Dibakar Sarker

# Achieving Digital Transformation Success: Interplay of Performance, Business Models and Digital Twins in Supply Chain Management

Master's thesis

NTNU
Norwegian University of
Science and Technology

Dibakar Sarker

# Achieving Digital Transformation Success: Interplay of Performance, Business Models and Digital Twins in Supply Chain Management

**NTNU**
Norwegian University of
Science and Technology

# Preface

This thesis is an official requirement for completing the multidisciplinary Master of Science in Engineering ("Sivilingeniør") in Project Management degree program at NTNU with a specialization in Production and Quality Engineering.

Aside from being an growing research field, digital transformation is impacting both technical and leadership behaviors across all sectors. Research and industry professionals need to build resources to bridge this digitalization divide. Therefore, following the direction of TPK4250 Project and Quality Management Specialization Project, contributing to this field seemed novel and important to me which inspired me to initiate this work of research. I have drawn from the fields of supply chain management as well as business modeling to navigate the research work from multiple perspectives by following a systematic review.

It was a long and arduous task worth of 30 ECTS credits. Despite having to deal with multiple personal challenges in this semester, I managed to pull through and complete the report in time through my dedication and hard work. It was a rewarding experience that I hope will open up new opportunities in the future.

Dibakar Sarker
Trondheim, Norway
10 July 2023

# Abstract

Digital transformation, as a paradigm shift in the global socio-economic scene, is impacting all businesses. This shift is multidimensional in nature. As many industries to struggle to reach their digital transformation targets, the need for scientific work on the idea increases. There have been many efforts from the research community on the topic, but few have addressed the issue in the context of leading digital transformation projects and taking initiatives combining the fields of business models, supply chains, and technology.

This master's thesis intended to investigate how today's managers are handling this shift with the help of state-of-the-art technologies like digital twin in the context of supply chain and logistics management. For this purpose, a systematic literature review was conducted and a semi-structured interview scheme was executed with professionals from ten different organizations to gather data and extract information. How digital transformation is reinventing business models was also studied along with the supply chain and logistics issues facing the industries today. Additionally, the context of digital project management was also considered.

The findings of the master's thesis revealed that numerous success factors of digital transformation, opportunities for business model innovation, barriers facing supply chains, and numerous digital technologies, including novel digital twin solutions exist with high future application potentials. Finally, insights and suggestions for future research have been presented.

# Sammendrag

Digital transformasjon, som et paradigmeskifte i den globale sosioøkonomiske scenen, påvirker alle virksomheter. Dette skiftet er flerdimensjonalt av natur. Ettersom mange bransjer sliter med å nå sine digitale transformasjonsmål, øker behovet for vitenskapelig arbeid med ideen. Det har vært mye innsats fra forskningsmiljøet om temaet, men få har tatt opp problemet i sammenheng med å lede digitale transformasjonsprosjekter og ta initiativer som kombinerer feltene forretningsmodeller, forsyningskjeder og teknologi.

Denne masteroppgaven hadde til hensikt å undersøke hvordan dagens ledere håndterer dette skiftet ved hjelp av state-of-the-art teknologier som digital tvilling i sammenheng med forsyningskjede og logistikkstyring. For dette formålet ble det gjennomført en systematisk litteraturgjennomgang og et semistrukturert intervjuskjema ble utført med fagpersoner fra ti forskjellige organisasjoner for å samle data og trekke ut informasjon. Hvordan digital transformasjon gjenoppfinner forretningsmodeller ble også studert sammen med forsyningskjeden og logistikkspørsmål som bransjene står overfor i dag. I tillegg ble konteksten for digital prosjektledelse også vurdert.

Funnene i masteroppgaven avslørte at det finnes en rekke suksessfaktorer for digital transformasjon, muligheter for innovasjon i forretningsmodeller, barrierer for forsyningskjeder og en rekke digitale teknologier, inkludert nye digitale tvillingløsninger, med høye fremtidige applikasjonspotensialer. Til slutt er det presentert innsikt og forslag til fremtidig forskning.

# Table of Contents

# List of Figures

# List of Tables

# List of Abbreviations

Dtrans = Digital Transformation
Dtech = Digital Technologies
Dtwin = Digital Twin
ERP = Enterprise Resource Planning
CRM = Customer Relationship Management
SRM = Supplier Relationship Management
SC = Supply Chain
BM = Business Model
B2B = Business-to-Business
B2C = Business-to-customer
CSF = Critical Success Factor
ROI = Return on Investment
CAD = Computer Aided Design
BIM = Building Information Modelling
AI = Artificial Intelligence
CPS = Cyber Physical System
AR/VR = Augmented Reality/Virtual Reality
IT = Information Technology
IS = Information Systems
RFID = Radio-Frequency Identification
AECO-FM = Architectural, Engineering, Construction, Operation and Facility Management

# 1 Introduction

This section of the thesis introduces the reader to the background which provides a contextual overview of the subject in which this thesis research as well as a problem definition which further defines the challenges that exists within the research subject. Furthermore, the specifics of the thesis are stated within the purpose and research questions followed by the identification of the scope throughout the delimitations.

*"It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change." - Charles Robert Darwin*

## 1.1 Background and Motivation

This subsection lays the foundation of the primary research agenda of this thesis and how it builds the logical connection between the motivation and the research questions.

### 1.1.1 Digital Transformation: Definitions and Perspectives

The usage and integration of digital transformation (Dtrans) frequently has a wide-ranging impact on enterprises, even extending outside their boundaries, influencing commodities, corporate procedures, sales channels, and supply chains. The potential benefits of digitization are shown to be numerous, including higher sales, productivity, value creation, innovations, and new methods of connecting with customers, employee incentives, etc (Alieva and Powell, 2022). Dtrans is upsetting the traditional paradigm of businesses across all industries with a rapid pace of innovation where more and more products and services are being created with improved processes and human-machine interactions (Schwertner, 2017). This calls for further research in this field.

Even though a definition is given to any term for its distinguishment, there appears to be no unified definition of Dtrans. Researchers have different interpretations of it. Table 1 provides a selection of its definitions from several researchers that is beneficial for a broader understanding of it (Kraus et al., 2021).

**Table 1: Selected definitions of digital transformation with references. Source: Kraus et al., 2021.**

| Author(s) | Definition(s) |
|---|---|
| Solis et al. (2008) | The realignment of, or new investment in, technology and business models to more effectively engage digital customers at every touch point in the customer experience lifecycle |
| Fitzgerald et al. (2013); McDonald and Rowsell-Jones(2012) | Use of new digital technologies, such as social media,mobile, analytics or embedded devices, in order to enable major business improvements like enhancing customer experience, streamlining operations or creating new business models As such, the Digital Transformation goes beyond merely digitizing resources and results in value and revenues being created from digital assets. |
| Martin (2008) | Digital Transformation is now commonly interpreted as such usage of Information and Communication Technology, when not trivial automation is performed, but fundamentally new capabilities are created in business, public government, and in people's and society life |

**Table 1: Selected definitions of digital transformation with references. Source: Kraus et al., 2021 (continued).**

| Author(s) | Definition(s) |
|---|---|
| Westerman et al. (2011) | Digital Transformation is defined as the use of technology to radically improve performance or reach of enterprises. |
| Stolterman and Fors (2004) | Digital Transformation are the changes that digital technology causes or influences in all aspects of human life |

Thus, Dtrans is a multidisciplinary field combining technology, policies, culture, and consequently, people. It consists of several transition phases, which can be described as shown table 2 (Savić, 2019).

**Table 2. Distinction between digitization, digitalization, and digital transformation. Source: Savić, 2019.**

| | Digitization | Digitalization | Digital Transformation |
|---|---|---|---|
| **Focus** | Data conversion | Information processing | Knowledge exploitation |
| **Goal** | Analog to digital format conversion | Automate traditional business operations and processes | Change company's culture, operations, and thought process |
| **Activity** | Convert paper documents, photos, microfilms, LPs, films, VHS tapes, etc. to digital format | Creation of completely digital work processes | Creation of a new digital company or transformation into a digital one |
| **Tools** | Computers and conversion/encoding equipment | IT systems and computer applications | Matrix of new (currently disruptive) digital technologies |
| **Challenge** | Material (volume) | Price (Financial) | Resistance to change (human resource) |
| **Instance** | Scanning paper-based registration forms | Completely electronic registration process | All electronic, from registration to content delivery |

Digitization is a crucial component of Industry 4.0, which seeks to completely disrupt organizations and present economic paradigms (Huckstep, 2016, Gökalp and Martinez, 2021).

One of the key reasons for the relevance of Dtrans research is that it assists firms in understanding the advantages and disadvantages of using digital technologies at scale. According to Sundaram (2020), firms that embrace digital transformation should expect enhanced operational efficiency, better customer experiences, and revenue growth (Sundaram et al., 2020). However, the same survey notes that many firms confront hurdles in their digital transformation journeys, such as a skilled worker shortage and the difficulty of integrating new technology with current systems. Consequently, leadership characteristics around Dtrans must progress from being managers only looking for incremental improvements to innovators with the courage to develop compelling objectives

and courageously envision the future of their organizations. McKinsey (2023) suggests five possible shifts in the leadership traits in this new era as shown in figure 1 (McKinsey, 2023).

| | | Go beyond... | Extend to... | |
|---|---|---|---|---|
| **What we focus on** | As **manager**, deliver profits to shareholders, with a mindset of **preservation** | Profit | Impact | As **visionary**, generate holistic impact for all stakeholders, with a mindset of **possibility** |
| **How we create value** | As **planner**, compete for existing value through advantage, with a mindset of **scarcity** | Competition | Cocreation | As **architect**, cocreate new value through reimagining, with a mindset of **abundance** |
| **How we organize** | As **director**, command through structured hierarchies, with a mindset of **authority** | Command | Collaboration | As **catalyst**, collaborate in empowered networks, with a mindset of **partnership** |
| **How we get work done** | As **controller**, administer through detailed prediction, with a mindset of **certainty** | Control | Evolution | As **coach**, evolve through rapid learning, with a mindset of **discovery** |
| **How we show up** | As **professional**, meet expectations, with a mindset of **conformity** | Expectations | Wholeness | As **human**, be our whole best selves, with a mindset of **authenticity** |

**Figure 1: Five traits redefining leadership for the disruptive new era. Source: McKinsey (2023)**

Furthermore, from a macroeconomic perspective, increasing governmental strategic moves and investments in the digital spectrum across the globe are noticeable, e.g., China, the world's second largest economy, attributed to 39.8% of its gross domestic product (GDP) to its digital economy, amassing up to USD 7.1 trillion (Na et al., 2022). In 2022, the global Dtrans spending touched nearly USD (U.S. Dollars) 1.6 trillion, which is projected to reach up to USD 3.4 trillion in 2026 (Global digital transformation spending 2026, Statista). Meanwhile, a 2017 survey suggests that a large section of the industries see Dtrans as technological integration and therefore, only as information technology (IT) innovation. They fail to see that a successful integration means organizational culture needs to change first rather than investing in technology (Attaran, 2020).

## 1.1.2 Business Model Innovation for Digital Transformation

Virtually, every business needs to create its own business model (BM) in its initiation phase which it builds up on single or multiple existing models or an innovative one created by its business team. BM innovation is necessary for modern business to achieve superior performance while setting and reaching its most value-generating goals (Frankenberger et al., 2013). Morris and Jamieson (2005) have presented a general framework for BM innovation as shown in figure 2 (Morris and Jamieson, 2005).
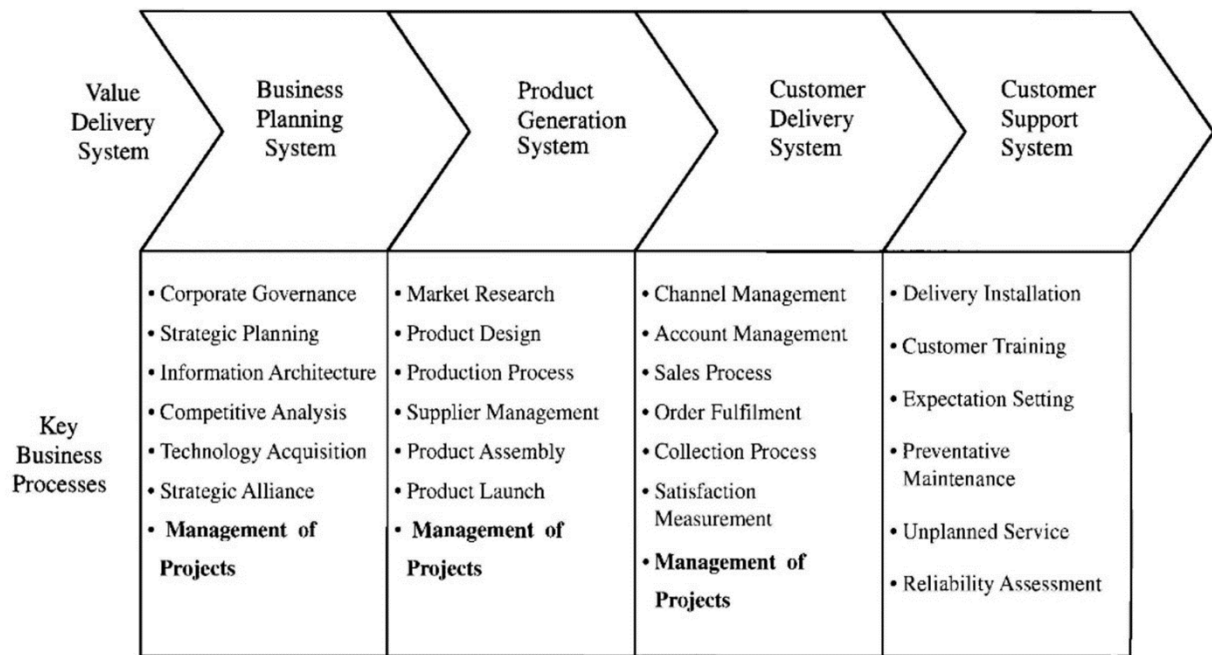
**Figure 2: Generic business enterprise model. Source: Morris and Jamieson (2004)**

Thus, it is noticeable that BM has to do with the management of value for stakeholders: value creation, value capture, value proposition, and value delivery (Klos et al., 2022). Dtrans is having a huge impact on their evolution (Favoretto et al., 2021, Klos et al., 2022).

