three general groups – 7 from the Management position, 6 were Team Leads or Supervisors, and 8 were Team Members or Individual Contributors. In the context of the research, Team Leads are considered the first-line managers, to whom the Team Members report to, while all middle and upper management respondents were grouped in the Management group. In the dimension of Function, there is a bigger skew towards IT employees with 14 respondents out of the 21 grouped in the IT function, but this is expected due to DT being a technology triggered and enabled process, furthermore, in the context of the Company and this research, IT function is a wide-reaching organizational function, that has the most experience with DT processes and projects. On average, the respondents are 7 years with the Company, with the minimum being 1 year, maximum – 21 years, and a median of 5 years. The respondents in the Management group are on average 12 years with the Company, Team Lead group – 5 years, and Team Members – 3 years.

This purposeful sample of respondents can provide a wide range of experiences and knowledge on both KM and DT processes. The selection across three different regions can help identify any cultural or regional differences, perspectives of different functions can help uncover the different risks and solutions as perceived by the IT professionals directly involved with the technologies and more business processes-oriented professionals, while the difference in the organizational levels of the respondents could also represent the difference in perspectives of leadership and employees of the Company.

3.4. Data Collection and Analysis

Based on the conceptual model, a semi-structured interview guide was developed, following the guidelines by Galletta (2013) and Kallio, Pietilä, Johnson, & Kangasniemi (2016). can be found in Appendix 1. Based on the guidelines by Galletta (2013), the interview has three segments – opening, middle and closing. In the opening section, the goal is to establish comfort of the interviewee, ask broad questions and establish the general narrative of the interview based on the respondent and his questions. In this semi-structured interview, the respondents were first informed about the confidentiality of the interview and then asked three introductory questions, in order to better understand the current role of the respondent, their history with the Company, how long and in what capacity they are involved with DT and KM processes – this helps set the narrative tone for the interview, allows the respondent to explain KM and DT in the context of their work and knowledge.

The goal of the middle section is to add more specificity to the research, and the middle section of this interview is constructed of three different parts. One of the findings of the literature review, was that KM and DT are often researched only from one direction – either how KM impacts DT (Wolf & Erfurth, 2019; Zoppelletto, Orlandi, Zardini, & Rossignoli, 2020; Siuko, Myllärniemi, & Hellsten, 2023), or how DT and technologies impact KM (Fakhar Manesh, Pellegrini, Marzi, & Dabic, 2021; Tortorella et al., 2022; Yan, Xiong, Gu, Lu, & Zhang, 2023), this one-directional approach can be easier to understand for the respondents as well, as they could be more familiar with one of the directions of the interaction, but the answers to questions exploring either KM impact on DT or DT impact on KM, are still relevant to the overall research and its goal and then can lead to more in-depth follow-ups and questions (Kallio, Pietilä, Johnson, & Kangasniemi, 2016). Therefore, the first two parts of the middle section are focused on a single direction of the interplay – it starts with a more

general questions, on how the respondent understand the impact of KM on DT or DT on KM, and then probes for the risks and solutions that emerge from that connection. The third part of the middle section builds on the first two, and gets more in-depth with specific questions on the interplay, common solutions, risks and opportunities. The concluding segment is constructed with the goal for the respondent to first reflect on the interview, return to any examples or experiences mentioned before, and provide any final thoughts or, from their perspective, unexplored points relevant to the research and interview. Finally, the confidentiality clause of the interview is repeated again, and the interview is completed.

Due to the globality of the Company and multi-nationality of the respondents, all the interviews were conducted in English, with the use of Microsoft Teams application to record and transcribe the interviews, with explicit agreement of the respondent. All interviews were conducted during the two weeks starting April 1st ,2024 and ending April 13th, 2024, for each of the interviews a one-hour time slot was allocated – most of the interviews fit into the time and used all of it, with one interview extending to 70 minutes. The interview length varies from 45 to 70 minutes.

Afterwards, all transcriptions were reviewed together with the audio recording of the interview to fix any automatic transcription errors and inconsistencies. The transcripts were then analyzed and coded using MAXQDA application. Each of the interviews were first coded based on the elements of the conceptual model, in order to identify the core foundations, elements, risks and synergistic solutions of the interplay between KM and DT, then, all interviews were analyzed in the context of the dimensions of the region, organizational level and function, and finally, all interviews were analyzed as a single group.

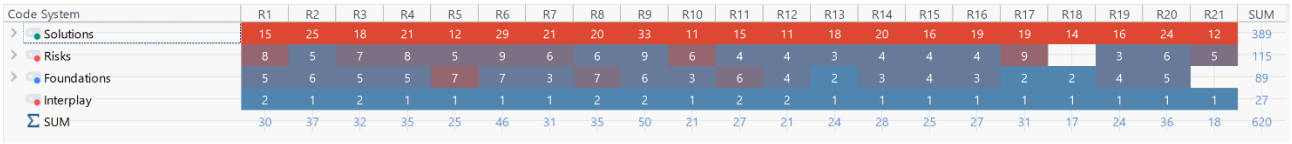
The expected outcome of the described research methodology, is the validation of the conceptual model of KM and DT interplay, practical insights on the common challenges and risks that emerge from the interplay, as well as the possible synergistic solutions and focus areas that the Company could invest its resources in, to advance both processes towards more synergistic value creation.

4. Findings of the Empirical Research

In the following chapter, interview coding results will be analyzed and reviewed according to the conceptual model of KM and DT interplay. Based on the results, the conceptual model is expanded with new dimensions and theoretical and managerial recommendations are then made, that would help the Company to advance the interplay and synergistic value creation of KM and DT.

4.1. Overview of the Research Results

Figure 7 shows the initial coding results of the key elements of the conceptual model – solutions, risks, foundations and the interplay. In total, 620 codes were identified in the interviews, and majority, of them, 389, were about the solutions of KM and DT interplay, while risks were the second most popular grouping of codes, with 155 results, and lastly – foundations and interplay with 89 and 27 codes respectively.



Code System	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	SUM
Solutions	15	25	18	21	12	29	21	20	33	11	15	11	18	20	16	19	19	14	16	24	12	389
Risks	8	5	7	8	5	9	6	6	9	6	4	4	3	4	4	4	9		3	6	5	115
Foundations	5	6	5	5	7	7	3	7	6	3	6	4	2	3	4	3	2	2	4	5		89
Interplay	2	1	2	1	1	1	1	2	2	1	2	2	1	1	1	1	1	1	1	1	1	27
SUM	30	37	32	35	25	46	31	35	50	21	27	21	24	28	25	27	31	17	24	36	18	620

Figure 7. Code matrix of KM and DT conceptual model key elements

The foundational idea of the conceptual model is the continuous interplay of DT and KM, which was identified in all the interviews. Al the respondents talked specifically about the interplay at least once, and Table 14 shows the selected interview quotes, that provides the overview of the interconnected and continuous manner of DT and KM relationship.

Table 14. Selected interview quotes on the interplay between KM and DT

Element	Quote
Interplay	"I kind of see the digital transformation and knowledge management as like two sides of the same coin. One cannot exist without the other" (R1, Pos. 20)
	"So I think these processes are equally important to one another, they have equally big impact to one another as well, but if a company is only focusing on one side, like digital transformation but then lacks focus on knowledge management, it does not allow them to think how to better create collaboration between departments, how to share knowledge and here is where knowledge management can help so focus and strategy equally on both is important then you would start seeing big changes" (R3, Pos 141)
	"Knowledge management can be one of the data resource for our digital transformation. So it will help our digital transformation initiatives to identify the opportunities and also will help us to ensure the success of the related initiatives. And then back to what's the relationship between digital transformation and knowledge management, I think, yeah, digital transformation enhance the knowledge management from data quality perspective, and also automation perspective, and also it can contribute to knowledge management, creation, storing and sharing." (R8, Pos. 20)
	"You cannot have digital transformation done without proper knowledge. Knowledge management processes in place. Uh, otherwise you will bring in all this new and shiny

	tech, but if you're unable to support, your team is unable to support it, it will be very difficult for you to maintain or reap the benefits of the this transformation" (R9, Pos. 63)
	"So for me, the knowledge of everything that we are doing as part of digital transformation is the foundation of the digital transformation success." (R12, Pos. 84)

The responses of the respondents, on the interplay of KM and DT, validates the interconnected manner of the two concepts, and further proves the necessity and importance of this research to practice. One respondent describes KM and DT as "two sides of the same coin", highlighting their mutual dependence and coexistence as a factor for overall organizational efficiency (R1). Organizations need to focus on both KM and DT, because focusing exclusively on DT can hinder the cross-functional collaboration and knowledge sharing, which are crucial for the organizational transformation (R3). Without robust KM, not only the initial transformation or implementation of new technologies will be difficult, but also the long-term maintenance, support and overall transformational efforts will be hindered and the full potential of transformation might not be reached at all (R9). More specifically, KM is a crucial process for identifying transformation opportunities, dissemination of knowledge, encouraging collaboration during the transformation efforts, while DT, and technologies brough with it, can enhance the quality of collected knowledge, automate the KM processes, provide technologies for easier creation, storage and sharing (R8). The responses illustrate the synergy and interplay between KM and DT, confirming their role in the creation of sustainable, long-term organizational transformation and value, which requires a balanced focus on both KM and DT.

4.2. Knowledge Management and Digital Transformation Synergy Core Foundations

Second element, the foundations that are needed for the KM and DT interplay, had the second-least amount of codes identified, after the synergy itself, and Figure 8 shows the key foundations identified in the conceptual model, and their prevalence in the individual interviews.

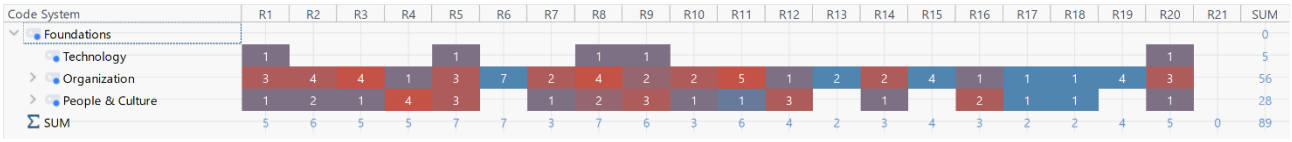


Figure 8. Code matrix for KM and DT foundations element

The foundation that was found to be the most impactful and appeared in the interviews the most, is the Organizational dimensions, such as leadership, strategy and processes. In this group, strategy is found to be one of the most critical foundations, with respondents specifically identifying it as the most important one: "*The essential is that knowledge management and digital transformation should now be a corporate strategic objective. The real objective, not marketing. <…> So it is essential for an organization to have a strategic goal with a plan."* (R6, Pos. 246), as well as identifying the need of a common strategy between KM and DT: *"the common strategy, let's say who drives digital innovation or transformation and who manages or coordinates how knowledge management is done in the company, need to have a common vision, a common strategy, so that the synergy could reach its full potential"*(R3, Pos. 84) and having effective leadership, that "buys in" to the importance of

KM and DT, and then builds the strategies around that interplay – *"<…> there is a common denominator for both. That would be the people who decide on strategies."* (R6, Pos. 274).
People & Culture is the second most important foundation, as they are the actual driving factor of the organizational strategy, the users of new technologies. The culture of a company and its people are what brings it all together – "*Like we can say all these things, but then it it is still burden on the people to make sure everything is in place.*" (R1, Pos. 188). The key elements of this foundation are the culture of collaboration, which is also found in the synergistic solutions element – "*Collaboration between departments is important so that it would be easier, and the idea generation would be encouraged by learning from each other.*" (R3, Pos. 64), having entrepreneurial mindset and culture – *"I think people should have the mindset that they. The they should strive for best, right? For for the, I don't know, ideal."* (R2, Pos. 348), as well as overall human-centricity of the organization, that builds other capabilities on the expertise of their employees – *"So with good people, I think that's the one, one of the essential capabilities where we are really strong, the productive interplay between KM and DT needs people, because everything will be done by people and then without the right team, right talent, it is really hard to do anything"* (R8, Pos. 112).
The foundation that was found to be of least importance for the Company, due to being mentioned in only 5 of the 21 interviews, was technology. This finding coincides with the results of literature review, that technology can trigger and enable DT and KM, but it has to be supported by the organization and its employees. The first respondent clarified why the technology dimension was not as relevant for the Company as other foundations, by saying that *"I think we finally can provide with the platforms, being in the technical team, right, we can make it easier for people to access the information at the right time."* (R1, Pos. 184), this notion of already having the needed tools, is also repeated by Respondent 5: *"technology first of all of all, already simplifies knowledge management, because for now, it's super easy to search for information, to share this information"*(R5, Pos. 40).

Code System	Asia	Europe	North America	Team Member	Team Lead	Management	Business	IT	SUM
Foundations									0
Technology	1	2	2	1	1	3	1	4	15
Organization	18	23	15	18	13	25	24	32	168
People & Culture	8	13	7	10	11	7	9	19	84
Σ SUM	27	38	24	29	25	35	34	55	267

Figure 9. Code matrix of core foundations split by respondent groups

Figure 10 shows the code matrix of the core foundations summarized by all three of the respondent groups – as the codes and their weighs in the code matrices are analyzed vertically, for the ease of analysis, all the groups are joined together into a single matrix table, but analyzed only between the same dimensions.
This shows a similar view, but some small differences can be identified across the groups. First of all, the most important foundation for all of the groups, remains the Organization. Respondents from Europe also puts slightly more emphasis on the foundation of People & Culture, compared to the respondents from Asia and North America. Respondents identified as Team Leads also mentioned People & Culture almost as many times as the Organization, and, comparatively, more then the respondents in Management and Team Members groups. The differences between the groups of IT and Business is smaller and harder to interpret because of the bigger difference between the count of

respondents in each group (14 in IT and 7 in Business), but the respondents in IT group mention both Technology and People & Culture slightly more often than the respondents in the Business group.

From the coding of identified critical foundations, it is clear that the respondents, in the context of the Company, believes that the key foundations are organizational and people-related, such as the organizational strategy, leadership, human-centricity and culture. Though technology is talked about in the contexts of a solution, but the technological foundations needed for KM and DT are often omitted as a foundational capability of the organization, which indicate that the needed capabilities are already implemented, and therefore not seen as critical by the respondents.

4.3. Knowledge Management and Digital Transformation Synergy Risks and Challenges

Figure 10 shows the breakdown of the risk and challenges element. All the challenges and risks identified in the conceptual model, were also discussed during the interviews. The risks that were identified the most, were poor knowledge quality, knowledge gaps and knowledge loss.

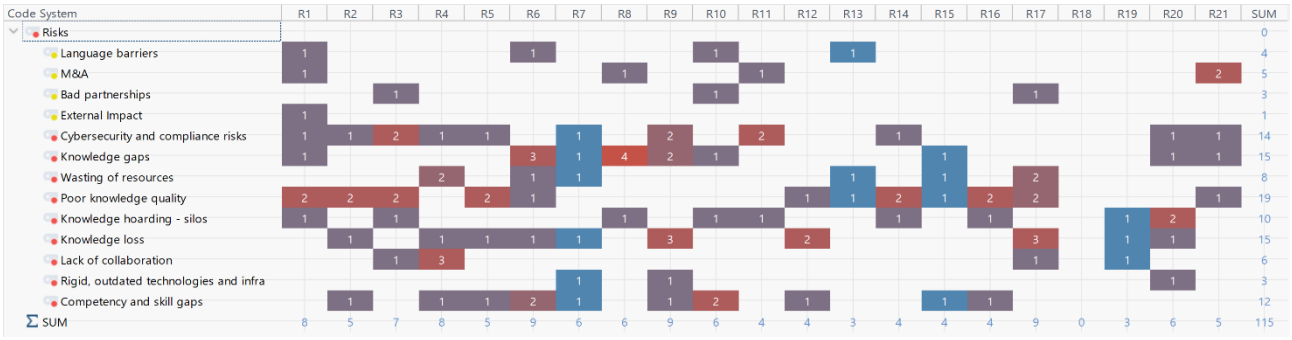


Figure 10. Code matrix for KM and DT interplay element of risks and challenges

Table 15 shows the selected quotes form the respondents that summarize the specific risks and challenges and their impact on KM and DT.

Table 15. Selected interview quotes on the KM and DT risks and challenges

Element	Quote
Cybersecurity and compliance risks	"The question of security becomes important, this is an important topic I think, because if some know-how is leaked, it can have a huge impact on the company." (R3, Pos. 24) "Not everything should be accessible for everyone, so that's where it becomes challenging to make sure that all your knowledge documents are properly protected as well" (R9, Pos. 83)
Knowledge gaps	"If it does not exist, you don't know what you don't know, you can't use what you don't know" (R6, Pos. 227) "Without having knowledge or well managing knowledge on the existing processes, you can drive digital transformation in the wrong way or or don't deliver the expected results." (R20, Pos. 232)

Wasting of resources	“People implement technologies, but a lot are bad or have some some limits, not that are not useful, that are not answering to the people's problem in the company and you may waste some time, some money and some value in buying, purchasing some technology.” (R4, Pos. 92) “<…> but they do it pretty much from zero again, because the solution is not written down anywhere.” (R17, Pos. 194)
Poor knowledge quality	“Like quality of information goes to the root of either digital transformation or knowledge management <…> because technology can access every piece of information, right, like how do you account for stale information or bad quality?” (R1, Pos. 92) “Information overload can be one of those risks I would say. So when there is a lot of information, that is unstructured, and it is easily reachable, then it is also easy to get lost.” (R3, Pos. 28) “Relevance of information, accuracy of information and not to keep old knowledge when, let's say, new technologies are supposed to replace old ones and only what is needed for the new technology should remain.” (R6, Pos. 180)
Knowledge hoarding – silos	“First of all, it's most of the knowledge they still in people's mind not stored somewhere. That's one of the biggest common risk, not only for KM, but also for for DT.” (R8, Pos. 120) “Maybe people don't really want to share their knowledge, maybe they feel more important to the company, if that information is only in their heads so then they are not as replaceable.” (R16, Pos. 46)
Knowledge loss	“Where is the biggest know-how that you have to save, it is the products, the processes, the specifics, it is normal that engineers rotate, but they each take with them some of the knowledge that we don't have anymore, so to get it back, it will be expensive.” (R6, Pos. 246) “Knowledge can go out of the company, maybe more easily than you think, when there are 50 people in the room that are just listening to someone, then they are gone and they just have the information in the brain. But if we put information everywhere available for everyone, there is a risk that the information goes out.” (R12, Pos. 68)
Lack of collaboration	“In knowledge management, the employee resistance to move towards that transformation, can make people just stop sharing knowledge and information” (R3, Pos. 93)
Rigid, outdated technologies and infrastructure	“Let's say the tool is very good, but it doesn't have proper support documentation in place. It is then that should be a red flag before you bring that tool into the organization at all” (R9, Pos. 115)
Competency and skill gaps	“To implement, you know, AI or machine learning, these are all new stuff. So we need to to find people that are qualified to do that, and it's getting there, there are more and more people, but it's still the beginning.” (R4, Pos. 228) “Definitely with the new tools and technologies coming in and even our existing resources need to improve their skill set, keep on learning the new technologies in order to adapt to those new technologies” (R9, Pos. 30) “We need to be sure that not only the trainer knows how to use the technology, but we also need to explain. So using new technology to share knowledge also requires to share knowledge related to the new technology.

	If I can say so, we need to make sure we have people that speak the same language than the business users." (R12, Pos. 44)
New – Language barriers	"We should not forget some people don't speak English or don't have the correct understanding of all the technology vocabulary of English <…> It's not their first language and the just brings on your barrier for knowledge transfer. This kind of of yeah, it is a barrier." (R16, Pos. 412)
New – M&A	"There are a lot of knowledge still in people's mind, in like, in their head, uh especially in some of the locations that we have through M&A" (R8, Pos. 80) Before we didn't have this needs. Uh, the company started buying other companies. It means more employees. It means more information. It means we need to grow with the company and our tools needs to grow with it." (R21, Pos. 313)
New – Bad partnerships	"For example, I can tell you right now, in managed services we struggle a lot <…> to get people engaged and get people with enough experience and knowledge to get involved in projects or resolve issues. Resolve incidents." (R10, Pos. 219)
New – External impact	"So always have to account for that external, governmental or market impact, and make sure that we have enough knowledge and like transformation capabilities to support external impacts." (R1, Pos. 124),

The array of selected quotes underscores the critical risks and challenges intertwined with KM and DT that are identified in the conceptual model. The risks that appears on the conceptual model, but was identified by the respondents the least amount of times, is the risk of rigid, outdated technologies and infrastructure – only 3 respondents identified the technological risk, which further strengthens the research finding, that in the context of the Company, technology is not believed to be a risk or a key foundation for the interplay. During the interviews, four new risks were also identified, firstly, the impact of various external factors, such as changes in the markets or government regulations, trigger the need to ensure that the organization has all the required knowledge and transformational capabilities to address them, while the bad or ineffective partnerships, formed in order to find those capabilities, can reduce the effectiveness of DT as well (R1, R10). The other two new identified risks, are specific to the nature and the strategy of the Company. Firstly, the Company has established multiple manufacturing locations and shared-service centers in Europe, Asia and North America, which creates the challenge of language barriers (R16). Secondly, the company grows through M&A activities, which creates the need to constantly integrate new tacit and explicit knowledge from the acquired companies (R8), and integrate more people into the processes and technologies of the company (R21). These two risks, emphasize the complexity of managing knowledge and transformation efforts in an increasingly global and diverse organization.

The three elements that were discussed the most during interviews, were poor knowledge quality, knowledge gaps and knowledge loss. Concerns over the quality of knowledge, were the most popular among the respondents, who identified challenges such as outdated and stale or irrelevant knowledge (R1, R6), which are made more prominent when new technologies can access and process vast amounts of it, thus organizations need to create strategies to deal with the quality challenges (R1). These vast amounts of data or not curated knowledge can also be overwhelming and cause information overload, which further emphasizes the need for strong KM and curation practices (R3). The risk of knowledge loss is also a critical concern as critical know-how of the Company, about its

products or processes, can be lost during the natural process of turnover, and if the impacted area lacks robust KM practices, getting the lost knowledge can be very costly for the organization (R6). One respondent also identified the risk of losing knowledge due to poor KM practices, security or even corporate espionage (R12), which is also discussed as a part of the cybersecurity and compliance risk, which identifies the need to protect knowledge from leaks or unauthorized access, as it can hurt the organization and its DT (R3, R9).