## 1.1.3 Digital Technologies: The Potential of Digital Twin

A digital twin (Dtwin) is not a single device or entity, but rather a whole system of elements that act together which demand special technical expertise from several areas, e.g., sensor and data analytics. A Dtwin is a machine or computer-based model that emulates, mirrors, or "twins" the life of a physical entity, which can be an item, a process, a human, or a human-related feature (Barricelli et al., 2019).

The impact of Dtwin in the near future is likely to be immense, as shown in the figure 3 below (Qi et al., 2021). Its uses range across a multitude of industries and thus, it is gaining momentum as a research interest. It is quickly finding its way into SC and logistics where it promises improvements in different possible ways, including traditional parameters like efficiency as well as modern customer demand management (Moshood et al., 2021).
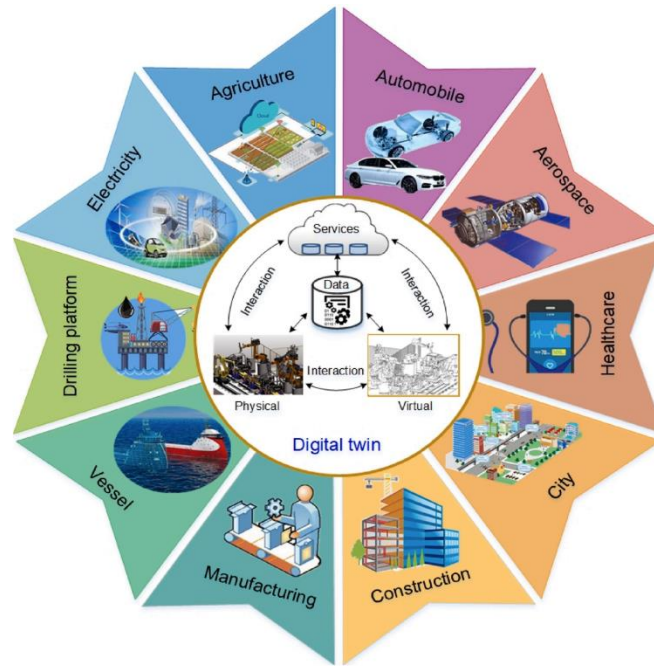
**Figure 3: Numerous applications of the digital twin. Source: Qi et al. (2021)**

### 1.1.4 Digitalization of Supply Chain and Logistics Management

Supply chain (SC) disruptions and innovation is driven by Dtrans (Agrawal and Narain, 2018). Market saturation with virtually an innumerable variety of products caused by globalization has generated a desire for innovative production processes in firms to acquire competitive advantages – all while pushing for green production with diminishing natural resources (Ülkü and Hsuan, 2017). Digitalization here may prove to be ultimately beneficial for such endeavors as it might minimize resource uses (Nyagadza, 2022). Thus, for traditional service providers, especially those involved in logistics, Dtrans has been becoming increasingly vital in recent years.

## 1.2   Problem Description

Dtrans projects and endeavors fail in many industries in many instances, which is why large corporations as well as small and medium sized enterprises (SMEs) are rushing to digitalize their products and services with much care (Ramesh and Delen, 2021).

While not all metrices used in project management performance may be applicable to the Dtrans, existing research works imply that variables that significantly influence the Dtrans success in a business can be identified which can benefit managers and other professionals (Berghaus and Back, 2016).

Dtrans suggests the introduction of innovative digital BMs, leaving many concerns unresolved, such as their value proposition, production, and capture (Osmundsen et al., 2018, Klos et al., 2022). Therefore, from a top-down management perspective before developing a new BM, significant criteria like as technical and leadership issues must be considered (Taran et al., 2015).

## 1.3   Objectives and Research Questions

The objective of this graduate-level research is investigate how organizations can achieve Dtrans success and what factors are making a difference. Thus, this acts as the **central**

**research question (RQ)**. To dig deeper into the field, particularly three sub-questions have been formulated to facilitate the central RQ and find further meaningful insights that can lead to future research possibilities. These questions are demonstrated as follows:

*RQ1: What are the success factors of digital transformation of organizations in general? What type of measures are in use to evaluate the progress of digital transformation projects and endeavors?*

This is the sub-question that dictates the research direction as it captures the essence of the central RQ and leads to the core findings of the whole thesis work. The purpose of this question is to pin down the most important organizational variables that makes any Dtrans effort win. Additionally, this questions deals with metrics that can be exploited to gauge Dtrans progress at a given scenario, and what kind of organizational criteria (e.g., strategy, leadership, decision-making, culture, growth, etc.) prove to be relevant and influential.

*RQ2: How does digital transformation impact business models? How does it further translate to supply chains?*

As discussed earlier, the Dtrans phenomenon influences business leaders to think beyond their traditional ways of making organizational decisions. This question intends to emphasize the changes caused by Dtrans that significantly impact the businesses, their strategic dynamics, and their respective markets. Furthermore, it investigates how supply chains are being digitalized along with such business model innovations, either directly or indirectly.

*RQ3: What are the challenges or barriers that supply chains and logistics face today? What is the role of digital technologies and capabilities, particularly digital twin, for overcoming such predicaments in today's industries?*

This questions highlights the problems in the logistical and supply chain operations in the present industries that hamper efficiency and value creation for the stakeholders. As such, it aims to find out the key challenges in the aforementioned areas. Besides, it plunges into the Dtech available today that the professionals are using to improve their supply chain and logistics activities, while taking a special interest in the state of the art of the technology called Dtwin.

These sub-questions provide a logical path that guides to the answer of the main RQ with the goal of leading Dtrans projects in a company that strives to innovate its business offerings and successfully manage its supply chain relationships. It is desired that the findings will open pathways for further scientific research work as well.

## 1.4 Scope of the Study

The scope of the study primarily centers on different organizational behaviors around Dtrans, BM innovation, supply chain, and logistics management. The challenges in the supply chain and logistics management are mostly within the boundaries of the respective organizations presented in the literature and the interview studies performed.

Interviews with specialists from various organizations are done to ensure the quality of the study. The primary purpose is to acquire as in-depth professional insights and feedback as feasible in order to finally compare the outcomes of the scholarly discoveries from an industrial viewpoint. This serves as a foundation for understanding Dtrans's function and SC difficulties from an organizational standpoint. The research questions are evaluated, addressed, and discussed using the findings from the literature and interviews.

## 1.5  Out of Scope

The study does not consider the impact and magnitude of all the external forces that might exist outside of the organizations under discussion. Furthermore, the metrics and practices presented and/or suggested in this work are only from a limited set of individuals engaged in a number of industries. Thus, these may not applicable to other scenarios and/or industries which calls for benchmarking or other forms of test.

## 1.6  Structure of the Thesis

The thesis report is an empirical work of scientific research. It begins with an introduction which has been presented in this section. Then, chapter 2 is presented where the methodology of the research is discussed in detail for clear reproducibility, validity, and reliability. Chapter 3 offers critical information in the manner of theory that is required to obtain the essential knowledge that comes from within the area of the research. It comes from the literature study. Then, chapter 4 provides the results of the literature and interview studies. Chapter 5 discusses the findings and interpretations. Finally, Chapter 6 provides concluding remarks and suggests possible future research directions.

In the next section, methods for gathering important information are discussed, which includes the many forms of literature used in this work as well as the interview procedure

# 2 Methodology

This part elaborates on the study strategy, methodologies, reasoning, and data collection methods used in this thesis, including the interview process. Each subsection includes an explanation of why these specific techniques were selected, ending with a segment explaining the research quality assurance.

## 2.1 Research Approach

A framework presented by Patel and Davidson (2003) has been adopted as the flow of executing the research work as presented in table 3 (Patel and Davidson, 2003).

**Table 3. Research approach (Patel and Davidson, 2003)**

| Steps | Description |
|-------|-------------|
| 1 | Knowledge acquisition |
| 2 | Problem Construction |
| 3 | Research method and techniques selection |
| 4 | Data Collection |
| 5 | Data Processing and Analysis |
| 6 | Results Presentation |

These steps come with multiple layers that builds up on each other logically. They are briefly described below: -

1. **Knowledge acquisition:** According to Patel and Davidson (2003), the first stage in any research procedure is to gain information about the topic and a thorough grasp of the background. The more precise the problem formulation, the better the comprehension of the topic. Gaining topic knowledge is an iterative and ongoing process throughout the study, so it is critical to maintain an open mentality in order to keep improving. The foundation for problem formulated began from the introduction chapter as stated earlier in the thesis.
2. **Problem Construction:** The problem construction phase follows, in which the issue is recognized and a description is written. It is described in the problem statement along with the RQs. The research is founded on resolving the problem statement; it is critical that the research query be precise so that the research's goal is met in the end. According to Patel and Davidson, the research topic can be improved and optimized throughout the research process. These two steps are critical because they determine the remainder of the research process; thus, the results of these two steps establish the standard for the methodologies, implementation, analysis, and results.
3. **Research method and techniques selection:** The third stage is to choose a strategy and strategies for resolving the issue statement. It is critical to determine the sort of research approach; is it more beneficial to use a quantitative method, a qualitative method, or a combination of both? Following that is the sort of research reasoning, whether inductive or deductive. Inductive reasoning is the analysis of observations and data collecting in order to build new hypotheses or conceptions. Deductive reasoning, on the other hand, relates to the development of hypotheses and ideas that are supported by facts and findings.

4. **Data Collection:** The next stage is to gather data using the research methodologies and logic that have been determined. Depending on the study approach, several data collection methods are accessible; the most generally utilized ones for qualitative methods include interviews, literature studies, and internet sources such as websites, articles, and videos.
5. **Data Processing and Analysis:** The fifth phase in the research process is processing and analyzing, in which the data obtained and inspirations from the literature are combined and examined to provide preliminary results. It is possible to finish and answer the RQs posed in step 2 by performing more research and analysis.
6. **Results Presentation:** The final phase in this process is reporting and presenting, in which the report must gather all of the study data in a systematic way. The findings and conclusions must be related to answering the research question. It is also critical to guarantee that the research objective is met (Patel and Davidson, 2019). These six phases of the research technique depicted above were helpful in carrying out the thesis.

## 2.2   Literature Review Process

This entire subsection is dedicated to the presentation of the process used to gather the existing knowledge relevant to the thesis. It refers to a part of the data collection process as mentioned in subsection 2.1.

### 2.2.1   Categories of Literature Review

According to Green et al. (2006), literature reviews can be categorize into three different types: 1. Narrative reviews, 2. Quantitative systematic reviews, and 3. Qualitative systematic reviews (Green et al., 2006). They are briefly described below.

### 2.2.2   Narrative Review

A narrative review is a traditional way of doing literary evaluations that is separated into three sections: unsystematic narrative reviews, commentary, and editing. An unsystematic narrative review is referred to as a narrative overview. This type of literature study is frequently handled and published by previous professionals and writers who are familiar with the subject and have previously conducted research in similar fields. Commentaries are biased evaluations that encourage and urge readers to engage in scholarly dialogue and participatory action research with one another. Lastly, an editorial literature review is frequently conducted by journal visitors or editors who are requested to express their views and give remarks on the journal's articles or other events (Bartunekl, 1993, Green et al., 2006).

### 2.2.3   Quantitative Systematic Review

A quantitative literature review, also known as a meta-analysis, is the process of studying and assessing a vast quantity of data using statistical methods and procedures, testing different aspects, and finding their association. Later, the findings and accumulated data might be presented in further detail. Experimental design and survey research are two of the most well-known quantitative research approaches (Creswell, 2014).

### 2.2.4   Qualitative Systematic Review

In contrast to quantitative research, qualitative research does not deal with numerical data, and it is a strategy of gathering diverse books in order to comprehend a scenario or the

complexities of a subject. Case studies and interviews with questions to elicit qualitative data are two of the most well-known qualitative research approaches. These results and data can also be expressed in tables or graphs, making it simple to compare studies and find gaps (Green et al., 2006, Creswell et al., 2014). Due to the nature of the thesis, a qualitative systematic review based approach was chosen for this research that follows a particular method. Table 4 summarizes all the search parameters with evaluation criteria for the literature review, while table 5 provides the logical keyword sets used for searching literature.