Knowledge hoarding or formation of knowledge silos, where information and knowledge remains in its tacit form, usually in the minds of employees that are not engaged and want to remain irreplaceable by keeping the knowledge to themselves, limits the knowledge sharing critical for DT (R8, R16). The lack of collaboration, often due to resistance from employees towards KM and DT initiatives, further complicates the sharing and utilization of knowledge across the organization (R3). Hoarding, lack of sharing, poor quality and other related factors, can create knowledge gaps, which are noted for their negative impact on the effectiveness of DT initiatives, as it relies heavily on good understanding of the processes or resources being transformed (R6, R20). These gaps, not understanding business needs, can then create poor investment or duplication of effort risks, which also increases the waste of money, time, and other organizational resources (R4, R17). Respondents also identified that in the context of DT, especially when implementing new technologies, lack of technical expertise to implement and use the technologies is a critical risk (R4, R9), but lacking a varied skillset, that also covers the competencies to teach other employees, explain the technologies, and essentially speak the same language as the end user of the technology, is just as critical to the success of DT (R12). This is also critical in the context of the Company, as it is a manufacturing company first, and a lot of DT initiatives are started and promoted by the IT function, which requires the competencies to be able to share their knowledge and promote the initiatives in a way, that is easy to understand for the business, without losing the technical capabilities to implement, use and support the newest technologies.

Code System	Asia	Europe	North America	Team Member	Team Lead	Management	Business	IT	SUM
Risks									0
Language barriers		2	2	1	1	2	2	2	12
M&A	2		3		2	3	1	4	15
Bad partnerships	1	1	1	1	2		1	2	9
External Impact			1			1		1	3
Cybersecurity and compliance risks	3	6	5	2	7	5	6	8	42
Knowledge gaps	6	4	5	1	4	10	3	12	45
Wasting of resources	4	4		4	2	2	2	6	24
Poor knowledge quality	5	9	5	11	5	3	9	10	57
Knowledge hoarding - silos	3	4	3	3	2	5	3	7	30
Knowledge loss	4	6	5	7	5	3	4	11	45
Lack of collaboration	1	4	1	2	4		1	5	18
Rigid, outdated technologies and infra	1	1	1		1	2		3	9
Competency and skill gaps	3	5	4	4	5	3	4	8	36
SUM	33	46	36	36	40	39	36	79	345

Figure 11. Code matrix of interplay risks split by respondent groups

Across the different groups of respondents, the findings are also very similar. For the respondents in Asia, knowledge gaps and poor quality where the most important risks, for respondents in Europe, the most important one was knowledge quality, and the cybersecurity and knowledge loss are both

second, while North American respondents talk about the knowledge loss, quality, gaps and cybersecurity as equally important. In the organizational level groups, there are more slight differences, where knowledge quality is the most important for the Team Members group, as they are most likely both the primary creators and users of knowledge, therefore for them, using the correct knowledge is critical for the effectiveness of their work. For the Team Leads, cybersecurity and compliance risks were the most important, whereas the Management group talked about the risk of knowledge gaps the most. For the Business employees, knowledge quality was also a critical risk, while the employees in the IT group sees knowledge gaps, loss and quality as the three most critical challenges.

To summarize, these findings empirically validates the challenges identified in the conceptual model, but also provides more perspective into what challenges the Company identifies as critical due to its unique set of variables.

4.4. Knowledge Management and Digital Transformation Synergistic Solutions

Figure 12 shows the breakdown of the synergistic solutions element, which is the most discussed element of the conceptual model. All possible solutions identified in the conceptual model, though some lack the prevalence expected after the literature review.

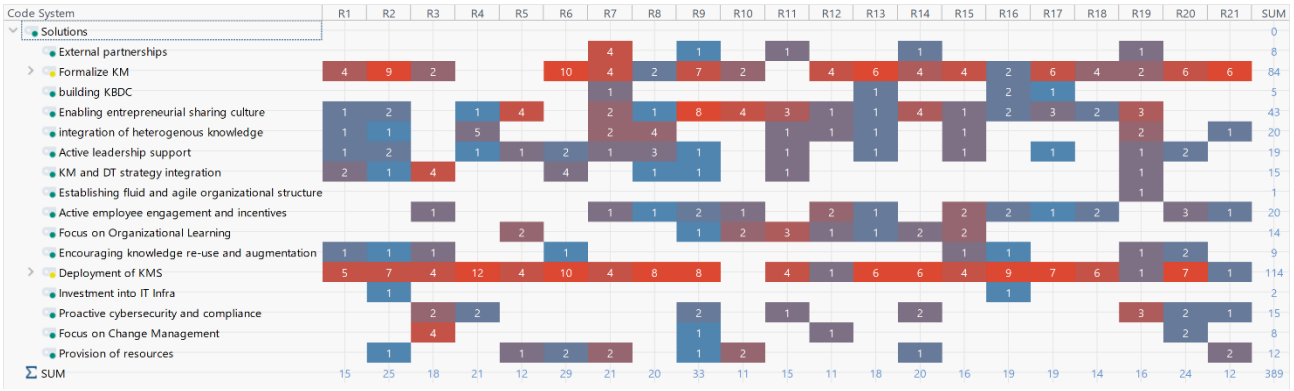


Figure 12. Code matrix for KM and DT interplay element of synergistic solutions

Table 15 shows the selection of quotes from the respondents, that identify the possible synergistic solutions, their context in the Company and possible application to mitigate some of the risks caused by the interplay of KM and DT.

Table 16. Selected interview quotes on the KM and DT synergistic solutions

Element	Quote
Building KBDC	"You need to be able to adapt, so that you can change something that is broken quickly before it creates a problem, and if it already created a problem, you need to be able to fix it quickly, but then you need information or knowledge somewhere at the center of it." (R17, Pos. 60)

Enabling entrepreneurial sharing culture	“Organizations need to give some freedom to the people for them to try stuff.” (R4, Pos. 48) “If you can share the knowledge to each other, it can be very powerful, I mean, no matter if it's digital transformation or any other activities.” (R7, Pos. 230) “So every resource in the company has to take 4 hours a week to just have that dedicated concentrated period to acquire knowledge about these new tools and technologies so that they can take benefits of this digital transformation.” (R9, Pos. 179) “<…> and try to promote our knowledge sharing across the region, across the BU, across the sites, even across the different functions, right?” (R11, Pos. 138) “Collaboration, would be a culture, with a culture of collaboration and knowledge sharing, teamwork, more focus on the team, not the individual.” (R16, Pos. 100)
Integration of heterogenous knowledge	“To my understanding you might need a lot of knowledge from everybody, so the database will be infinite.” (R7, Pos. 192) “Having a person being capable to understand, for example, a little bit of networking, a little bit of manufacturing, a little bit of databases, so they can easily transfer the knowledge to someone else.” (R10, Pos. 163) “So we need to to have a kind of combination of profiles which are comfortable enough with the new technology, but close enough to the business to explain them how to use it and how it works with their own words and language to make sure they understand and get value from it.“ (R12, Pos. 48)
Active leadership support	“<…> senior leaders have this awareness and understand how important the knowledge management is, because without that, it's really hard for us to build the roadmap for transformation.” (R8, Pos. 84) “Uh, also having management involved and <…> to convince their organization that knowledge management through digital transformation is a key.” (R20, Pos. 256)
KM and DT strategy integration	“So having more of those discussions openly and educating everyone, why is this important, right that this is fundamental as we are evolving, shifting to changes both internally and externally to stay competitive like both terminologies should be part of every vocabulary.” (R1, Pos. 144) “The essential is that knowledge management and digital transformation should now be a corporate strategic objective. The real objective, not marketing. <…> Because if it's not included in the strategic objectives, you won't achieve too much.” (R6, Pos. 246)
Establishing fluid and agile organizational structure	“These are the examples like a database manager, a server team, a cloud team, data. There's no longer those, right? It is just a workload manager and they manage the workload efforts, right, manage a priority list of XY and Z. Basically, organization of work. You have someone manage that, but then each one of these disciplines support that, right?” (R19, Pos. 260)
Active employee engagement and incentives	“If there is lack of communication or trying to hide some transformation or changes, it creates even more fears, hiding or gossip on different levels of the organization” (R3, Pos. 101) “Example if some employee contribute to the knowledge database, they can receive some awards. This way, we encourage to summarize the expertise or knowledge they have into any format of document.” (R18, Pos. 116) “Not only asking them to to do things, but explain them why we are doing things and and for <…> to feel involved in the change <…> you have to embed the ones

	who are the most willing to use the tool first, because these are the promoters of the project." (R20, Pos. 284)
Focus on Organizational Learning	"So then once again, continuous learning to stay up to date with the newest information or newest trends or newest technology platforms and so on." (R5, Pos. 268) "And we also need maybe add more and more training and to and some development programs to help our colleagues to learn how to use the technology efficiently <…> we should support the some kind of the learning and development for our employees." (R11, Pos. 78)
Encouraging knowledge re-use and augmentation	"<…> one location for example, can use the benefits of another location. You reduce the redundancy by actually sharing the knowledge." (R9, Pos. 71) "When we are driving digital transformation project we should collect best practices or things that are not doing well to improve for the next time." (R20, Pos. 192)
Deployment of KMS	"We have to make it easy for people to access information and store their ideas or retrieve information, right? So if we don't provide tools for this to happen, then you know it's like a bird and it becomes a burden." (R1, Pos. 68)
Investment into IT infrastructure	"And then you also need infrastructure, that would help to quickly pull the needed information" (R16, Pos. 132)
Proactive cybersecurity and compliance	"When it comes to data security we can do a lot of proactive actions, training on how to avoid some data leaks so when we are building our own tools or processes, to always think about the security." (R3, Pos. 40) "So you have to you have to have policies and to have mechanisms in place which which prevent any security risks which maybe come with technology." (R14, Pos. 92)
Focus on Change Management	"When people are afraid because of the new technologies they can start sharing less knowledge in the company avoiding some changes or maybe innovation" (R3, Pos. 76) "Change management, <…> we have to explain people why they have to to share their knowledge first, what's the value for the company, what value they bring to the company doing that, what value will it bring to them, and do it the right way" (R20, Pos. 108)
Provision of needed resources	"We need to understand that both knowledge management and digital transformation demands investment. initial investment will be very high."(R6, Pos. 284) "When you're estimating the investment for your digital transformation, a fraction of your investment should definitely go to knowledge creation and storing, because the transformation cannot survive without knowledge." (R9, Pos. 272)
New – Formalize KM	"<…> knowledge governance it's maintenance, some sort controls, standards would help in dealing with it. at least make the errors or impact smaller, that could happen because of poor data or knowledge." (R3, Pos. 80)
New – External partnerships	"<…> I do believe that they already had some use cases or successful practice in other companies, so we can just reference that. What is challenge and we can mitigate some risk in the beginning." (R7, Pos. 144) "To scale up into the new technologies and support the transformation. It's very hard to do without that external support <…> the knowledge that they bring in with their experience with other clients, that is greatly helpful for us." (R9, Pos. 243)

Firstly, the investment into IT infrastructure was only identified by two respondents as a synergistic solution, which also strengthens the finding of the strong technological core that the Company already has (R2, R16), while the establishment of fluid and agile organizational structure was only identified by one respondent, as a possible solution to manage the transformation workloads more efficiently (R19). There were also two new solutions identified – external partnerships, and the formalization of KM.