**Table 4. Parameters for literature search with evaluation (inclusion and exclusion) criteria**

| Search Parameter | Parameter Type | Evaluation criteria |
|---|---|---|
| Language | • English<br>• Others | The majority of the research works are available in the English language. Works from other languages are selected only if they are deemed indispensable with the help of online translators. |
| Research area | • Digital Transformation<br>- Critical Success Factors<br>- Measures and Metrics<br>• Business Model<br>• Supply Chain and Logistics<br>- Challenges<br>• Digital Technologies<br>- Digital Twin | The research area is determined by the RQs. Any item not relevant to the RQs gets eliminated after initial title and abstract scanning. |
| Industry/Sector | Private and public sectors | The study considers on Dtrans of organizations in general. Furthermore, it considers business models with a special focus on supply chain and logistics providers that utilizes digital technologies. |
| Location | • Worldwide<br>• Norway<br>• EU/EEA | First, global relevant literature is searched. Then, it considers literature from Norway and EU/EEA for making inferences and/or recommendations. |
| Literature class | • Scientific journals and reports, including original research and reviews<br>• Conference proceedings<br>• Books<br>• Financial reports<br>• White papers | Journals and conference proceedings are relevant for the research, including review articles that provide substantial insights, especially recent ones.<br>Furthermore, financial reports, white papers, and other databases are used to enrich comparison and analysis. |

**Table 5. Boolean keyword combinations utilized for literature search based on the research questions**

| RQ1 Search Query | RQ2 Search Query | RQ3 Search |
|---|---|---|
| ("Digital Transformation") AND ("Success Factors" OR "Critical Success Factors") | ("Digital Transformation") AND ("Business Model" OR "Digital Innovation") | ("Supply Chain and Logistics") AND ("Challenges" OR "Barriers" OR "Obstacles" OR "Difficulties" OR "Problems") |
| ("Digital Transformation") AND ("Metrics" OR "Measures" OR "Key Performance Indicator" OR "KPI" OR "Readiness" OR "Performance") | ("Digital Transformation Business Model") AND ("Supply Chain" OR "Logistics") | |
| ("Digital Transformation Project") AND ("Metrics" OR "Measures" OR "Performance") | | ("Supply Chain and Logistics") AND ("Digital technologies") OR ("Digital Twin") |
| | | ("Digital Twin") AND ("Facility Management" OR "Inventory Management" OR "Asset Management") |

Multiple scholarly online search engines have been utilized for performing a thorough literature search. The short descriptions of the engines used and their retrieved number of hits are presented in table 6. Figure 4 is an example showcase of one of the search engine results. Figure 5 shows the overall literature search and selection process based on the framework provided by Kristoffersen et al. (Kristoffersen et al., 2020). *Snowballing*, which is referring to the citations of a paper to identify additional literature sources (Wohlin, 2014), and *handsearching,* which is a manual screening of pre-identified literature that get overlooked during the indexing procedure (Craane et al., 2012), have been performed and added to the study list. Additionally, a selection of articles were used from the TPK4250 Project and Quality Management Specialization Project Report in order to theoretically introduce some important concepts to the reader in the theory section.

**Table 6. Search engines used for literature search**

| Search Engine | Description |
|---|---|
| Google Scholar | Scholarly search engine for journals, conference proceedings, books and other data |
| Scopus | Database for journal and conference publications |
| Oria (NTNU intranet) | NTNU Database for journal and conference publications |
| Web of Science | Database for journal and conference publications |
| Litmaps | Finds most relevant articles to a given RQ using AI models |
| Connected Papers | Finds related papers based on a central publication |
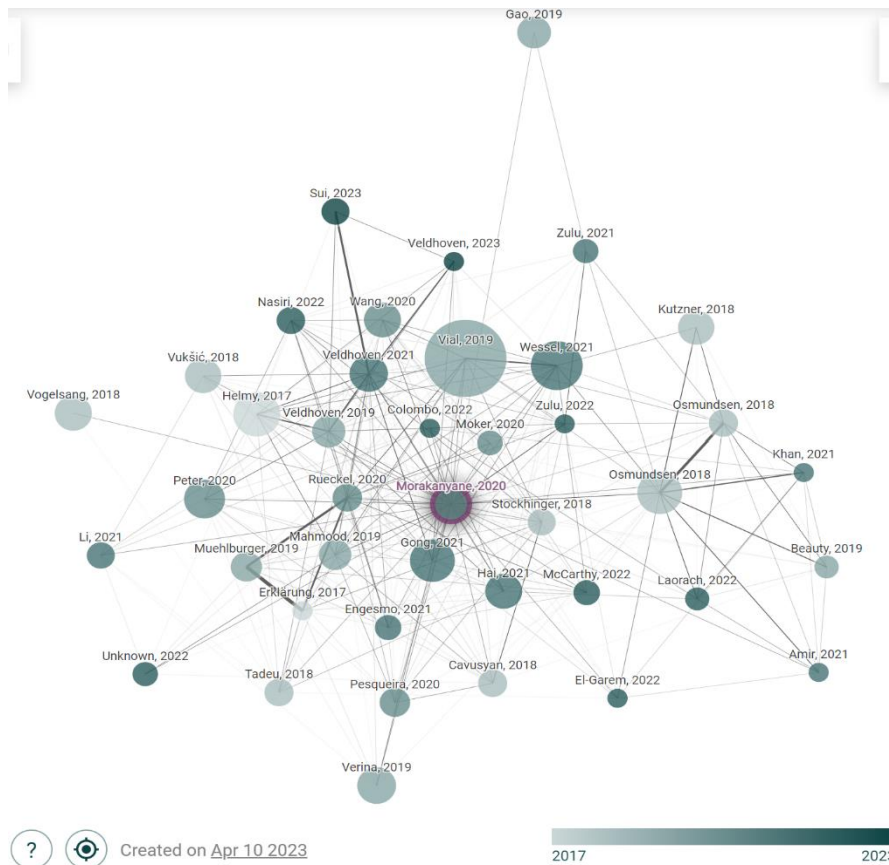
**Figure 4: Example of retrieved nodes from the AI-based search tools (picture example: Connected Papers)**
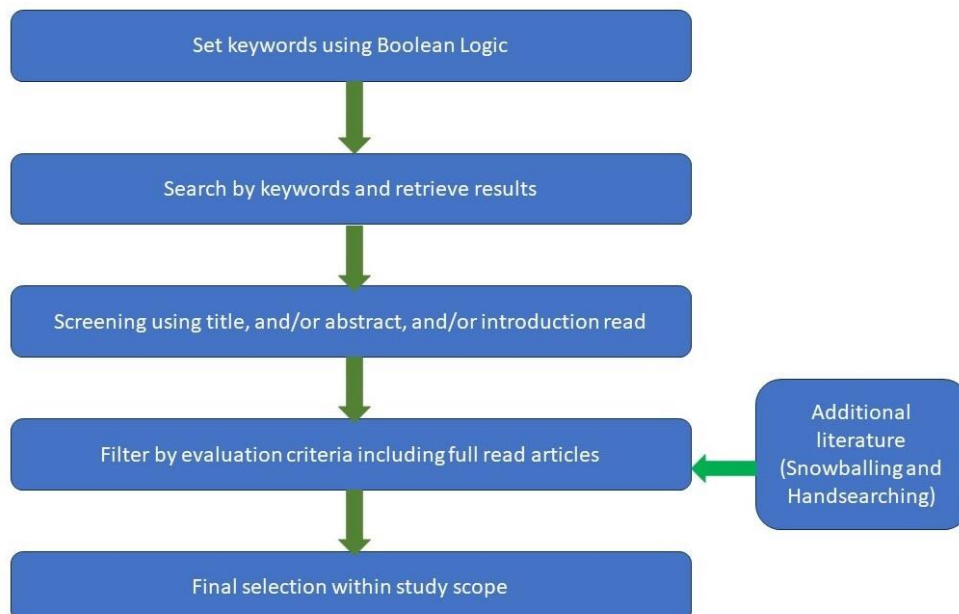


**Figure 5: Simplified process of final literature selection, Source: own creation, inspired by Kristoffersen et al. (2020)**

As mentioned in the research approach, a particular method called the Preferred Reporting Items for Systematic Reviews and Meta-Analyses or, PRISMA, have been utilized for the qualitative literature review documentation protocol.

## 2.2.5 Literature Review Protocol: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses, more popularly known as the PRISMA, is a proof minimal collection of items for systematic review and meta-analysis reporting. PRISMA is mainly intended for the reporting of reviews evaluating the impacts of interventions, but it also has the potential to record systematic reviews with goals apart from evaluating interventions (Page et al., 2021). Currently, there is a revised version of the PRISMA statement (2020), originally published in 2009, which has been updated to incorporate improvements in techniques for identifying, selecting, evaluating, and synthesizing studies. Originally intended for statistical medical research, it is finding its way in other research domains (e.g., engineering, technology, business) as well, including qualitative areas (Page et al., 2021, Pahlevan-Sharif et al., 2019).

The PRISMA 2020 statement is made up of a 27-item checklist, which includes an enlarged checklist with reporting suggestions for each item, the PRISMA 2020 abstract checklist, and new flow schematics for original and revised reviews (Page et al., 2021). This checklist is required to be completed by researchers when applying PRISMA, which is provided in the appendix section.

The PRISMA flow diagram after the final screening is presented in figure 6. It has been suitably simplified to meet the criteria of the non-statistical needs of a qualitative research study (Appendix B).
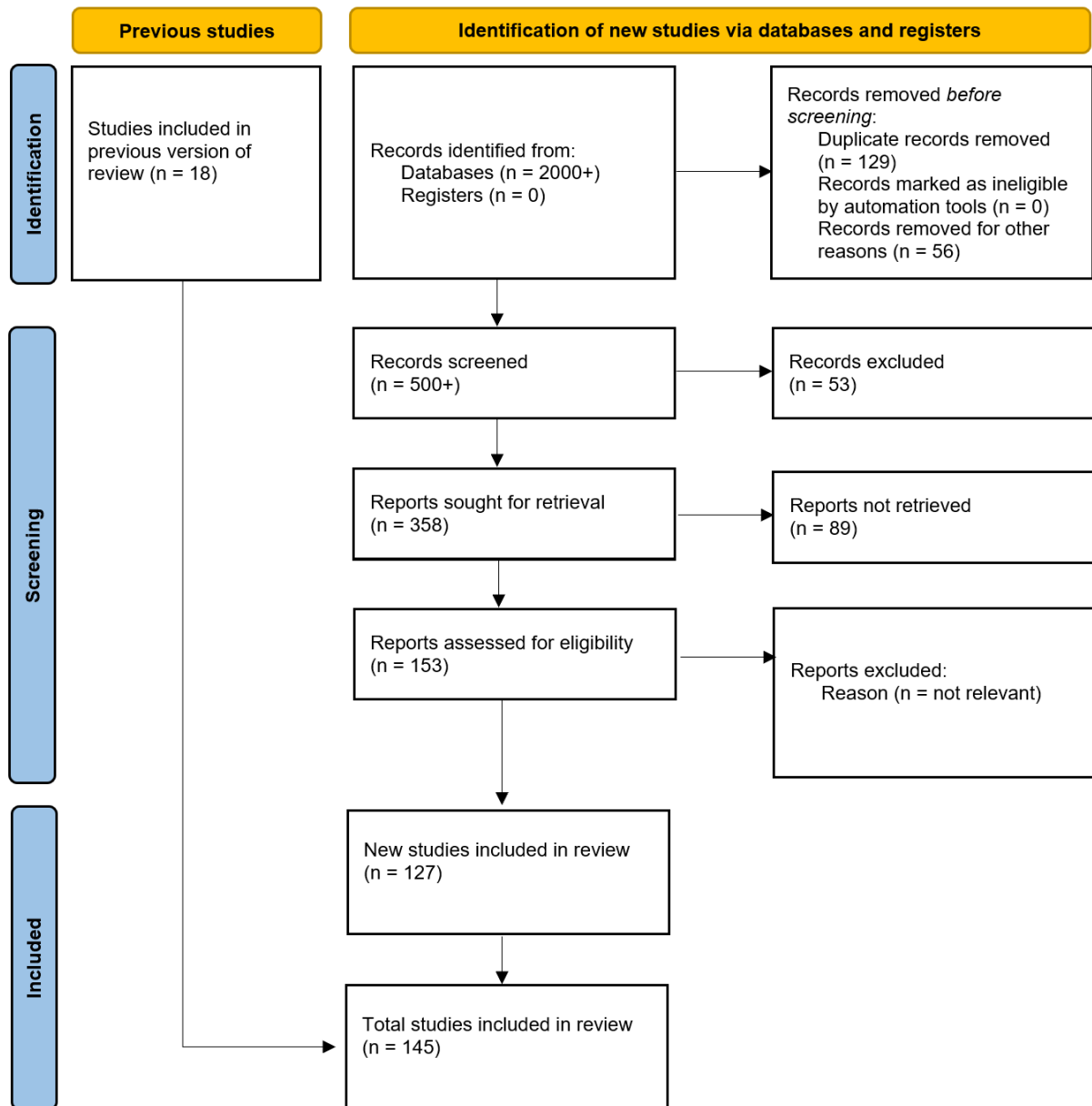
**Figure 6: Modified PRISMA 2020 flow diagram used for the systematic literature review. Source: own production.**

The PRISMA checklist for the thesis is presented in the appendix A. The diversity of the finally selected literature for full reading in terms of research fields is presented in figure 7.

## No. of Papers Selected for Full Read
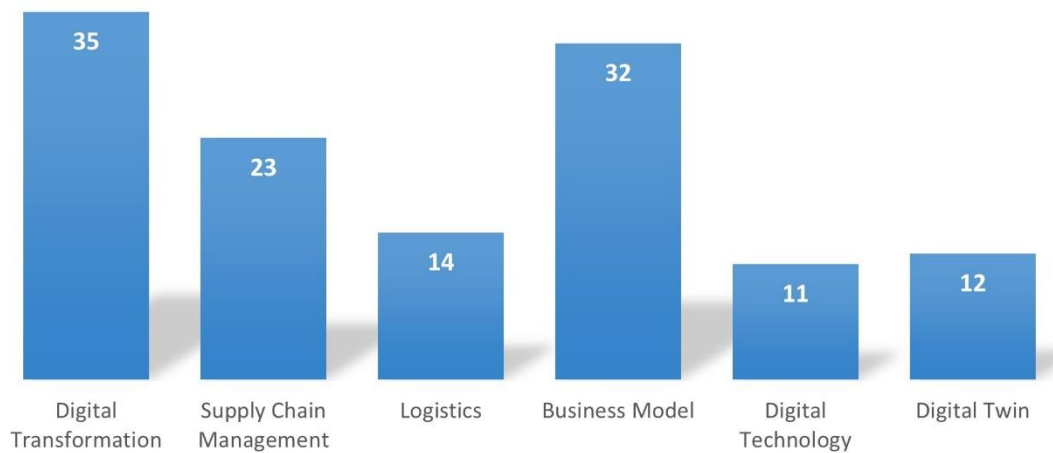


**Figure 7: Final selection of literature for analysis according to relevant topics (own production)**

## 2.3 Interview of Professionals

As mentioned earlier, professionals working in several industries have been contacted and interviewed for relevant data. The process is described here.

### 2.3.1 Interview Process

A semi-structured interview questionnaire was prepared for the case companies as presented in the appendix B. The questionnaire was prepared based on the findings from the articles listed in table 7 during the literature search. These articles provide the respective authors' standpoints on Dtrans CSFs and overall process.

**Table 7. Papers particularly relevant for logical formation of interview questionnaire**

| No. | Author, Year | Title | Relevance |
|-----|-------------|-------|-----------|
| 1 | Osmundsen et al., 2018 | Digital Transformation: Drivers, Success Factors, and Implications | Dtrans CSF |
| 2 | Morakanyane et al., 2020 | Determining digital transformation success factors | Dtrans CSF |
| 3 | Vial, 2019 | Understanding digital transformation: A review and a research agenda | Dtrans process |
| 5 | Sebastian et al., 2017 | How Big Old Companies Navigate Digital Transformation | Digital technologies |

Vial (2019) provided the framework for the interview questions while Osmundsen (2018) and Morakanyane (2020) determined the critical success factors (CSF) that are deemed to be common with a high number of citations for validity. The relevancy regarding this is discussed further in the theory section. Sebastian et al. (2017) provided the popular digital tools used in the organizations for evaluating their usage through the questions.

After preparing the questionnaire and the information letter that describes the project, they were sent to Sikt (Norwegian Agency for Shared Services in Education and Research: https://sikt.no) for approval. It included the consent of recording the interview sessions.

After receiving clearance from Sikt in around two weeks, the hunt for locating and contacting possible interview items formally began. Both my personal and my supervisor's professional networks were employed for this reason. Furthermore, suitable specialists were found online using the Google search engine and LinkedIn, and then approached for participation in the study. The primary criterion for selecting interviewees was that they would have to be a working professional with knowledge and experience in one or more the followings:

- Digital Transformation
- Digital Supply chain and logistics management and/or
- Project management with digitalization expertise/experience
- Information Technology (IT)

The interviewees were asked for one hour each for their individual interview, nonetheless, some of them had taken longer than that as they had room for speaking more about their ideas and experiences. The interviews lasted between one hour and one and half an hour. Among the potential interviewees, the ones who replied back and agreed to participate in the interview are listed in table 8 along with their respective roles, organizations, and locations. Almost all of the contacted personnel belonged to different industries with diverse backgrounds as shown in the pie chart (figure 8). Finally, 11 personnel were interviewed working in 10 different organizations. For one of the organizations, several (2) personnel agreed to be interviewed.

**Table 8. Interviewee roles in their respective organizations**

| Participant Code | Organization Code | Sector(s) of the Organizational Experience | Designation/Position of the Attendee | Location |
|---|---|---|---|---|
| A1 | A | Metallurgy (aluminum) | Regional Manager | Norway |
| A2 | | | Material Management Lead | |
| B | B | IT and construction | Chief Executive Officer (CEO) | Norway |
| C | C | Consulting (Analytics) | President | United States |
| D | D | Digital Estates (University) | Department Manager | Norway |
| E | E | Oilfield services, subsea (technology) engineering | Digital Advisor | Norway |
| F | F | Wholesale/Distribution | IT Leader (Project Management Office) | Norway |
| G | G | Auditor in assurance and risk management | Digital Transformation Advisor | Norway |

**Table 8. Interviewee roles in their respective organizations (continued)**

| Participant Code | Organization Code | Sector(s) of the Organizational Experience | Designation/Position of the Attendee | Location |
|---|---|---|---|---|
| H | H | Research, academia and construction | Professor | Netherlands |
| I | I | IT, Software-as-a-Service (SaaS), Internet of Things (IoT) | CEO | Norway |
| J | J | IT, SaaS, Architecture, Engineering and Construction (AEC) | Architect and Chief technology officer (CTO) | Norway |

## CORRESPONDENT DISTRIBUTION

■ Private Company    ■ University



18%

82%
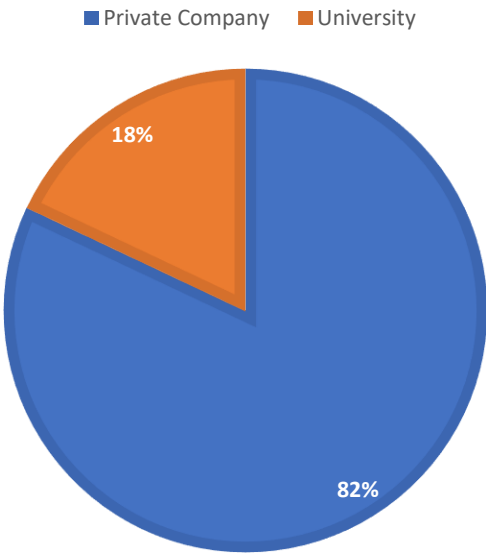
**Figure 8: Pie chart showing the distribution of the industries of interviewed organizations**

All the personnel were sent emails via NTNU's organizational email. The interviews were conducted via Microsoft (MS) Teams due to logistical limitations and ease of use. Thus, the data was kept safe and unbiased while transcribing to safeguard the interviewees and their organizational stakeholders.

### 2.3.2    Interview Data Processing

The whole process of contacting interviewees, data collection, data transcription, and analysis for presenting in the results are noted sequentially in figure 9. The "pre-interview" step or phase encompassed the identification of candidates, emailing, response, and scheduling of interviews. Then, the interviews took place and they were simultaneously recorded on MS Teams. Next, in the "data processing" step, the recordings were

transcribed by typing on a personal computer via listening and reading from the dialogue generated by artificial intelligence (AI) algorithm built in MS Teams. Each transcription took two hours on average. Then, the data was categorized in terms of the interviewees, research fields and aforementioned RQs. Afterwards, the transcriptions were analyzed and concisely further extracted into the thesis report. The financial claims made by the interviewees were compared with the data publicly available (i.e., annual reports, financial databases) about the businesses they work for.
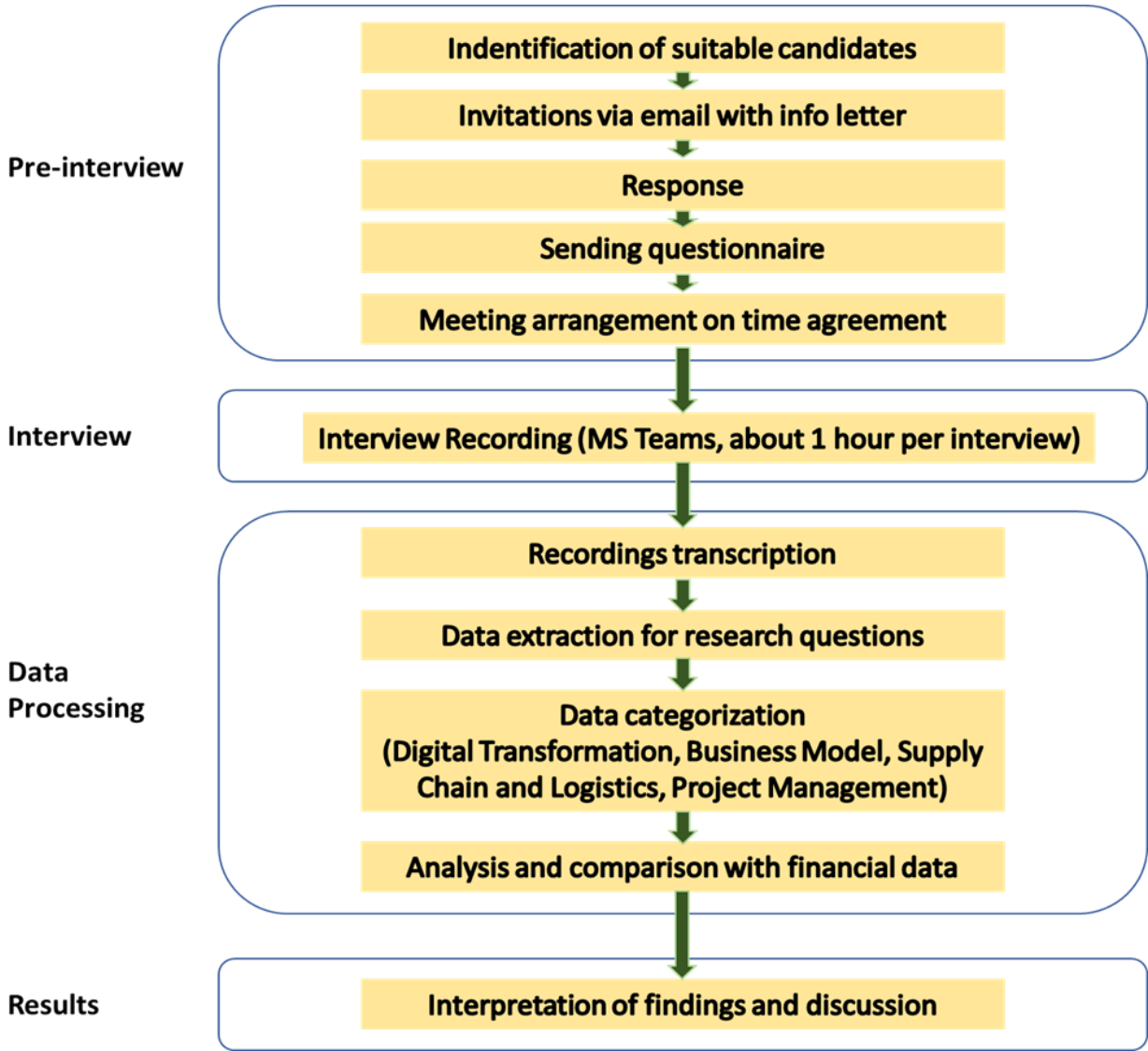


**Figure 9: Interview data handling steps for comparison and research outcomes**

The relevant interview findings have been presented, visualized, and discussion with respect to interviewees and their organization in the results and the discussion sections.

## 2.4 Quality of the Research

It is critical to ensure that research maintains norms of excellence by improving validity and reliability. As a result, this thesis concentrated on establishing internal and external consistencies to ensure its credibility as discussed below.

### 2.4.1    Validity

In qualitative research, validity or credibility is essential (Denscombe, 2017). Kumar (2018) describes validity as "an instrument's ability to measure what it is designed to measure" (Kumar, 2018). Checking the validity of a qualitative study is more difficult than checking the validity of a quantitative study since it is rare that all of the researchers or participants reach the same conclusion. However, there are various methods that researchers may use to validate the information they are given. Readers may also be certain that the facts and information presented have been validated and are genuine in this manner. The following procedures was used to validate interview data: "Triangulation" is a technique for verifying interview material consistency by cross-referencing interview data with other sources such as papers, observations, and even additional interviews (Patton, 1990). For this research, financial databases and annual reports were searched to validate interview statements. Another technique to examine the quality of the data in this thesis was to seek for patterns in the transcript. This technique recommends doing several interviews rather than relying on a single interview so that the researcher may use the data with more confidence (Denscombe, 2017).

### 2.4.2    Reliability

Reliability refers to the consistency of research equipment in producing the same findings under the same conditions again and over (Kumar, 2018). According to Denscombe (2017), examining the credibility or compliance of a tool in qualitative data is as difficult as analyzing the validity of the data in this type of study since it is impossible to replicate the same circumstances with the same persons. However, if a researcher demonstrates that the results of the research can be relied on and used by other researchers regularly throughout time, the approach can be acknowledged as reliable.

### 2.4.3    Ethical Considerations

In the context of meta-analysis, the removal of any information that can be traced back to an individual participant is considered to be an ethical obligation (Taichman et al., 2016). There are usually specific protocols and considerations that must be followed while conducting an interview. According to Norwegian research rules and regulations, all researchers who collect personal data must fill out the Sikt (Norwegian Agency for Shared Services in Education and Research) form so that the center can assess and approve the data collection process in the thesis's compliance with data protection legislation. The information acquired in this form was forwarded to the participant so that they may become more acquainted with the thesis topic, the interview procedure, and their own personal data rights. Both the project student and the supervisor signed the document. Participants were also asked to thoroughly read the form, sign it, and return it to the thesis writer. All personal data is saved on the NTNU infrastructure, such as OneDrive, SharePoint, and Microsoft Teams, for increased data protection and safety. The responses are anonymized and utilized in this thesis, and the recordings will be erased after the research is done. It is also ensured that their personal information is not revealed in newspapers and that their interview has no bearing on their connections or positions in their companies.

### 2.4.4    Limitations

In spite of the scholarly, professional, and intellectual efforts that went into this research work, there are some constraints or biases that must be recognized for ensuring the clarity and standpoint of the thesis. As it is a characteristic of a systematic literature review, this research study does not constitute an entire collection of material accessible on the issues

under consideration. The number of organizations taking Dtrans as a crucial strategy is limited and not readily available to interview.

The study does not consider the impact and magnitude of all the external forces that might exist outside of the organizations under discussion. Also, the industries that were interviewed had not all the experience required to relate to every aspect of the RQs. Not all interviewed organizations owned financial data at the time of the research either because of being an early-stage startup or because of being a not-for-profit organization.

Furthermore, the metrics and practices presented and/or suggested in this work are only from a limited set of individuals engaged in a number of industries. Thus, these may not applicable to other scenarios and/or industries which calls for benchmarking tests.

## 2.4.5    Synopsis

The approach in the thesis is based on qualitative methods such as a systematic literature study and interviews with experts from various companies. The purpose of the literature study and interviews was to gather information about the chosen research topics from empirical work and industrial insights, mainly based on the idea of Dtrans with overlapping concepts of SC, BM, and Dtech. The identified information from the literature and the interviews have been presented as mentioned in this methodology section in order to answer the RQs.