Because deployment of the KMS, as well as the new solution of formalizing KM, were the two solutions that had the most prevalence in the interviews, in order to better understand them, they were further split into more granular dimensions and are reviewed more in-depth in the sub-sequent sub-chapters.

Encouraging an entrepreneurial culture and providing employees with the freedom and time to experiment, create and acquire new knowledge on DT, new tools and technologies, is important to fully benefit from the DT (R4, R9). The second step is focusing on the needs of the team or organization, and sharing that knowledge across different teams, functions or business units, so that the knowledge could also be effectively re-used across the organization (R7, R11, R16). In the context of the Company, its global footprint makes the creation of such entrepreneurial knowledge sharing culture a necessity to advance its DT efforts. This culture can be created by actively engaging employees, firstly with clear communication to prevent any possible resistance or spread of misinformation that can arise from the transformation initiatives (R3), the engaged employees should be made a part of the DT initiatives from the very start, so that they can generate the tacit knowledge, share it with others, promote the initiatives across the organization (R20), furthermore, employees can be motivated to share and document their knowledge, which can come as bonuses, awards or gamification of the KM processes (R18). Engaged leadership, is just as important as engaged employees – senior leadership need to understand the synergy and importance of DT and KM, as they are the ones who communicate that to the employees and keep them engaged (R8, R20). The leadership or upper management, are also responsible for strategy formulation, so they need to make sure, that there is a strategy for both KM and DT as well as their common integration, the respondents believe that they need to become part of the daily activities (R1), and be a part of the corporate strategic objectives, so that the strategy of DT and KM can become an achievable plan, instead of a marketing tool (R6). Furthermore, both DT and KM requires very high initial investment, with long-term and hard to measure returns, leadership needs to be aware of that, they need to ensure the initiatives are provided the required organizational resources. One way to make sure that the required investments are provided, as identified by respondent R9, is to dedicate a fraction of the budget for DT initiatives to capturing, storing and sharing the knowledge of those initiatives. DT, by its nature, creates the aforementioned fears, mistrust and misinformation, which can lead to a reluctance to change, share knowledge and collaborate (R3), therefore, leaders should also focus on the change management, communicate with the employees affected by the changes, explain the value that knowledge sharing brings to the company and to the employees themselves (R20).

Respondents also identified that DT needs robust cross-disciplinary, heterogenous knowledge integration, either in a form of an ever-growing knowledge database (R7), or through employees, that have a wide range of technical skills, covering the different technologies, aspects of their implementation, and a range of soft skills that would enable them to explain those technologies and easily disseminate the require knowledge across the organization (R10, R12). Respondents also agree that cybersecurity and compliance needs to be, and in the context of the Company already is, a

proactive process to set up policies and measures, to secure the data and prevent knowledge leaks (R3, R14).

According to the respondents, the integration of new technologies and overall process of going through DT, requires the organizations to continuously learn and update their knowledge (R5), as well as provide new internal and external training and development opportunities, so that those technologies can be utilized more efficiently (R11), which can be summarized with the Organizational Learning focus. The unique context and global footprint of the Company, can also be used as a solution to minimize knowledge gaps, redundancies or loss, by reusing knowledge from different locations (R9), and DT projects should also focus on capturing all reusable knowledge and making it available for others (R20). External partnerships were also identified as one of the ways to manage the knowledge risks, as they can provide some best practices or knowledge from other DT implementations (R7), and respondents find the partnerships especially important for implementing and scaling new, unfamiliar technologies, such as AI, which requires knowledge that the Company most likely does not have yet (R9). Building KBDCs, is one of the least mentioned synergistic solutions, called out only by 4 of the respondents, and all of them mention the need to use knowledge and quickly adapt to changes, both external – in the market or the industry, and internal – specifically when there is a new and unexpected problem.

Code System	Asia	Europe	North America	Team Member	Team Lead	Management	Business	IT	SUM
Solutions									0
External partnerships	5	1	2	2	1	5	2	6	24
Formalize KM	22	32	30	28	26	30	26	58	252
building KBDC	4	1		4		1	1	4	15
Enabling entrepreneurial sharing culture	14	11	18	19	15	9	13	30	129
integration of heterogenous knowledge	8	7	5	5	7	8	3	17	60
Active leadership support	7	7	5	5	4	10	5	14	57
KM and DT strategy integration	2	8	5	1	6	8	9	6	45
Establishing fluid and agile organizational structure			1	1				1	3
Active employee engagement and incentives	9	7	4	8	5	7	4	16	60
Focus on Organizational Learning	5	6	3	8	3	3	9	5	42
Encouraging knowledge re-use and augmentation	2	4	3	3	2	4	2	7	27
Deployment of KMS	42	50	22	38	32	44	35	79	342
Investment into IT Infra	1		1	1	1			2	6
Proactive cybersecurity and compliance	1	8	6	5	7	3	5	10	45
Focus on Change Management		7	1	1	5	2	5	3	24
Provision of resources	2	4	6	2	6	4	4	8	36
Σ SUM	124	153	112	131	120	138	123	266	1167

Figure 13. Code matrix of synergistic solutions split by respondent groups

In the regions of Asia and Europe, the two most popular synergistic solutions were the Deployment of KMS, and Formalization of KM, while in North America it is the opposite – the most mentioned solutions are part of the Formalization, while Deployment of KMS is second and the entrepreneurial sharing culture is a close third. When compared to the previous coding results, this finding is especially interesting, as the respondents from Europe put slightly more emphasis on the foundations of People & Culture, whereas in the case of the synergistic solutions, it is not as critical as it is for the North American group. This can be due to differences in understanding of culture as a foundation or a needed solution, and is very similar to the findings around Technology – different groups might believe that the required culture is already there – respondent R9, who is a Team Lead from North America illustrates this finding by saying – *"We have great group of talent within our organization,*

young and experienced, both, right. We have a good synergy between both those groups, <…> the young learn from the experienced and the experienced learn from the young as well." (R9, Pos. 151).

Across the organizational level groups, there are less differences – Team Members and Team Leads very similarly focus on the need to Deploy KMS and Formalize KM, and these two are even a bigger focus for the Management group, as the solution of culture was a strong third place for the first two groups, for the Managers it is a close fourth place only. There are even less differences between IT and Business groups – they both emphasize the Deployment of KMS and Formalization of KM as well.

The extensive discussion with the respondents of the interview about the synergistic solutions, similarly to the findings about risks and challenges – emphasizes the unique variables of the organization, validates and expands the solutions identified in the conceptual model, and provides a very comprehensive view of their practical application.

4.4.1. Formalization of Knowledge Management Processes

Figure 14 shows the code matrix of the new, KM Formalization solution, identified by the respondents. The major factor of KM formalization, is the creation of a documentation culture, as well as creating standards, requirement and policies for knowledge capture, curation and storage.

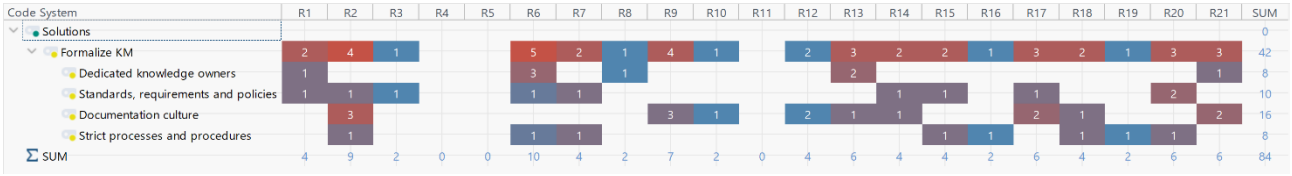


Figure 14. Code matrix for the KM formalization solution

To better understand the concept of this solution, the selected interview quotes are summarized in Table 17.

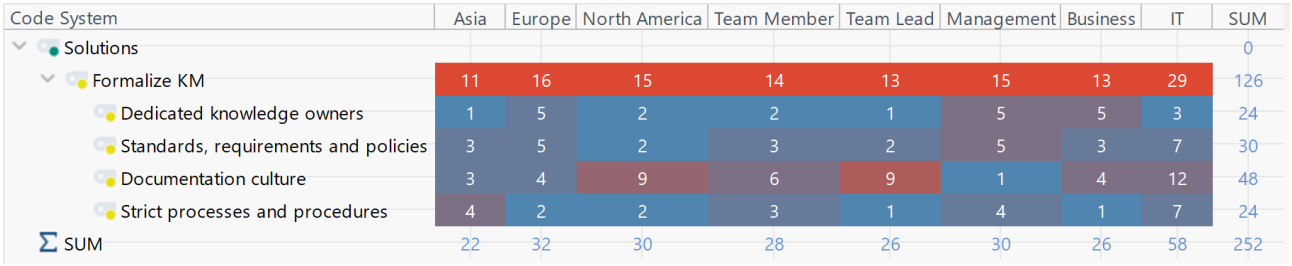
Table 17. Selected interview quotes on the KM Formalization solution

Element	Quote
Dedicated knowledge owners	"Who will oversee that knowledge management, similar to the digital transformation who will do what, how the system will work who is responsible, how will the approvals work" (R6, Pos. 204) "The only solution I found personally is that I only take care of the knowledge base about the software I manage, and I don't touch to anything else. Because I know the business behind that. I know my software and I know what will really help the user because I have all point of views." (R13, Pos. 172) "I would say the the main thing to address is to have dedicated people or dedicated resources to constantly update the information that is there and to constantly create new knowledge articles" (R21, Pos. 144)
Standards, requirements and policies	"I think, all should think of knowledge management as part of our daily jobs. <…> or like these are like the minimum information for future viability of the department or function should be captured." (R1, Pos. 96) "Knowledge governance it's maintenance, some sort controls, standards would help in dealing with it. At least make the errors or impact smaller." (R3, Pos. 80)

	"We should have clear or defined templates for each types of the knowledge." (R7, Pos. 260) "I'm writing a lot of IT processes, there has to be a structure to store, share it, manage the revisions, the templates and so on." (R20, Pos. 352)
Documentation culture	"But I think having the culture to document everything, and like at least, like, the majority of stuff and also write different tags, if maybe some people will try to search it in different terms so that the content is actually useful now." (R2, Pos. 120) "It has to be part of the process, right, from the implementation or the inception of the new technologies that you bring in or any new enhancements, patches, everything that you bring in <…> everything has to be recorded and with the new tools and technologies that we have in place, I think that is definitely possible. Documentation should be in essential step of your every project." (R9, Pos. 54) "By documenting every process that we are following, I think is is a very important part of every company. The proper documentation of the processes and that you can follow and improve." (R21, Pos. 108)
Strict processes and procedures	"Like some kind of procedure? How we capture what learn from previous mistakes or previous errors or previous projects, right? That's and how we share our best practices for future project or team members." (R2, Pos. 320) "So then maybe maybe some sort process should happen if someone shared their knowledge on some platform. It should be tested or checked by someone else. Maybe, that would help the other person find new knowledge as well." (R16, Pos. 90) "So like during shift change <…> people were just talking between themselves to exchange some data about what happened the last day. <…> And we've leveraged software to digitalize this knowledge. First of all it help to keep traceability of it and to share with to make it visible to to more people." (R20, Pos. 56)

The most important element of the formalization, is identified as the creation of documentation culture that would prioritize comprehensive knowledge documentation practices. This culture involves documenting and tagging, for easier discovery, as much of the processes or work as possible (R2, R21) and making documentation part of the regular process of bringing in new technologies, updating, fixing or enhancing them (R9). This culture needs to be supported by minimal requirements of what knowledge needs to be documented by every department for its future viability (R1), every different type of knowledge that can be documented, should have a template to make the capture and sharing easier (R7), the documents also need a structure or architecture to store, share, manage and maintain them (R20), and these standards, governance and maintenance, would primarily help deal with the challenge of poor knowledge quality or make the impact of it smaller (R3). The collection of knowledge, even its documentation needs to be supported by the governance, strict processes, and procedures on how knowledge, know-how or best practices are captured from previous DT projects, how are they then shared and disseminated across the organization (R2), how is any captured knowledge or documents checked and tested for quality (R16). R20 provides a specific example from the Company, where production employees, instead of sharing their information to a new shift by simply talking, are now following a strict procedure of digitizing it first, which not only helps the new shift, but also creates new opportunities for the Company as well, by providing a way to track much more information, record the tacit knowledge about a production process, make it visible to the whole organization. And lastly, all of these processes, templates, policies and standards, have to be supported by either dedicated knowledge management teams or resources, to make sure that the

policies are being followed, templates are updated, knowledge quality remains high (R21), and that there is a general understanding of who is responsible for what step of the KM processes (R6), or every application, technology or DT project, needs to have dedicated knowledge owners, who instead of being a dedicated team just for KM, would manage and be responsible for the knowledge generated by their function or project, as they are the experts of that knowledge (R13).



Code System	Asia	Europe	North America	Team Member	Team Lead	Management	Business	IT	SUM
Solutions									0
Formalize KM	11	16	15	14	13	15	13	29	126
Dedicated knowledge owners	1	5	2	2	1	5	5	3	24
Standards, requirements and policies	3	5	2	3	2	5	3	7	30
Documentation culture	3	4	9	6	9	1	4	12	48
Strict processes and procedures	4	2	2	3	1	4	1	7	24
SUM	22	32	30	28	26	30	26	58	252

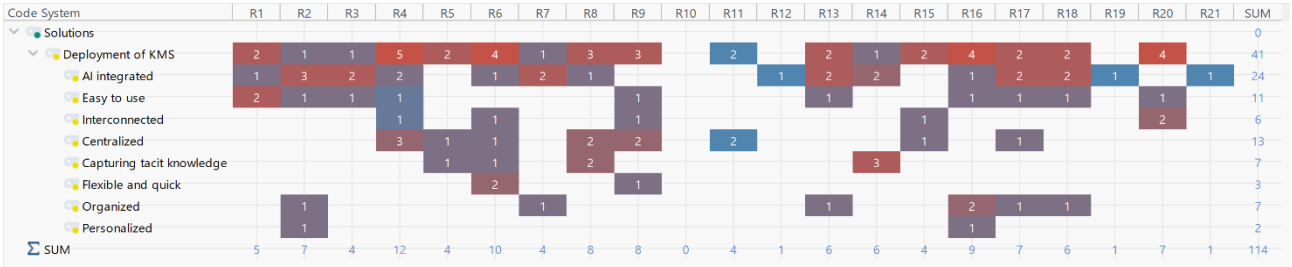
Figure 15. Code matrix of KM formalization split by respondent groups

Across the respondent groups, there are very few differences. North American and Team Lead respondents focuses much more on the need to first create the documentation culture, but the importance of KM formalization elements is very similar across all other groups.

KM formalization was not originally identified as a synergistic solution in the conceptual model – only one case study briefly summarized in the literature review, by Smith & Beretta (2020), identified the KM paradox in the environment of DT. The authors believed that KM and specifically knowledge sharing, needs to be more informal at the beginning of DT, where knowledge is more ambiguous, and it is more advantageous to share it faster and in more informal ways, while once the acquired knowledge and DT efforts scale up, it is necessary to implement some level of formalization, to make sure knowledge is aligned and shared across functions. The prevalence of KM Formalization in the interviews, shows that the Company is already advanced in its DT efforts, and therefore, respondents already feel the need to formalize all the KM processes around it.

4.4.2. Development of Knowledge Management Systems

Figure 16 shows the further breakdown of the KMS deployment solution, which was mentioned by the respondents the most.



Code System	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	SUM
Solutions																						0
Deployment of KMS	2	1	1	5	2	4	1	3	3		2		2	1	2	4	2	2		4		41
AI integrated	1	3	2	2		1	2	1				1	2	2		1	2	2	1		1	24
Easy to use	2	1	1	1					1				1			1	1	1		1		11
Interconnected				1		1			1						1					2		6
Centralized				3	1	1		2	2		2				1		1					13
Capturing tacit knowledge					1	1		2						3								7
Flexible and quick						2			1													3
Organized		1					1						1			2	1	1				7
Personalized		1														1						2
SUM	5	7	4	12	4	10	4	8	8	0	4	1	6	6	4	9	7	6	1	7	1	114

Figure 16. Code matrix for the KMS deployment solution

And Table 18 shows the selected quotes, to better understand, what elements respondents identify as critical for KMS.

Table 18. Selected interview quotes on the KMS Deployment solution

Element	Quote
AI integrated	"Give us some advice on what is going on and to also mix all those data to see if there is some recurring pattern <…> and it can help us take those decision. It can give us the possibility to understand everything." (R4, Pos. 200) "If we had, you know, artificial intelligence in our processes, <…> then it works like this global organism in the company. Using knowledge with artificial intelligence you get a lot of value and reuse of the knowledge." (R6, Pos. 340) "So it would be possible to just put all of the information in to some place, and it would be converted to knowledge by AI." (R16, Pos. 136)
Easy to use	"It is also important that the tools used in knowledge management are user friendly, because if they are not intuitive or not very easy to work with, employees most likely will not use them, and with time any enthusiasm to do something will go away" (R3, Pos. 24) "Because it has to become more accessible, information has to become more accessible to everybody <…>. It's not only just accessible, it should be easily retrievable, so tools and that can provide these kind of capabilities as what will be more essential for us to manage our knowledge better." (R9, Pos. 34) "I think that the technology itself should be so effective, that it would be easy to put the knowledge and then share it." (R16, Pos. 28)
Interconnected	"We also need some to implement some technologies that will be able to connect to each other and to show all the data or information together." (R4, Pos. 36) "Let's say a real knowledge management tool on top of the ticketing system <…> a common tool where we can see what is our software portfolio, what different companies have, what are the roadmaps, even be able to compare software used across different sites." (R20, Pos. 340)
Centralized	"If there was a database where people, who have the knowledge and skills, could share and the information would be accessible to everyone, that would speed up all your digital transformation" (R6, Pos. 196) "So I think if we can have an enterprise level <…> knowledge management platform and that can accommodate all the knowledges from different functions and also even can be searched by some search engine that will be very helpful to remove the gap or help on that." (R8, Pos. 56) "We should have a strong central knowledge management repository so that that transformations can be success." (R15, Pos. 114)
Capturing tacit knowledge	"The whole architecture of that knowledge management system has to be so that very practical knowledge is added to it, which is usually only in our heads." (R6, Pos. 352) "But you know without good knowledge management platform the knowledge transfer will always be by talking." (R8, Pos. 120) "And basically thinking about systems, it needs to capture the implicit knowledge and to to organize it and to to be able to retrieve it." (R14, Pos. 156)
Flexible and quick	"Digital transformation should make sure, that all the knowledge is archived, it is available where it needs to be, and I can access it when I want it and how I want it" (R6, Pos. 314)

	"<…> at the same time, you should be able to give the flexibility to the users to modify it a correct according to their needs" (R9, Pos. 71)
Organized	"<…> the structure for the knowledge management or the knowledge database we build, so it should be well organized. For example, we should have a clear tags for each of the document." (R7, Pos. 240) "<…> ideally as some sort of a technological platform, where all information is stored and <…> maybe some sort of a knowledge map, where you can dig in and find some topic, then go deeper into it and find the information that you need." (R16, Pos. 74)
Personalized	"<…> for me and my colleagues, one knowledge is more important, for others, something else completely. Maybe they don't need so much in-depth information, maybe something more on the surface level is easier to understand and more important that customization could also be part of that platform" (R16, Pos. 164)

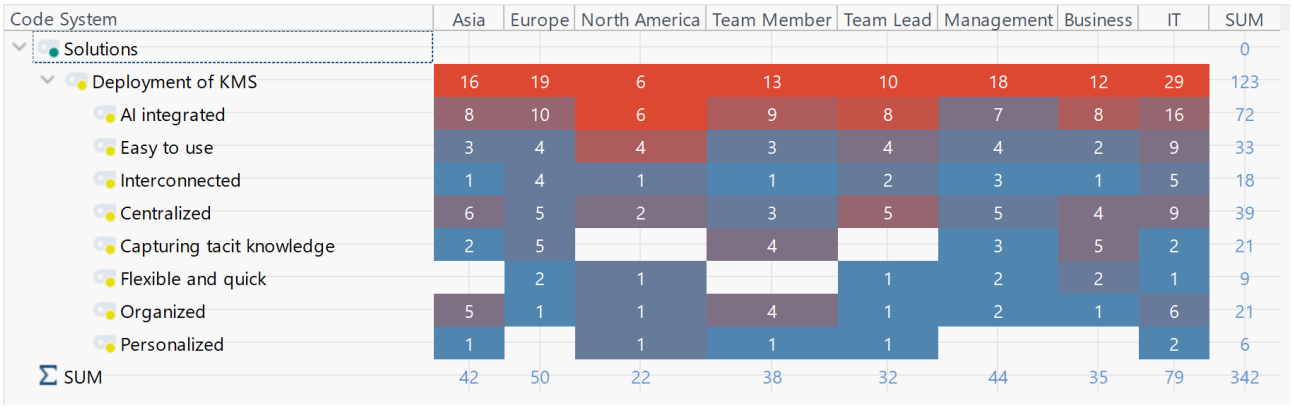
The most visible trend among the respondents, is the integration of AI and generative AI technologies with KM, that could combine multiple data sources and provide relevant knowledge to the employees, identify patterns, improve decision making (R4), it would increase the knowledge reuse across the organizations, as it improves knowledge discoverability (R6) and AI would help transform the vast amounts of collected data into information and knowledge that can be reused and applied (R16).

KMS, especially when integrated with newest technologies, such as AI, can help capture the tacit knowledge of the employees, and be one of the foundations and driving factors of the knowledge conversion process. KMS needs to be able to capture the tacit and practical knowledge that employees have, effectively organize it and make it shareable (R6, R8), as without a good KMS, employees will revert to the informal knowledge transfer methods (R8), therefore impacting the long-term success of DT efforts as well.