# 3 Theory

A literature review has been presented here that creates a summary of the existing research work on Dtrans, BM innovation, Dtech, supply chain and logistics management and their interconnectedness with project management. This chapter builds the necessary framework for investigating the RQs based on relevant publications in the specific fields. A systematic review of the literature has been documented in subsections 3.1 to 3.5.

## 3.1 Digital Transformation

This subsection describes the literature review discovered on the Dtrans area and shows how it builds on the context of reaching success.

### 3.1.1 Significance of Digital Transformation

Being an interdisciplinary issue, Dtrans deals with socio-economic and behavioral factors that play crucial roles in building relationships with stakeholders by providing value and improving processes both internally and externally (Zaoui and Souissi, 2020). Thus, leadership is significant in any institute's digital journey. Researchers have endeavored to connect organizational leadership and performance of the transformation phenomenon and how the interplay between leaders, decision makers and employees impact their organizations. According to McCarthy et al. (2021), digital leaders must juggle between eight human and technical dimensions (characteristics) as shown in figure 10 (McCarthy et al., 2021).
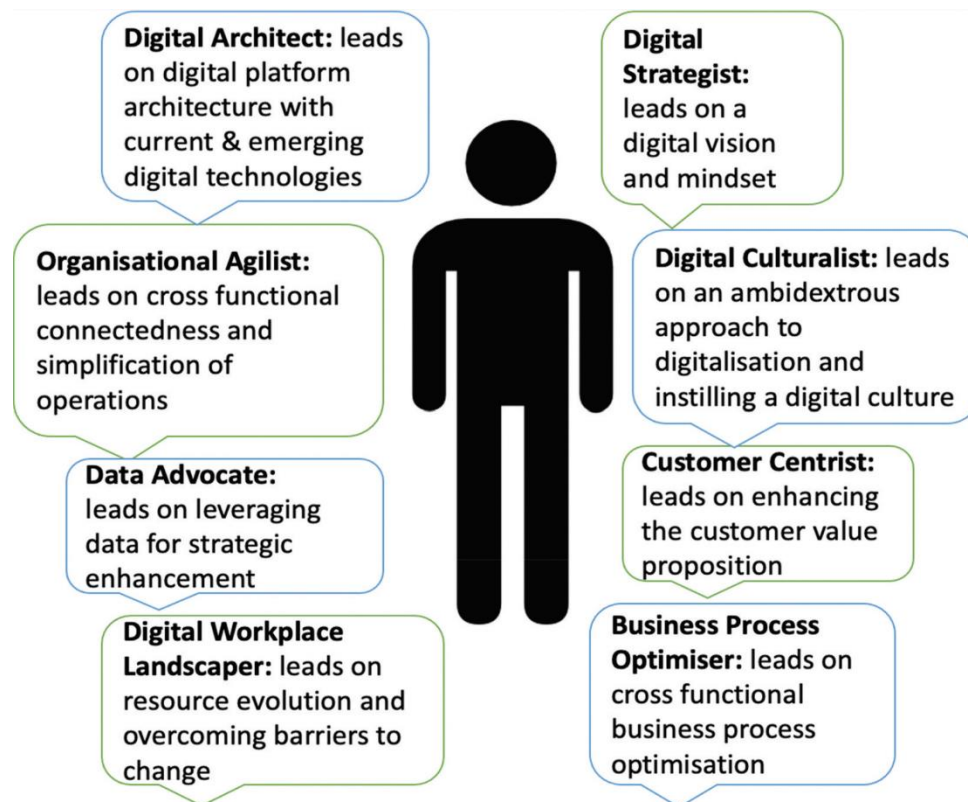


**Figure 10: Characteristics of Digital Transformation leaders. Source: McCarthy et al., 2021.**

Dtech have caused many new businesses start within a digital environment, leading to so-called "digital-born" organizations which have significant advantages over non-digital born businesses, such as, digital and environmental regulations, process efficiency, and corporate relationships (Vadana et al., 2021).

### 3.1.2    Digital Business Maturity and Readiness

As businesses start their Dtrans, they reach certain stages or levels at certain points. In other words, they mature with their processes along the line. The term "Digital maturity" first got special attention from the work of Westerman et al. (2014). Organizations with developed digital skills but lacking in leadership are dubbed "Fashionistas," whereas organizations with mature leadership but lacking in digital capabilities are dubbed "Conservatives." According to Westerman et al., organizations must develop both competence aspects in order to reach "digital mastery." Firms that do such a thing have greater business success as assessed by metrics such as revenue per employee, profits before interest and taxes, and product margins. (Westerman et al., 2014, von Leipzig et al., 2017, Rossmann, 2018).

Azhari et al. (2014) presented a digital maturity model with multilevel degrees of digitalization (Azhari et al., 2014). They are strategy, leadership, products, operations, culture, people, governance, and technology, which can be achieved by a business to varying degrees at a given period of time. It is shown in figure 11 (von Leipzig et al., 2017, Azhari et al., 2014).
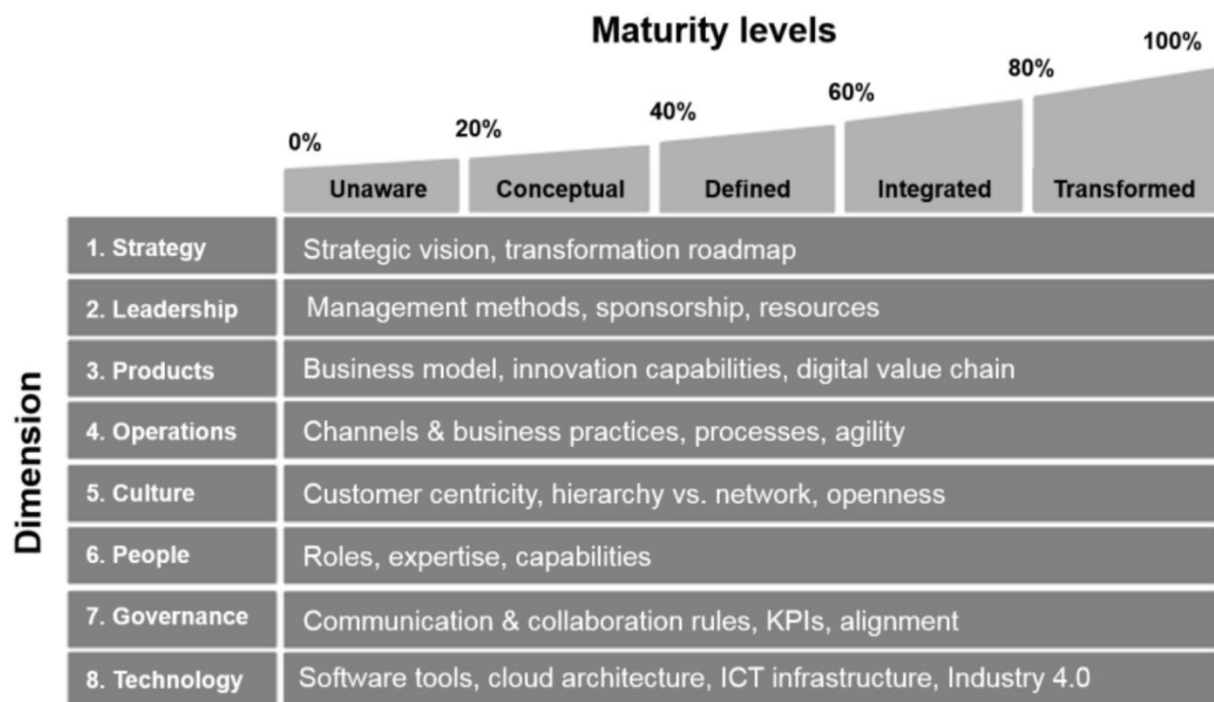


**Figure 11: Organizational digital maturity. Source: von Leipzig et al. (2017) based on Azhari et al. (2014).**

How ready a business is to digitally transform can be evaluated during its beginning (Hizam-Hanafiah et al., 2020). Based on this premise, the literature study revealed that finding an organization's strategic needs and benefits (Roos and Nilsson, 2020, Weiner, 2009, Machado et al., 2019b), detecting threats and opportunities, assets, capacities (Hermann et al., 2019, Kane et al., 2018, Combe, 2014, de Sousa Jabbour et al., 2018, Pessot et al., 2020), endorse leadership, interdisciplinarity with vision (Colli et al., 2018, Kane et al., 2018, Nosalska et al., 2019, Kotter, 2014), ensuring transparent

communication all across the value chain (Geissbauer et al., 2016, Machado et al., 2019a, Machado et al., 2019b), measuring the Dtrans progress with need-based KPIs (Yeow et al., 2018, Issa et al., 2018, Bosman et al., 2019), ensuring digital knowledge management systems, autonomy, and Dtrans acceleration in the value chain (Pessot et al., 2020, Kotter, 2014, Ghobakhloo, 2018, Pirola et al., 2019) might be considered to build a solid premise for Dtrans progress measurement.

### 3.1.3    Digital Transformation Process

From the idea of digital maturity, any Dtrans initiative takes a certain time to substantiate specific outcomes for the stakeholders to grasp. Therefore, strategic decisions are deemed to be necessary before diving into the technological part of a Dtrans process (Schwertner, 2017). Vial (2019) constructed a framework for incorporating Dtrans along with strategic and structural widths as shown in figure 12 (Vial, 2019). It was also used to create the interview questionnaire for the thesis. Wengler et al. provided a market-oriented Dtrans matrix with several evolving processes as shown in figure 13 (Wengler et al., 2021). Also, Korachi and Bounabat (2019) compiled 34 different processes across 9 blocks or steps that can utilized for an extensive Integrated Methodological Framework for Digital Transformation Strategy Building (IMFDS) as given in figure 14 (Korachi and Bounabat, 2019).
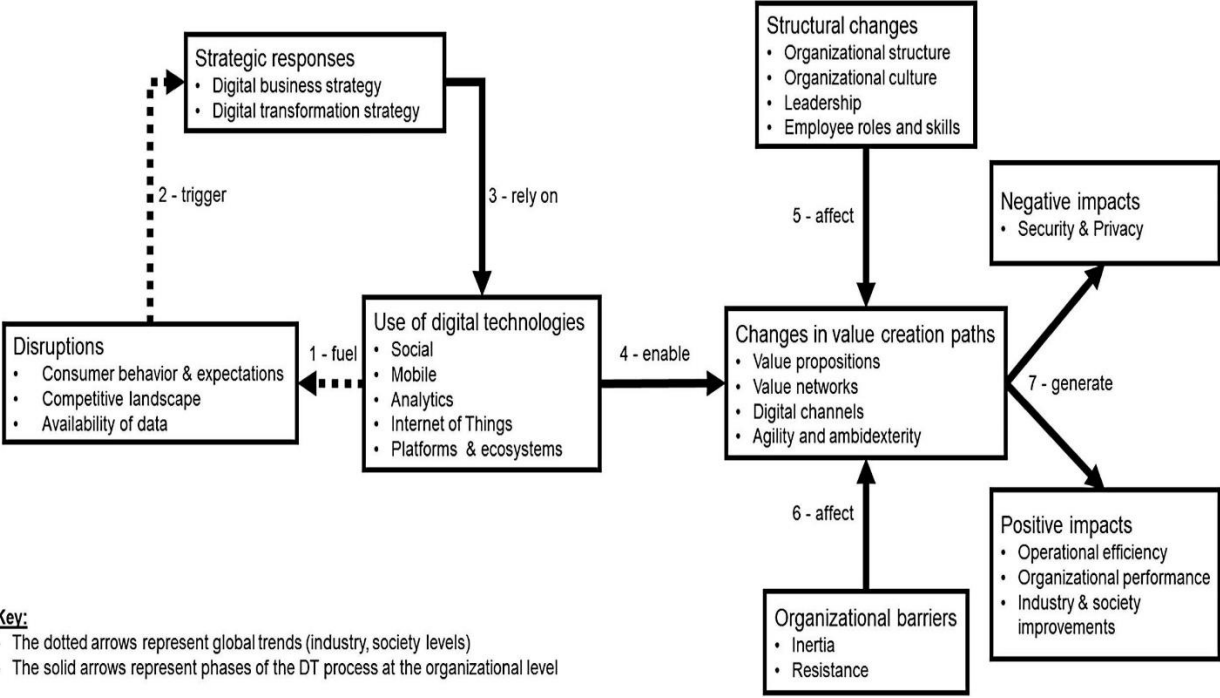


**Figure 12: The fundamental construction of digital transformation process, where "DT" stands for digital transformation. Source: Vial, 2019.**

| | Digitization | Data Integration | Process Automation | System Integration | Self-learing Systems |
|---|---|---|---|---|---|
| **People** | • know their processes<br>• can handle simple IT programs<br>• involve themselves in the digitization process of "their" data<br>• give gradually their analogue data up<br>• participates actively in the discussion about the next digitization steps | • ability to work in teams<br>• willingness to change<br>• comprehensive understanding of market interdependencies<br>• strong customer focus<br>• key account management mentality<br>• data literacy<br>• owner of cross-departmental processes<br>• no silo mentality | • experts in their field of<br>• team worker<br>• understanding customer requirements<br>• derive activities from analyses<br>• willingness to give up assigned tasks and to take on new ones<br>• global access to experts<br>• allocation of coordinators<br>• chat-video-communication | • digital learning (e.g. WBT)<br>• digital interaction<br>• ability to solve problems<br>• creativity<br>• self-reliant<br>• complex data analyses<br>• cross-departmental collaboration<br>• distinct adaptability<br>• full support for digital processes and procedures | • specialist in IT<br>• high ability to adapt<br>• tech translation<br>• agile working<br>• high self-confidence<br>• agile organizational structure<br>• very self-reliant<br>• entrepreneurial mentality<br>• high problem solving competence |
| **Processes** | • isolated processes<br>• internal focus<br>• standard processes<br>• low process transparency<br>• first digitized processes | • cross-departmental process optimization<br>• clearly defined interfaces<br>• process adaptations<br>• process transparency | • valid & updated processes<br>• clearly defined process owner<br>• emergency procedures in the case of IT problems<br>• Clearly defined human-machine-interfaces<br>• Transparency regarding automated processes<br>• early-warning-system in the case of disturbances | • linking of automated processes<br>• cross-departmental and cross-company coordination and definition of processes<br>• process integration<br>• intensive process optimization (from customers' perspective) | • self-learning processes<br>• Tracking and controlling of all process changes<br>• continuous monitoring on ethical compliance |
| **Data** | • data are available in digital format<br>• diverse data bases in use<br>• individually determined data formats<br>• systematic collection of data<br>• product- and departmental-oriented, but not customer-oriented data storage | • integration of diverse databases<br>• platforms<br>• unified data formats<br>• interface definition (API's)<br>• data cleansing<br>• idea for a "centralized" database (e.g. CRM system)<br>• data protection<br>• single sign-on | • data quality ensured<br>• data stability ensured<br>• only homogenous data<br>• continuous error routine<br>• well-ensured up-to-dateness<br>• ensured data availability/ data access<br>• fully data access granted<br>• data protection ensured | • clearly defined data strategy<br>• continuous data controlling<br>• intense collaboration with customers and partners<br>• clearly communicated interface requirements (API's)<br>• IT security ensured<br>• Full compliance of data protection regulation | • flow of data ensured<br>• permanent data analysis<br>• indication of anomalies<br>• special AI programs<br>• IT equipment with sufficient resources |