Respondents also call for the KMS to be both centralized and interconnected. The systems need to be accessible by everyone in the organization and be a central place to share the knowledge that employees from different functions have (R6, R8), this would make the DT processes both faster and more successful (R6, R15). As a centralized system, it should also pull all the available information and knowledge from other systems, thus the need for interconnectivity (R4), and provide a single view of the software, project portfolio and roadmaps of the whole organization (R20), this would also increase the speed of DT processes, reduce the risk of wasting resources and help build the knowledge sharing culture. If the KMS is interconnected and centralized, it also calls for good organization of the knowledge to avoid the risk of information overload, which can be supported by the formalization solution analyzed before, and by specific examples provided by the respondents, such as knowledge maps that would create some structure to the gathered knowledge and make it easier to search (R16), or clearly tagging all the gathered documents (R16).

The respondents also identify three main dimensions for the user experience of KMS – it needs to be personalized, flexible, fast, and easy to use. Personalization is required to deal with the information overload risk, as not all of the knowledge is necessary or important to all of the KMS users, therefore only the important knowledge should be initially surfaced, with the ability to customize it (R16). All the knowledge collected in KMS, needs to be stored and archived in a way that can be quickly accessed by the users (R6), and modified or maintained if needed (R9). The last, but most important element, is the ease of use – the implemented KMS needs to be user friendly, all the knowledge stored needs to be easily accessible, retrievable and shareable (R9, R16), and it should also make the

processes of capturing knowledge into KMS user friendly (R16), otherwise it will not be effectively used by the employees, even if supported by strong policies and requirements (R3).



Code System	Asia	Europe	North America	Team Member	Team Lead	Management	Business	IT	SUM
Solutions									0
Deployment of KMS	16	19	6	13	10	18	12	29	123
AI integrated	8	10	6	9	8	7	8	16	72
Easy to use	3	4	4	3	4	4	2	9	33
Interconnected	1	4	1	1	2	3	1	5	18
Centralized	6	5	2	3	5	5	4	9	39
Capturing tacit knowledge	2	5		4		3	5	2	21
Flexible and quick		2	1		1	2	2	1	9
Organized	5	1	1	4	1	2	1	6	21
Personalized	1		1	1	1			2	6
Σ SUM	42	50	22	38	32	44	35	79	342

Figure 17. Code matrix of KMS deployment split by respondent groups

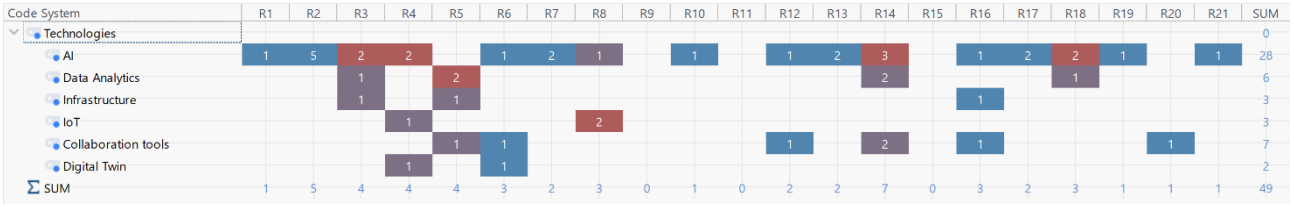
As evident from other findings, there are only minimal differences across the respondent groups. All of the groups identify AI integration as the most important element of a KMS. It is difficult to identify any other patterns or variations specific to the Company.

KMS covers all the technologies, platforms and solutions that enable KM processes; therefore it is one of the most visible and direct representations of the interplay between KM and DT. In the context of the Company, even though technology and infrastructure was not found to be a critical foundational element or risk, but their use specifically in the KM processes, was identified as the possible synergistic interplay solution by the majority of the respondents, which increases the importance of the KMS to the Company, and suggests that implementing it is needed to further advance its KM and DT strategy.

4.5. Knowledge Management and Digital Transformation Synergy Enabling Technologies and Impact

To create a more comprehensive view of the interplay between KM and DT, and address the literature gaps, various technologies that were mentioned by the respondents in the intersection of DT and KM, as well as the KM and DT synergistic impact to the organization, as seen by the respondents, were also captured and will be reviewed in this chapter.

Figure 18 summarizes the technologies that the respondents talked about.



Code System	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	SUM
Technologies																						0
AI	1	5	2	2		1	2	1		1		1	2	3		1	2	2	1		1	28
Data Analytics			1		2									2				1				6
Infrastructure			1		1											1						3
IoT				1				2														3
Collaboration tools					1	1						1		2		1				1		7
Digital Twin				1		1																2
Σ SUM	1	5	4	4	4	3	2	3	0	1	0	2	2	7	0	3	2	3	1	1	1	49

Figure 18. Code matrix of the mentioned technologies

The clear trend, as evidenced by the KMS deployment solution, is the various technologies associated with AI. As reviewed in the previous chapter, it can help with ingesting and processing vast amounts

of different data, documents, and then converting it to knowledge. It can covert unused documents into usable knowledge – *"There's documents, no ones reading them, but then if we introduce digital transformation such as AI Chatbots, it will become usable again"* (R2, Pos. 288), become personal assistants to the employees and increase their productivity – *"I think it would be great personal assistant and it could, <…> read like all of the documentation that you already have and maybe you need from others <…> So I think it would be really great personal assistant for everyone."* (R2, Pos. 396), by collecting and processing all the available knowledge, it can speed up the DT processes – *"AI would really improve the implementation of innovation, as well as knowledge sharing in the company, so let's say it could collect a lot of information already available, or lessons learned, and then it would give it to the employees in a form of some sort of recommendations or insights."* (R3, Pos. 117).

Second most popular set of technologies, are the various collaboration tools. Most respondents agree that the required collaboration tools are already being actively used such as Microsoft Teams – *"<…> like Teams, channels, <…> to have those collaboration platforms and to give it basically to everybody."* (R14, Pos. 136), OneNote – "*We have like a knowledge base in OneNote where we share knowledge."* (R16, Pos. 128), or Sharepoint – *"Today I'm using a lot SharePoint to share knowledge"* (R12, Pos. 36). One respondent also identifies the need for these online collaboration tools, it not only helps with knowledge capture and sharing in the global and multicultural context of the Company, but it also helps the younger generation, who might not be as proficient with sharing knowledge directly – *"They are sometime more willing to share their knowledge through a tool rather than talking to people and this digital transformation. So yeah, this is where the digital transformation could help the young generation to share their knowledge."* (R20, Pos. 72).

Other identified technologies are various versions of big data and data analytics, that would cover the data collection, storage, sharing and visualization – *"We have to think about how to collect that data. How to save that data? How to share the our the the same data? Also try to find the best ways or alternatives or, I don't know even, the platforms how we can visualize the data that to see something more inside from that data."* (R5, Pos. 32). Infrastructure is also mentioned in various contexts, mostly as a prerequisite for some other technologies – *"You need to start with some infrastructure, so that you could implement some tools, like Power BI has to have some infrastructure."* (R3, Pos. 24). From the various I4.0 enabling technologies, the two that are mentioned by the respondents are the IoT – *"I would also think the the IoT technology is also key important. Like I said, for knowledge, we need data. So <…> without using the digital transformation technologies, it's really hard for us to collect the data in the effective way and automatic way."* (R8, Pos. 172) and digital twins – *"if you go into that digital twin, you can click on any production line, any process go to any part of that line, it tells you what are the most often breakdowns, how long it takes to fix, what you need to do, everything is there so that is a very simple solution, <…> automatically you get all the knowledge about production process and the product or equipment, everything is in one place"* (R6, Pos. 296).

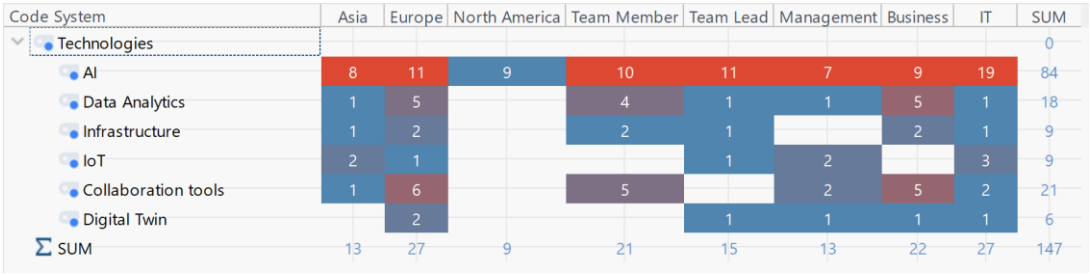


Figure 19. Code matrix of mentioned technologies split by respondent groups

Across the groups of respondents there are few interesting trends to review. The only technology mentioned by respondents from North America, was AI, while Europeans mentioned all the technologies at least once, and Collaboration Tools were the second-most mentioned technology in the interviews. Asian responses were a bit more spread out, with one or two mentions per technology, except the Digital Twins, but with a clear focus on AI as well. Similarly, Team Members also talked more about Data Analytics and Collaboration Tools, compared to Team Leads and Management, where major focus stayed on AI. This variance was also evident between Business and IT, where IT focused on AI, for the Business respondents Data Analytics and Collaboration Tools were also important.

The perceived impact of KM and DT synergy, by the respondents, is shown in Figure 20.

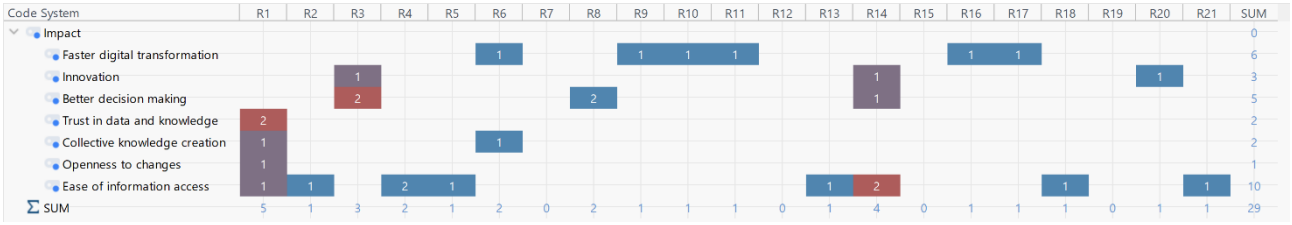
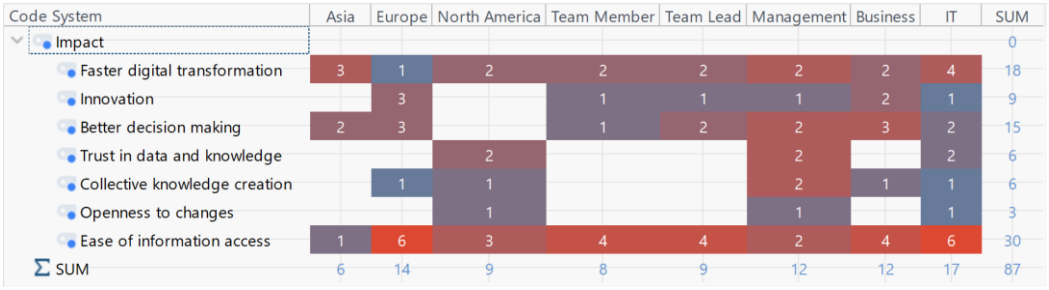