**Figure 13: Market-focus Dtrans matrix. Source: Wengler et al., 2021.**
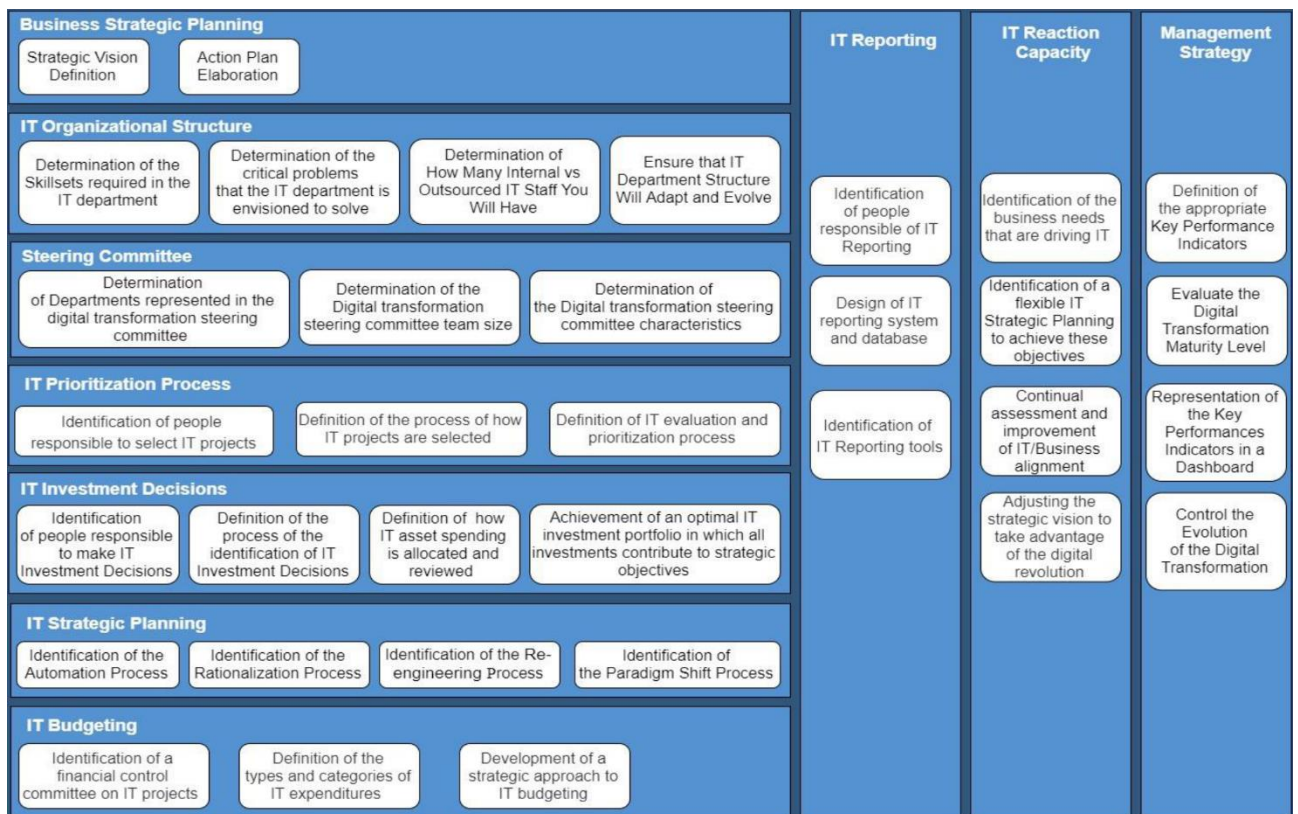


**Figure 14: Integrated Methodological Framework for Digital Transformation Strategy Building (IMFDS) Source: Korachi and Bounabat, 2019.**

### 3.1.4    Measuring Digital Transformation Success

As mentioned earlier, companies are trying to find out ways to make their Dtrans efforts successful in the long run. Researchers have tried to categorize business performance measures in several different dimensions, including the organization's internal and external perspective. Key performance indicators (KPI) are very common among businesses across all industries (Ishaq Bhatti et al., 2013). In the business world, indicators or KPIs are generally quantitative data that depict a company's structures and procedures. KPIs are now highly crucial for planning and controlling by supporting information, establishing transparency, and assisting management decision makers. They are the go-to means to gauge whether a business or its particular functions are going in the right direction or not (Meier et al., 2013).

There are numerous ways of presenting KPIs. The *"Balanced Scorecard"* proposed by Kaplan and Norton (1992) is particularly popular among managers as it *"gives them complex information at a glance"* (Kaplan and David, 1992). The Balanced Scorecard (BSC) keeps financial indicators as the ultimate result measures for firm performance, but supplements them with metrics from three additional perspectives - customer, internal process, and learning and growth - that the authors suggested as the drivers of long-term shareholder value creation (Kaplan, 2009) (figure 15).
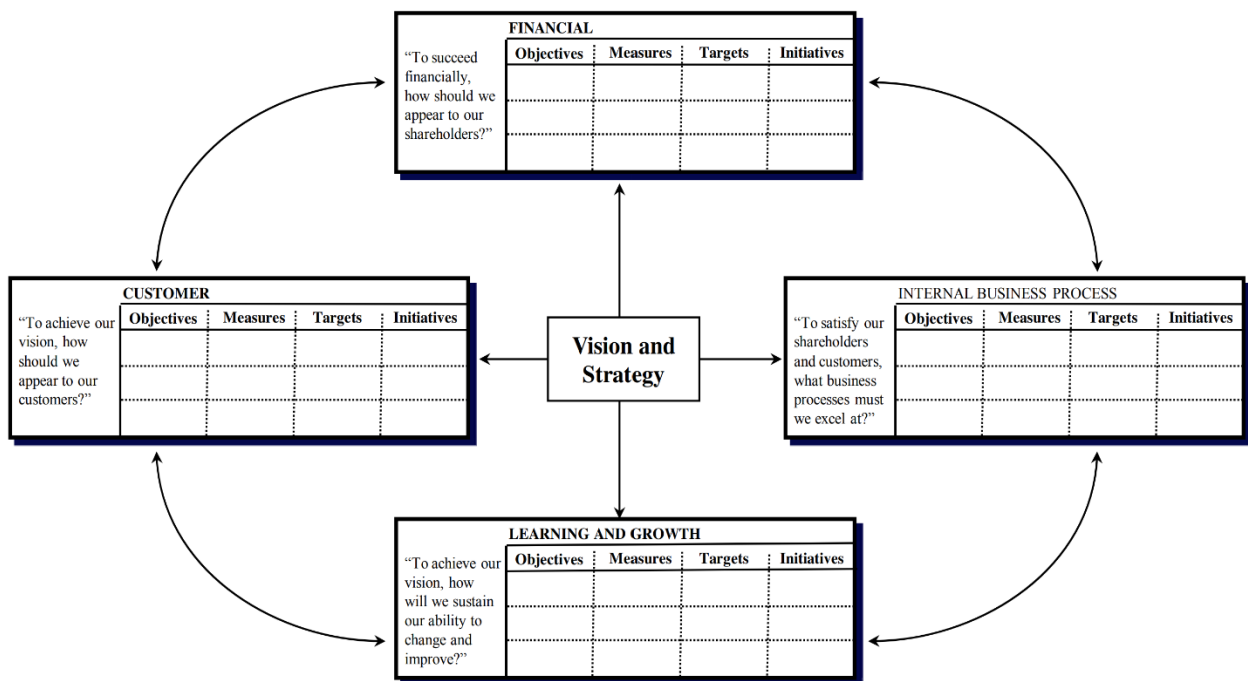


**Figure 15: The Balanced Scorecard. Source: Kaplan and Norton (1992).**

The literature review revealed no specific standard of KPI development for Dtrans of businesses as most businesses still use financial measures as their bottom lines (Machado et al., 2021). A handful of researchers touched such points in their works their includes other measures (Levkovskyi et al., 2021, Kuntsman and Arenkov, 2019, Ahmad et al., 2021, de Andrade and Sadaoui, 2017, Singh et al., 2020).

Michael Wade, professor of innovation and strategy at IMD Business School, and Massimo Marcoloivio, marketing manager at Dell Technologies, established a methodology for measuring digital business transformation. They created a system for categorizing measurements based on high-level objectives and KPI examples as shown in table 9.

**Table 9. An overview of the identified Dtrans KPI for a customer-centric business (A taxonomy of Digital Transformation KPIs (Wade and Marcoloivio, 2022)**

| Category | Operational Efficiency | Customer Engagement | Employee Engagement | New Sources of Value Creation |
|---|---|---|---|---|
| High Level Objective | To save cost and improve operational speed and efficiency | To improve customer satisfaction and engagement | To improve employee satisfaction and productivity | To find new sources of revenue and profit |
| KPI Examples | Time to market digital products and/or services | Customer Net Promoter Score (NPS) of digital tools | Employee Net Promoter Score (NPS) of digital tools | Percentage of revenue from digital products and/or services |
| | Employee hours saved by digital tools | Customer usage of digital tools (e.g., time spent) | Employee satisfaction with remote work | Percentage of revenue from digital channels (e.g., app, website) |
| | Cost savings by digital tools (e.g., maintenance, repair) | Percentage lead conversion across digital channels | Employee usage of digital platforms (e.g., intranet, apps) | Digital vs non-digital customer profitability |
| | Reduction in defects due to digital tools | Click-through rates (CTR) and other digital marketing measures | New ideas generated via digital tools | New customer acquisition via digital channel |
| | Percentage of operations performed by digital means | Customer retention by digital channels | Level of collaboration across digital tools | |
| | | Customer hours saved by digital tools | | |
| | | Percentage of customers active on a site or platform | | |

There have been a large set of works performed by researchers to find the factors contributing to Dtrans success across a diverse range of categories in different industries. Strategic alignment with IT/IS integration and well-defined digital visions are quite common success factors (Osmundsen et al., 2018, Sebastian et al., 2017, Eller et al., 2020, Stief et al., 2016, Gurbaxani and Dunkle, 2019, Morakanyane et al., 2020, Cichosz et al., 2020). Support from the top management with clear detection of impact zones, dynamic

capabilities development, curated pilot projects, and overall process standardization are attributable to Dtrans success at a higher level (Vogelsang et al., 2019, Stief et al., 2016, Morakanyane et al., 2020). Benevolent leadership, effective PM practices, supportive IT-business initiatives, individual development, and customer-focused product development are another set of parameters that benefits digitalization (Haffke et al., 2017, Bhanji et al., 2021, Bousdekis et al., 2020, Dehnert and Santelmann, 2021). Organizations need to have proper knowledge and skills management schemes exploiting internal and external sources of information. This involves bolstering technical infrastructures, platform and automation adoption as well as experimentation of new products and services that attract consumers (Sebastian et al., 2017, Vogelsang et al., 2019, Mhlungu et al., 2019). Data management is thus considered a crucial factor in Dtrans. Companies also need to strengthen their operational integration internally that leads to customer satisfaction while addressing environmental, legal, and creative partnerships externally (Bajic et al., 2021, Johansson et al., 2019, Bokrantz et al., 2017, Mhlungu et al., 2019). According to Sandkuhl et al. (2020), all the digital success factors overlap each other in different ways, and they can assembled under major categories such as products, technology, leadership, governance, competences, operations, strategy, and culture, as shown in figure 16 (Sandkuhl et al., 2020).
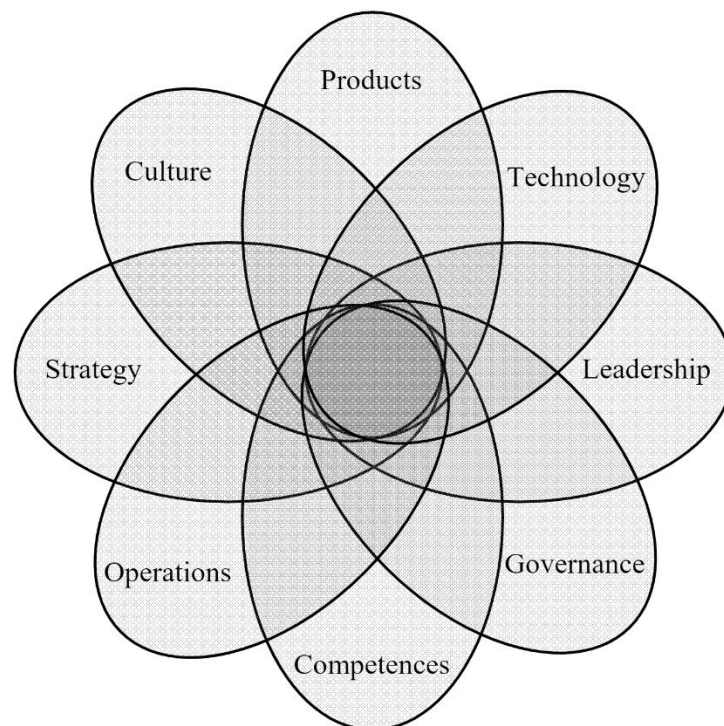


**Figure 16: Success factor criteria overlap for organizational Dtrans, according to Sandkuhl et a. (2020).**

As literature review article that are highly cited (over 700 in total), Osmunden et al. (2018) and Morakanyane et al. (2020) provided the most authoritative grasp of the CSFs for Dtrans within the available literature (Osmundsen et al., 2018, Morakanyane et al., 2020). Thus, for designing the interview questions, these two articles provided the base along with the Dtrans framework provided by Vial (2019) (figure 12). Table 10 shows the CSFs established by the two previous authors. Then, the process steps of the inductive framework by Vial (2019) was connected to the CSFs (table 11). The overlaps were eliminated and the list of seven CSFs pertaining to *three groups of organizational behavior: Digital Consciousness, Digital Implementation, and Digital Facilitation*, were established,

as shown in table 12. This table provided a foundation for the interview questionnaire formation.

**Table 10. The summary of critical success factors (CSFs) of Dtrans by Osmundsen et al. (2018) and Morakanyane et al. (2020).**

| Dtrans CSFs (Osmundsen et al., 2018) | Dtrans CSFs (Morakanyane et al., 2020) |
|---|---|
| Enabling Organizational culture | Determine Digital Trigger |
| Well-managed transformation activities | Encourage Digital Culture |
| Leverage external and internal knowledge | Develop Digital Vision |
| Engage managers and employees | Determine Digital Drivers |
| Grow information system (IS) capabilities | Establish Digital Institution |
| Develop dynamic capabilities | Determine Transformed Areas |
| Develop a digital business strategy<br>Align business and IS | Determine Impacts |

**Table 11. Connecting Dtrans CSFs to Dtrans process steps**

|  | Dtrans Process Steps (Vial, 2019) | Dtrans CSFs (Osmundsen et al., 2018; Morakanyane et al., 2020) |
|---|---|---|
| 1. | Use of Dtech | • Develop IS capabilities<br>• Create digital organization |
| 2. | Digital Disruptions | • Determine digital trigger<br>• Determine digital drivers |
| 3. | Strategic initiatives | • Develop a digital business strategy |
| 4. | Changes in value creation | • Develop dynamic capabilities |
| 5. | Structural alterations | • Well-managed transformation actions<br>• Affiliate business and IS<br>• Develop digital vision |
| 6. | Organizational obstacles | • Engage managers and employees<br>• Cultivate digital culture<br>• A supportive organizational culture |
| 7. | Impact Detection | • Determine impacts<br>• Decide transformation areas |

**Table 12. Critical Success Factors of Digital Transformation adapted from Osmundsen, 2020; Morakanaye et al., 2017; Vial, 2019 (used in interview questionnaire formation).**

| | |
|---|---|
| Group 1: Digital Consciousness ||
| **1.** | Consciousness of Digital Incentives |
| **2.** | Consciousness of Transformation Impacts |
| Group 2: Digital Implementation ||
| **3.** | Implementation of Digital Technologies |
| **4.** | Implementation of a Digital Business Strategy |
| **5.** | Implementation of a Digital Business Model |
| Group 3: Digital Facilitation ||
| **6.** | Facilitation of Multidisciplinary Collaboration |
| **7.** | Facilitation of an Encouraging Organizational Culture |

## 3.2 Digital Technologies

This section focuses on characteristics of the state-of-the-art Dtech with a particular focus on Dtwin that describe its configuration and activities. These are required for understanding and implementing them in the context of Dtrans and supply chain and/or logistics.

### 3.2.1 Industry 4.0 and Digital Technologies

The world is currently experiencing the Fourth Industrial Revolution with numerous on-premise and distant high-tech implementations, also known as the Industry 4.0, as it juxtaposes a myriad of digital and physical technologies with a human centricity (Ghobakhloo, 2020). Figure 17 gives an architecture of a typical Industry 4.0 system that visualizes the whole idea.
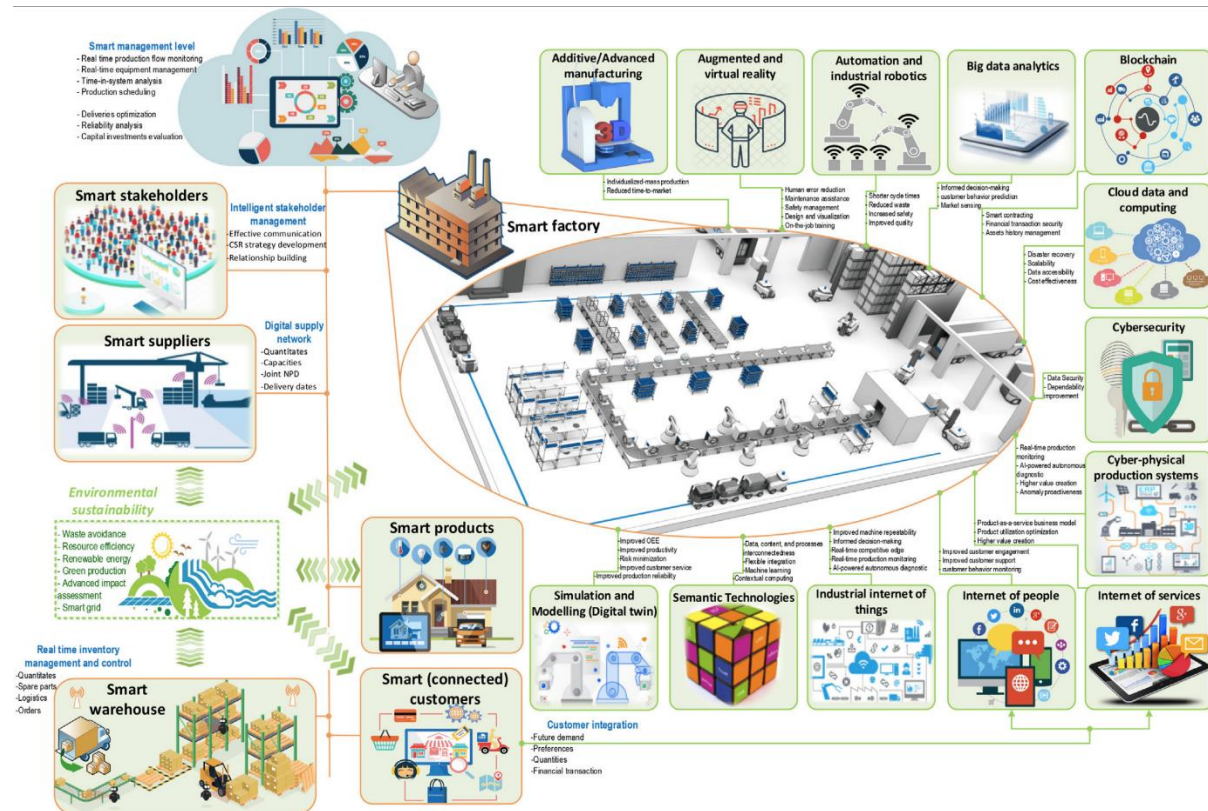


**Figure 17: The architecture of Industry 4.0. Source: Ghobakhloo, 2020.**

Because of its distinct characteristics, the goal of implementing such Dtech in business is no longer to broaden internal dimensions, but to reach customers and external partners, improve services, integrate processes, upset markets, and change industries (Spremic, 2017).

Broadly speaking, the Industry 4.0 Dtech can be categorized as Cyber Physical Systems (CPS), Internet of Things (IoT), Big Data Analytics, Cloud Computing, Fog and Edge Computing, Augmented and Virtual Reality (AR/VR), Robotics, Cyber Security, Semantic Web Technologies, and Additive Manufacturing/Three dimensional (3D) printing (Bajic et al., 2021). However, to establish a "digital organization", according to Sebastian et al. (2017), the accessible Dtech, in particular, social media, analytics, cloud technology, Internet of Things (IoT) (abbreviated as SMACIT) and digital platforms, play a fundamental role. To fulfill rising consumer expectations and avoid falling behind a competition, firms must be quick and flexible in their innovation. Organizations use a digital platform to

achieve the desired speed (Sebastian et al., 2017, Osmundsen et al., 2018). According to Sebastian et al. (2017), a digital platform is the technical and business capabilities that enable the fast creation and implementation of digital innovations. The author goes on to claim that a digital platform must have digital components capable of enabling both technical and commercial services, as well as repositories storing enormous volumes of data and analytical skills capable of converting the data into business insights.

### 3.2.2    Digital Twin

Barricelli et al. (2019) opines that Dtwins are machines or computer-based models that replicate, emulate, mirror, or "twin" the life of a physical entity, which can be an item, a process, a human, or a human-related quality (Barricelli et al., 2019).

The gap between DT and modern digital 3D models and 3D systems is considerable, despite its subtlety. When a virtual model solely replicates the physical model and has one-way data flow, this is referred to as a Digital Shadow (DS) (Sepasgozar, 2021). Figure 18 displays a one-way data flow in a DS from a digital model to a real tower crane object. However, in a Dtwin, both the virtual and physical entities must interact (Sepasgozar, 2021, Qi et al., 2021).
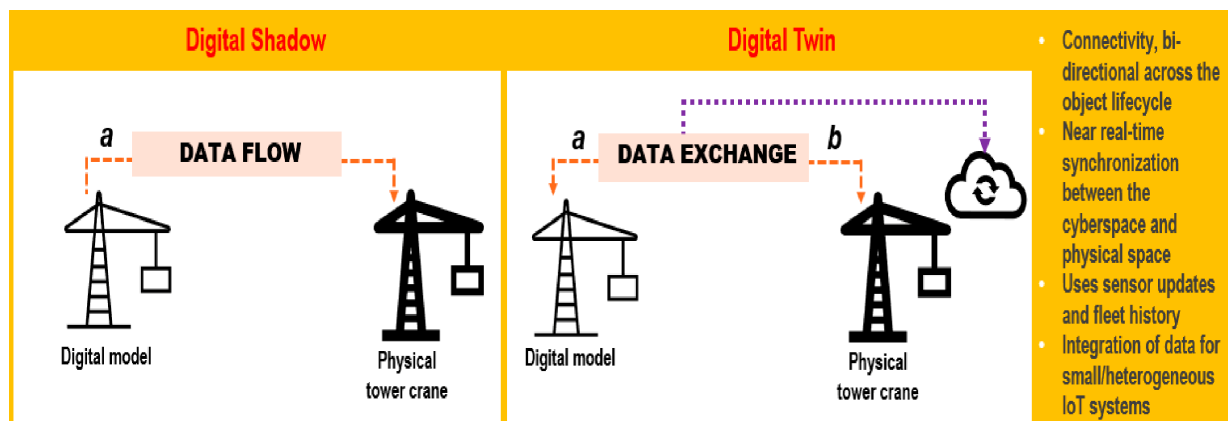


**Figure 18: A schematic illustration of "one-way" and "bi-directional" data flow to separate DS from Dtwin. Source: Sepasgozar, 2021.**

Tao et al. (2019) proposed a five-dimension based Dtwin model based on Grieves' (2014) Dtwin model to support the wider application of Dtwin in additional fields (Tao et al., 2019, Grieves, 2014) (figure 19). It can be expressed as follows: Dtwin, $M_{DT}$ = (PE, VM, Ss, DD,CN)

Here, PE = physical entities, VM = virtual models, Ss = services, DD is Dtwin data, and CN = connections.
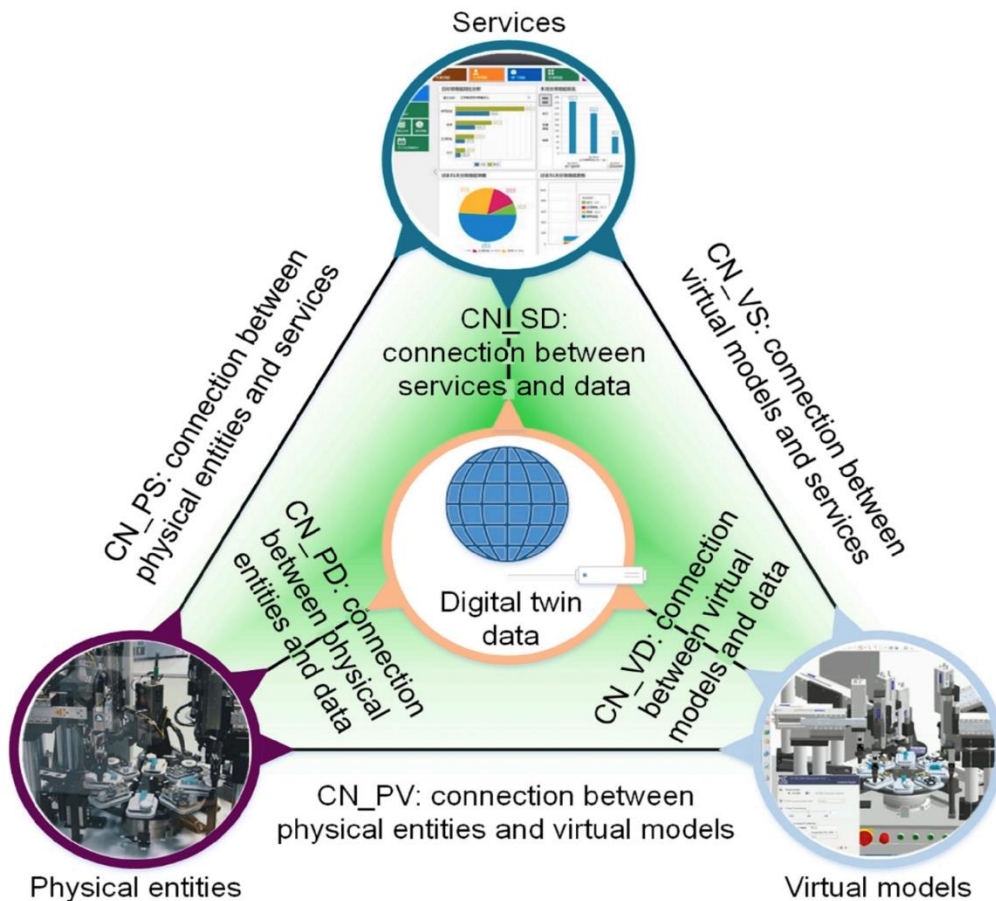
**Figure 19: A Dtwin model with 5 dimensions. Source: Qi et al., 2021.**

Dtwin applications are emerging in a variety of industries, including smart cities, manufacturing, healthcare, agriculture, cargo shipping, drilling platforms, automotive, aerospace, and power, all of which necessitate a comprehensive data collection and database management system (Qi et al., 2021). The Dtwin system therefore functions in the development, implementation, and backup of a given system or network of systems, where the interactions of several data collectors are critical.