Figure 20. Code matrix of identified KM and DT synergy impact

Majority of the respondents identified two key impact areas of KM and DT synergy – increased ease of information access and faster DT. The easier access of knowledge, when supported by digital technologies eases the burden of employees in the DT initiatives – *"There will not be such a heavy lift or burden, or at all levels of the organization because it's easy to disseminate the information and bring everybody at the same level."* (R1, Pos. 84), and therefore it helps accelerate the transformation – *"Good knowledge management would accelerate your digital transformation in my view."* (R6, Pos. 196), as well as enable its faster scaling – *"It can help transformation scale up very quickly it scales transformation up for example"* (R17, Pos. 52). Furthermore, it enables innovation and new DT projects – *"Knowledge is a gold mine from my point of view. Maybe on plugging some tool on the top of knowledge we could create new digital transformation initiatives or drive or initiate new new digital transformation projects."* (R20, Pos. 200), makes the decision making faster, more knowledge or data based – *"<…> then the whole organization can make decisions faster by using that information, and then the decisions are much more informed, knowledge based, more reliable"* (R3, Pos. 20) as well as creates more trust in the knowledge or data that is already collected and the decisions made with it – *"They can trust in the decisions that they make with the information that is surfaced to them through this synergy."* (R1, Pos. 156). It also encourages collective knowledge creation, that in the context of the Company, would use one of its main strengths – *"<…> if there is a common pool of knowledge, we would exploit that particular corporate strength that we have as*

corporation, it always has a spread over different regions and different educations, different countries, different approaches, it enables having that common pool" (R6, Pos. 116), as well help build the organizational openness to changes – *"When we have few of these, a copilot or an AI chat bot to unlock the institutional knowledge, then I think people will be more open to adopt changes that come through digital transformation much more easily."* (R1, Pos. 88).



Code System	Asia	Europe	North America	Team Member	Team Lead	Management	Business	IT	SUM
Impact									0
Faster digital transformation	3	1	2	2	2	2	2	4	18
Innovation		3		1	1	1	2	1	9
Better decision making	2	3		1	2	2	3	2	15
Trust in data and knowledge			2			2		2	6
Collective knowledge creation		1	1			2	1	1	6
Openness to changes			1			1		1	3
Ease of information access	1	6	3	4	4	2	4	6	30
Σ SUM	6	14	9	8	9	12	12	17	87

Figure 21. Code matrix of identified KM and DT synergy impact split by respondent groups

Figure 21 shows the perceived impact split by the respondent groups. All groups mention two impact areas – faster DT and ease of information access. Group of Asian respondents focus on three impact areas – faster DT, better decision making and ease of information access, which is also echoed in the groups of Team Members and Team Leads, but the Innovation area is also added there. There are three main gaps visible from the groups – North American group very equally sees importance in almost all of the areas, except innovation and decision making, where Team Members and Team Leads have not identified any impact in the areas of trust in knowledge, collective knowledge creation, and openness to changes.

This additional analysis of elements not indicated on the conceptual model, indicates the technologies and KM and DT synergy impact areas, that are deemed important by the respondents of the interviews. The insights collected from the interviews, shows a general trend towards the importance of AI in this interplay, which dominates the discussions about technology in the Company and in the industry in general, as well as the ability for the synergy to speed up DT, increase innovational capabilities of the organization by making information more accessible and decisions more trusted. This analysis helps bridging the gaps identified in the literature and offers a view on KM and DT elements that is grounded only in empirical research.

4.6. Updated Model of Knowledge Management and Digital Transformation Interplay

Findings of the analysis of the semi-structured interviews serves two purposes. Firstly, it validates the conceptual model of DT and KM interplay – all of the identified conceptual dimensions, risks and solutions, were also identified during the interviews, without prior knowledge of the model itself. Secondly, it provides a clear overview of the interplay of KM and DT, in the context of the Company – global manufacturer of electronic components and provides the Company with the key dimensions that are important in the unique context of the organization.
Furthermore, the interviews also provided some new elements to the three dimensions, as well as helps rank the most important elements, to create a more comprehensive model of the interplay between KM and DT. The updated model is visualized in Figure 22.

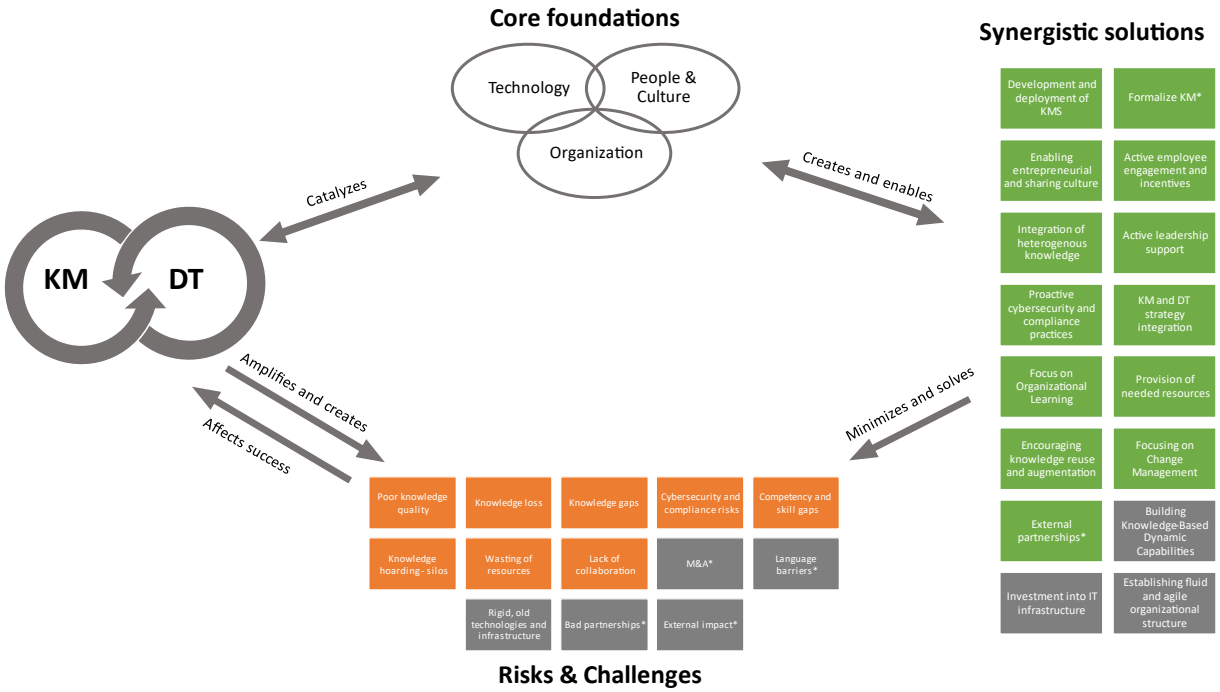


Figure 22. Updated model of KM and DT interplay

There are four main changes in the adapted model – adding newly identified elements, ranking of elements per dimension, and marking the ones that had the least prevalence in the interviews.

First of all, the new elements that were identified during the interviews, but were not originally part of the conceptual model, were added, and marked with an asterisk symbol. In the dimension of risks and challenges, these are the knowledge and transformational risks associated with M&A activities, language barriers that originate from the global nature of the organization, bad partnerships that can rise from the need to fill in knowledge gaps, as well as various external impacts. In the dimension of synergistic solutions, the only two new solutions were the highly discussed formalization of KM, and the external partnerships that the organization needs to build, in order to fill the knowledge gaps.

All the elements were then ranked based on the count of codes identified after the analysis of interview transcripts. In the conceptual model, their sequence is visualized first from left to right and then from top to bottom, therefore the two most critical risks are poor knowledge quality and knowledge loss, while the two most important solutions are development and deployment of KMS and formalization of KM.

Lastly, the elements that had the least prevalence, were colored in grey. These elements were not completely removed from the conceptual model, as they still are extensively covered in literature or discussed in the interviews, but their importance depends highly on the individual variables of the organization, its internal and external environments.

The KM and DT enabling technologies and impact areas that were identified in the interviews and analyzed in chapter 4.5, were not added to the updated conceptual model, as they were not analyzed in the literature review and do not have conceptual, academic arguments. These technologies and impact areas can ba a basis for future research and recommendations for the specific organization researched with this case study.

The new, updated model shows a detailed and comprehensive analysis of DT and KM synergy. It bridges the two main literature gaps identified, by covering and reviewing all different aspects of the interplay discovered in the literature, as well as the aspects that are found during the semi-structured interviews, to create an integrated KM and DT framework. Also, by grounding the theoretical analysis with empirical data of the case study, it advances the research area and collaboration between academia and practice. The updated model also provides a standardized framework for the creation of synergistic KM and DT interplay solutions. The managerial and theoretical implications of the research and the updated model are discussed in the following chapter.

4.7. Discussion and Recommendations

The following chapter discusses the findings of this research, in the context of what implications it provides to academia and practice.

4.7.1. Theoretical Implications

This study builds on the research threads of multiple authors, and provides additional empirical evidence to the research, and covers the main identified literature gaps. Firstly, the first gap identified in the chapter 2.4.1, is the lack of comprehensive, integrated frameworks of KM and DT synergy. The conceptual model built in this research, covers the finding of Fakhar Manesh, Pellegrini, Marzi, & Dabic (2021), and focuses on more DT dimensions, than just the technology. In the context of the research and the analyzed Company, technology was found to be just a supporting foundation for the organization, its people and culture. Furthermore, it complements the research and frameworks analyzed by Tinz, Tinz, & Zander (2019), by focusing more on how DT affects the organization, its employees and KM practices, provides empirical evidence and best practices on the data privacy and cybersecurity challenges, and includes the organizational learning, as proposed by the authors. One of the goals of the research, is also to provide a more standardized framework, that would connect the adoption of technology with a human centric approach, as called out by Li, Landström, Fast-Berglund, & Almström (2019). The research also addresses the second identified gap – lack of cross disciplinary studies. The proposed model was empirically tested in an organization (Wolf & Erfurth, 2019) and strives to reduce the gap in viewpoints between the academics and practitioners (de Bem Machado, Secinaro, Calandra, & Lanzalonga, 2021).
Furthermore, by focusing on a large, global electronic component manufacturing company, that spans not only multiple regions, but also multiple different industries, it also reflects the limitations of other research, who called for more comprehensive and varied case studies (Smith & Beretta, 2020; de Bem Machado, Secinaro, Calandra, & Lanzalonga, 2021; Abu-AlSondos, Alkhwaldi, Shehadeh, Ali, & Al Nasar, 2024), by conducting a semi-structured interview, with a limited comparison of findings across different regions and organizational level of the employees, it also reflects the limitations and research directions indicated by Cardoso et al. (2023).

4.7.2. Managerial Implications

This study provides managers with a comprehensive KM and DT integration model, set of guidelines and best practices, that are based on a large, global manufacturing organization working in multiple different industries. The empirically tested and validated conceptual model illustrates very specific, and therefore addressable, set of challenges and risks, that cover multiple foundations and dimensions

of the KM and DT interplay. It also provides a set of very specific synergistic solutions, that can also be used to quickly implement them and minimize or completely negate the impact of the identified risks.

The expansion of the model, into two main directions of KM formalization and KMS deployment, provides with even more actionable insights, that can become an implementation checklist for the analyzed Company, as well as other, similar organization. First of all, KMS deployment was found the most important synergistic solution to minimize the major risks and challenges, and managers need to make sure that the systems they are deploying or developing are AI integrated, covers all major organizational functions and knowledge creation areas, integrates with other systems and applications that organization already uses, but remains flexible, fast, personalized and most importantly – easy to use and able to effectively capture and disseminate tacit knowledge of the employees. The formalization of KM processes, needs to first focus on creating the culture of documenting every process and project, it needs to become part of the daily work of majority of the employees. The documentation culture, then needs to be supported by strict processes, procedures, standards, and policies, governance, adherence to the policies and overall stewardship of data, needs to be done by either a dedicated knowledge management team, or knowledge owners identified from within the project, application, or functional teams.

4.7.3. Limitations and Future Research

The main limitation of this study stems from analyzing a single company. The Company has a unique set of variables – internal and external environment, set of strategies, weaknesses and opportunities, which also creates a unique environment for both KM and DT (Gupta, Kr Singh, Kamble, & Mishra, 2022; Ubiparipović, Matković, Marić, & Tumbas, 2020), the size of the Company, maturity, industry and organization type, all have an impact on the technology adoption and KM activities of the company as well (Wessam & Nermin, 2023). Therefore, this research, is also more suited with addressing those unique variables, and future research could evaluate the applicability of the updated conceptual model, and the findings of the research, in similar, multi-national manufacturing corporations. A separate research direction would be the applicability of the updated model in SMEs, as they have a completely different set of internal and external variables (Lokuge & Duan, 2022), which could make the importance of certain solutions or risks higher or lower.

Secondly, the qualitative approach and semi-structured interviews, while providing a depth of knowledge, has their own set of limitations, and could be further expanded with a mixed-methods approach or larger sample of respondents. A mixed method approach, and a larger sample of respondents, could help with identifying more differences across the respondent groups. Even though the Company covers multiple regions and industries, and grows through M&A, where with every acquisition, company acquires a new cultural environment as well, it is evident, that the overall organizational culture and structure of the Company either negates the cultural differences, or makes them hard to identify with a small sample of respondents. The findings provided by the analysis of their groups are also limited, especially in their intersections – for example, majority of the respondents in the Team Lead group, were also from the North American region, and that group had no team leads from Asia, which skews the group-based findings. A larger respondent pool, as well as the aforementioned future research direction to focus on other, similar, organizations, could help with further evaluation of the pervasiveness of Company culture, as well as identifying the differences between different groups of respondents.

Lastly, the findings of the semi-structured interview analysis, provides two new research directions as well. The formalization of KM, which was found to be the second most important solution indicated by the respondents, was only discussed in one of the reviewed academic papers (Smith & Beretta, 2020), who argued that organizations, based on their level of DT, need to balance between formal and informal KM, but formalization was not found in the research covering risks, nor CSFs. This needs to be further investigated, with more focus on the impacts it has on different sizes of organizations and their DT stage. Also, AI has become a clear focus area for the practitioners of DT, with every respondent mentioning it as a technology that will have, or already has, an impact to both KM and DT, academic research should try to provide more in-depth frameworks for implementation and integration with KM solutions and focus on the areas of explainable and sustainable AI practices that would address the I5.0 paradigms.

Conclusions

1. **This thesis justifies the theoretical and practical premises for researching synergistic solutions in the interplay between KM and DT. As industries begin shifting from Industry 4.0 to Industry 5.0, AI and other digital technologies are becoming more accessible and are rapidly evolving, the synergy between KM and DT becomes a critical capability, that can drive synergistic value creation, innovation and competitive advantage in organizations.**

   Therefore, it is critical to review and understand areas of overlap and how these two concepts support each other, so that maximum synergy and value can be achieved. KM, with its focus on knowledge creation, transfer or sharing and application, provides the foundational processes for DT technologies to be effectively leveraged. On the other hand, DT technologies and concepts can be used to modernize and enhance KM processes and practices, making them more relevant, sustainable, and resilient. This creates a need for an integrated framework, that would blend KM and DT processes and concepts, build on the synergies and overlap, as well as fill in some of the gaps in the current literature, which often treats KM and DT in isolation. The practical problems currently faced by organizations, in relation to KM and DT include the lack of awareness, skills, resources, and culture to support KM and DT initiatives; the difficulty of integrating and managing heterogenous and complex data and information sources; the need for aligning KM and DT strategies with business goals and customer needs; and the challenge of measuring and evaluating the impact and value of KM and DT.

2. **The literature review underscores that DT and KM are interconnected, continuous processes that enhance organizational capabilities and performance through digital technologies and systematic knowledge practices, which creates a need for a standardized, integrated framework that merges their concepts and addresses common challenges with synergistic solutions.**

   DT can be understood as a holistic and strategic process of transforming the organization's capabilities, processes, products, and services through the adoption and integration of digital technologies. KM, on the other hand, is defined as the systematic and continuous process of creating, capturing, sharing, and applying knowledge to enhance organizational performance and innovation. The literature also identified various challenges, models, and frameworks for both KM and DT, as well as some examples of the synergy between them, such as the use of digital platforms, tools, and methods to facilitate KM practices and outcomes. Two research gaps were identified – lack of standardized, integrated frameworks, as well as lack of collaboration between academia and practice. This creates a need for a comprehensive, standardized framework that integrates the various concepts and processes of both KM and DT, founded on academic research and tested through practical review.
   The conceptual model proposed in this study consists of four main components: KM and DT interplay, core foundations needed to enable their interplay, common risks and challenges, as well as the synergistic solutions. The model suggests that there is a dynamic and continuous relationship between KM and DT, as they mutually reinforce and enable each other. The key foundations are technology, people and culture, and the organization itself. The identified challenges were competency and skill gaps, outdated technology, lack of collaboration, knowledge loss, gaps and hoarding, poor knowledge quality, wasting of resources, and various

cybersecurity and compliance risks. The synergistic solutions that can help minimize and solve the risks, are provision of needed resources, proactive focus on cybersecurity and compliance practices, investment in the IT infrastructure, deployment of KMS, knowledge re-use, OL activities, active employee engagement and leadership support, fluid organizational structure, KM and DT strategy integration, heterogenous knowledge integration, entrepreneurial and knowledge sharing culture, building KBDCs and change management activities.

3. **A qualitative research approach was used to empirically validate the conceptual model, provide an in-depth and cross-functional understating of the interplay of KM and DT, the common challenges, risks, foundation and opportunities, as seen in practice.**
   The research focuses on a single case study of a global manufacturing corporation, that produces electronical components, sensors and semiconductors for automotive, industrial, consumer electronics, and other various markets. A semi-structured interview approach was selected, that would allow for flexibility in the interview processes and help gather more in-depth information about the unique circumstances and approach to KM and DT interplay of the Company. A total of 21 semi-structured interviews were conducted, with respondents that are directly involved in the DT and KM activities of the Company. The respondents were also grouped into three main groups – based on the region they work in, groups of Europe, North America and Asia were formed; based on the organizational level of the respondents, they were grouped into groups of Management, Team Leads and Team Members; and the last two groups consist of respondents working in the IT organization or various other Business functions. The interviews were conducted in the time span of two weeks of April, 2024. Each interview was at least 45 minutes long and all interviews were conducted in English. The transcripts of the interviews were coded using MAXQDA application, in order to empirically validate and rank each element of the conceptual model, and find new elements of KM and DT interplay.

4. **The results of the empirical research, confirmed the validity and applicability of the model, revealed some insights and best practices for integrating KM and DT in the context of large, multi-national manufacturing organization, and revealed future research directions .** Based on the findings of this study, some implications and recommendations for theory and practice are provided. This study addresses both of the gaps found in the literature, first it contributes to the existing literature on KM and DT by providing a comprehensive, novel, and integrative view of their relationship, and second, the conceptual and empirically validated model addresses the need for more cross-functional collaboration between academia and practice. For practice, this study offers some practical guidance and suggestions for manufacturing organizations that aim to leverage KM and DT for improving their performance and competitiveness, such as developing a clear vision and strategy, fostering a supportive culture and leadership, deploying KMS and formalizing the KM processes. Future research should assess the applicability of the conceptual model and findings of the thesis in both similar organizations and SMEs, considering the differences in the unique environments and contexts of organizations of different size and DT maturity levels. Furthermore, a larger respondent sample or a mixed-methods approach could be used to evaluate the differences between the respondent groups. Lastly, the formalization of KM and impact of AI on the synergy between KM and DT were identified as two new research directions, because of their prevalence in the empirical research, but lack of academic studies focusing on these elements.

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Appendices

Appendix 1. Interview guidelines for the semi-structured interviews.

Section	Question	Objective
Introduction	Can you briefly describe your role, responsibilities, and how long are you with the organization?	Understand the role and experience of the interviewee, their connection to DT and KM
Introduction	How long and in what way, have you been involved with DT activities?	
Introduction	How would you define KM in the context of our organization, and your involvement with it?	
Impact	In your experience, how are the processes of DT and KM connected and how does it create value?	
DT IMPACT ON KM		
Impact	How has DT or adoption of digital technologies, influenced the way we manage knowledge within the organization?	Focus on the DT impact on KM side of interaction - understand the situation of the organization, identify perceived risks, challenges, viable solutions and capabilities
Capabilities	From your experience, what organizational or technological capabilities or foundations are needed to enhance KM through DT?	
Risks	Can you share any specific risks and challenges that emerge in KM, as a direct result of going through DT or implementing digital technologies?	
Solutions	What solutions or strategies have been, or can be, effective in managing these risks and challenges?	
KM IMPACT ON DT		
Impact	In what ways do you think KM contributes to the success of DT initiatives?	Focus on the KM impact on DT side of interaction - understand the situation of the organization, identify perceived risks, challenges, viable solutions and capabilities
Capabilities	Which KM related capabilities or foundations do you feel are critical to further empower DT efforts, based on your experience?	
Risks	What have been the most significant KM challenges that have influenced the direction or execution of DT projects?	
Solutions	Can you describe any solutions that have been implemented to address these KM-related risks in DT?	
INTERPLAY		
Capabilities	What do you see as the essential organizational, technological, or people-related capabilities to foster a productive interplay between KM and DT?	Focus on the interplay, common challenges, solutions and capabilities needed for synergy of KM and DT
Risks	Are there common risks you've noticed that affect both KM and DT? How does the organization typically handle these?	

Opportunities	Could you provide examples of how KM and DT have synergistically created opportunities or solved problems?	
Solutions	Reflecting on your current practices, if you could implement one major enhancement in how KM and DT work together, what would that be and why?	
Solutions	Considering the interplay between KM and DT, what unexplored strategies or innovative solutions do you think could advance this relationship?	
FINAL THOUGHTS		
Wrap up	Reflecting on our conversation, what would be your key recommendations to strengthen the collaboration between KM and DT going forward?	Wrap-up the interview with any final thoughts, personal insights and experience.
	Reflecting on our conversation, can you identify any patterns or recurring themes in how KM and DT interact?	
	Are there any emerging trends that you feel will significantly impact the synergy between KM and DT in the future?	
	To conclude, are there any additional insights or personal experiences regarding KM and DT that you'd like to discuss or that we haven't yet covered?	