## 3.3  Business Model Perspectives

### 3.3.1    Business Models and their Innovation

As connected with business strategy, BM has been always a center of attraction for entrepreneurs (Sundaram et al., 2020, Klos et al., 2022). However, traditional business models are becoming outdated as a result of digitalization, paving the way to technologically enhanced new alternatives (Pattnaik, 2018). New innovative models are being generated by startups as well as large corporations. An innovation typology of BM generation is suggested by Taran et al. (2015) based on complexity, outreach, and novelty (radicality) levels (Taran et al., 2015) (figure 20).
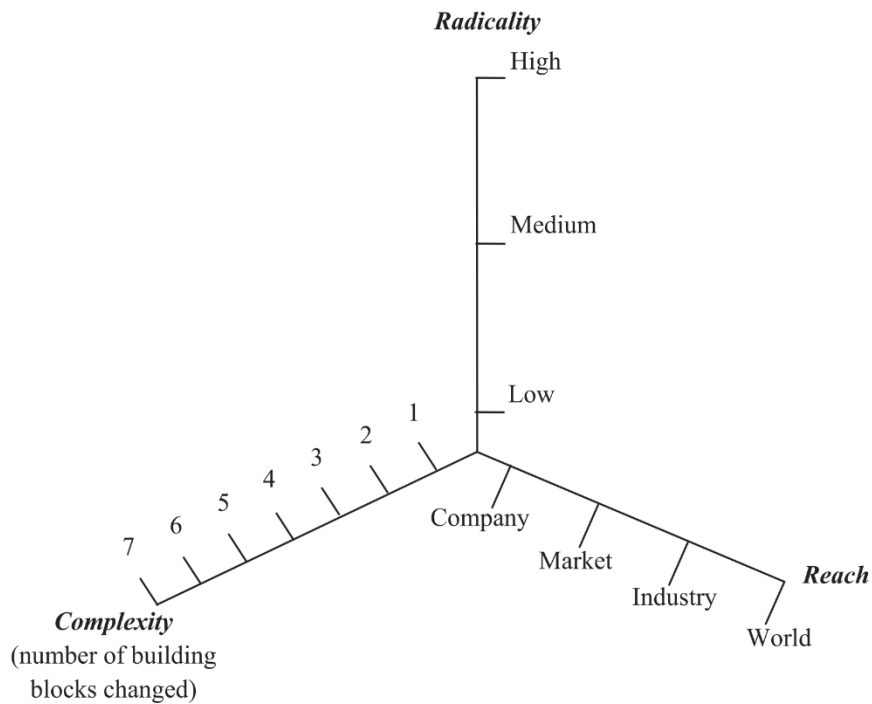
**Figure 20: A three-dimensional BM Innovation. Source: Taran et al., 2015.**

### 3.3.2    Digital Business Models

More focus and practice in BM innovation with digital means in taking place in research which is causing companies, both small and large, to adopt more digital-reliant BMs (Bouwman et al., 2019). Thus, Dtrans have remarkable effects on BM evolution. The literature shows that creating a digital strategy (Hess et al., 2016, Verhoef et al., 2021, Schallmo et al., 2019) with the help of the top management is crucial for strategic consistency (Brenner, 2018, Schneider, 2018, Mihardjo et al., 2019) as well as establishing a culture that cultivates digital excellence (Coreynen et al., 2017, Bouwman et al., 2019, Lenka et al., 2017).

Furthermore, across the value dimensions of BM, many constituents factors were found in the systematic literature search. They encompassed value creation through many types of organizational adjustments (Kiel et al., 2017, Zheng et al., 2019, Müller et al., 2018, Liao et al., 2017, Wang et al., 2016, Hahn, 2019, Kagermann et al., 2013, Birkel et al., 2019, Dean and Spoehr, 2018, Dalenogare et al., 2018, Frank et al., 2019, Sung, 2018, Gauthier et al., 2018, Warner and Wäger, 2019, Oesterreich and Teuteberg, 2016, Hasselblatt et al., 2018, Vendrell-Herrero et al., 2018, Camarinha-Matos et al., 2019, Horváth and Szabó, 2019, Witschel et al., 2019). And, for value proposition, mostly customization to meet customer needs was found to be prioritized (Brenner, 2018, Schneider, 2018, Coreynen et al., 2017). In the value delivery dimension, CRM and collaboration took the spotlight among the mentions (Vial, 2019, Rachinger et al., 2019, Hasselblatt et al., 2018). For value capturing, management of Dtech, revenue recognition, and risk were the sallient elements (Saarikko et al., 2017, Verhoef et al., 2021, Horváth and Szabó, 2019). Finally, IT and technological capacities with digital security measures were identified in evolving BMs (Oesterreich and Teuteberg, 2016, Verhoef et al., 2021, Dalenogare et al., 2018, Saarikko et al., 2017, Liao et al., 2017).

Prem (2015) suggested a comprehensive framework that combines value proposition with other organizational scopes like products, CRM, partners, resources, revenue, and IT, as

shown in figure 21 (Prem, 2015). It can used to link all important organizational elements to improve stakeholder gains.
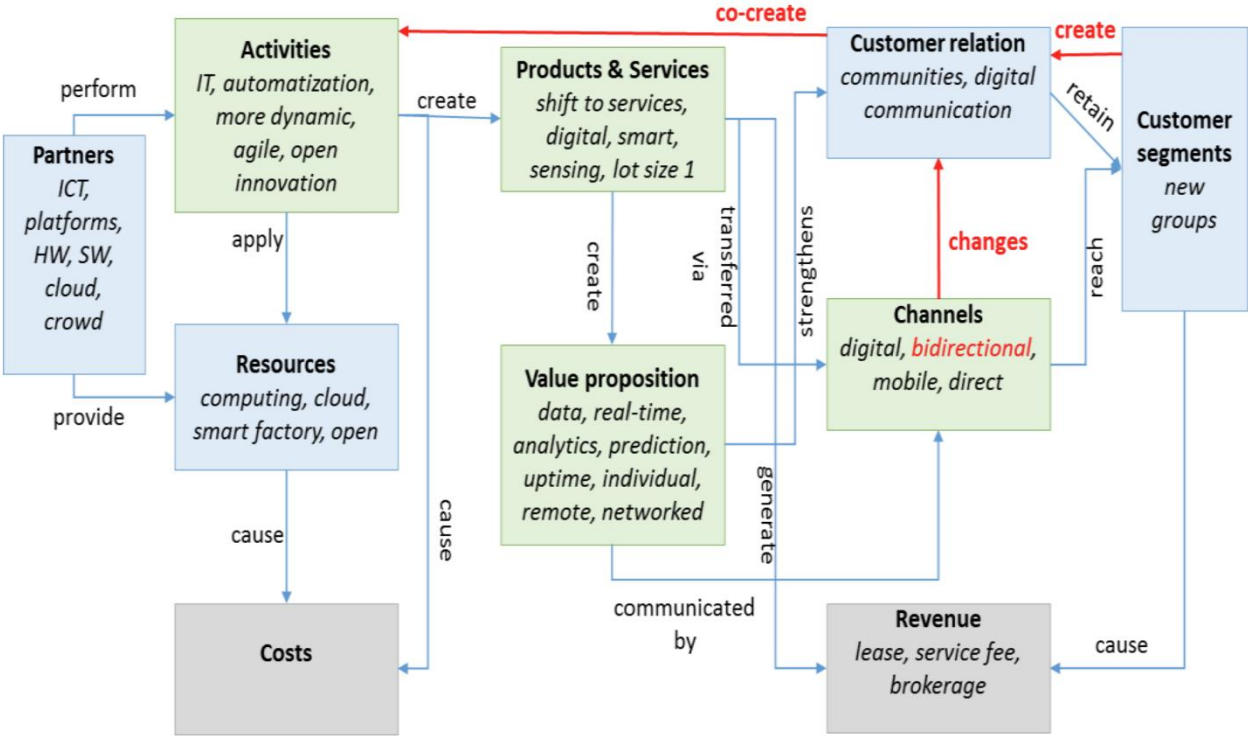


**Figure 21: A framework for digitalizing business model innovation. Source: Prem (2015).**

### 3.3.3    BM Innovation and SC and Logistics Management

Modern BMs of firms (for example, Google, Amazon, Alibaba, Airbnb, and Uber) are primarily based on digital technology. Other businesses, whether they have been in operation for five, ten, twenty, or even one hundred years, must modernize and adopt digital technology in order to compete (Arenkov et al., 2019). A digital supply chain is an intelligent and value-driven network enabled by evolving technology and analytics to innovate BMs and generate new income sources (Ageron et al., 2020). Thus, BM innovation inadvertently and inherently requires SC digitalization. Here, collaborative perspective with partners (Camarinha-Matos et al., 2019, Horváth and Szabó, 2019), Industry 4.0 implementation, and circularity in BM are all interconnected and correlated with each other (Belhadi et al., 2021). The Dtrans of BM is deemed necessary for financial prosperity of firms (Sundaram et al., 2020).

## 3.4   Supply Chain and Logistics Management

Digital technology may improve the performance of a supply chain to provide a positive customer experience and efficiency, while digital capabilities allow for a quick transition from manual transactions to digital information flow for both inter-firm and intra-firm activities (Korpela et al., 2017). The relevant literature is further elaborated below.

### 3.4.1    Traditional and Modern Supply Chains

Traditional SC merely considered itself as a one-way process that required procurement of raw material, production, and delivery to the customer. Now, the concept of green SC management has emerged which includes re-use, recycle, remanufacture and reverse logistics etc (Deshmukh and Vasudevan, 2014). The concept of green or reverse SC is

related to circular economy. According to Ellen MacArthur Foundation (2012), circular economy (CE) is defined as " an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models" (MacArthur, 2013). Thus, modern SC relates to sustainability management that comes with complexities and challenges (Plaza-Úbeda et al., 2020).

### 3.4.2    Obstacles in Supply Chain and Logistics

Traditionally, various barriers exists in SC and logistics mostly due to coordination problems between actors, such as the *bullwhip effect*, signifying information distortions between SC levels (Chopra and Meindl, 2007). In the literature study, today's industries are found to be battling such barriers or obstacles often in much more evolved and complicated manners. Ageron et al. (2020) found that implementing good PM practices is relevant in the context of SC and logistics management as it improves overall value and efficiency (Ageron et al., 2020). The lack thereof can be detrimental. Lack of leadership excellence is compounded by increasing complexities and lack of commitment (Manzouri et al., 2010, Narayanan et al., 2019, Stewart et al., 2016, Neri et al., 2018, Khan and Qianli, 2017, Kim and Nguyen, 2020, Alzawawi, 2014, Govindan et al., 2014). Human perspectives, labor, and performance shortage (de Jesus and Mendonça, 2018, Kazancoglu et al., 2020), initial high expenses in circular systems with underwhelming ROI (Neri et al., 2018, Kazancoglu et al., 2020, Stewart et al., 2016), and deficiency in technological infrastructures (Manzouri et al., 2010, Gupta and Barua, 2018, AlSanad, 2018, Fawcett et al., 2008) were found to be substantially harming SC and logistic development. Furthermore, subpar organizational culture (Fawcett et al., 2008, Kim and Nguyen, 2020, Hussain et al., 2018) and improper integration within the market (Delmonico et al., 2018, Stewart et al., 2016, AlSanad, 2018) are major SC and logistics issues across multiple industries.

### 3.4.3    Digital Enablers of Supply Chains

Eight different major types or categories of digital enablers of SC and logistics have been identified from the literature review based on Pettey (2019) and Büyüközkan and Göçer (2018) as shown in figure 22 (Büyüközkan and Göçer, 2018). Under these broad categories, a multitude of Dtech and components have been listed and mentioned by the researchers (Pagoropoulos et al., 2017, O'Leary, 2017, Bressanelli et al., 2018a, Bressanelli et al., 2018b, Salminen et al., 2017, Williams et al., 2013, Gupta, 2017). Furthermore, their possible contributions to SC improvement and problem-solving along the lines of advanced robotics (Ageron et al., 2020, Attaran, 2020), analytics (Dubey et al., 2019, Gölzer and Fritzsche, 2017), blockchain tech (Somapa et al., 2018, O'Leary, 2017, Williams et al., 2013, Gupta, 2017), additive manufacturing (Attaran, 2020, Attaran, 2017), IoT (Attaran, 2017), AR/VR (Ageron et al., 2020, Attaran, 2020), Radio-frequency Identification (RFID) (Reyes et al., 2007), and cloud technology (Attaran, 2017, Wei et al., 2021) have been mentioned and discussed by researchers.
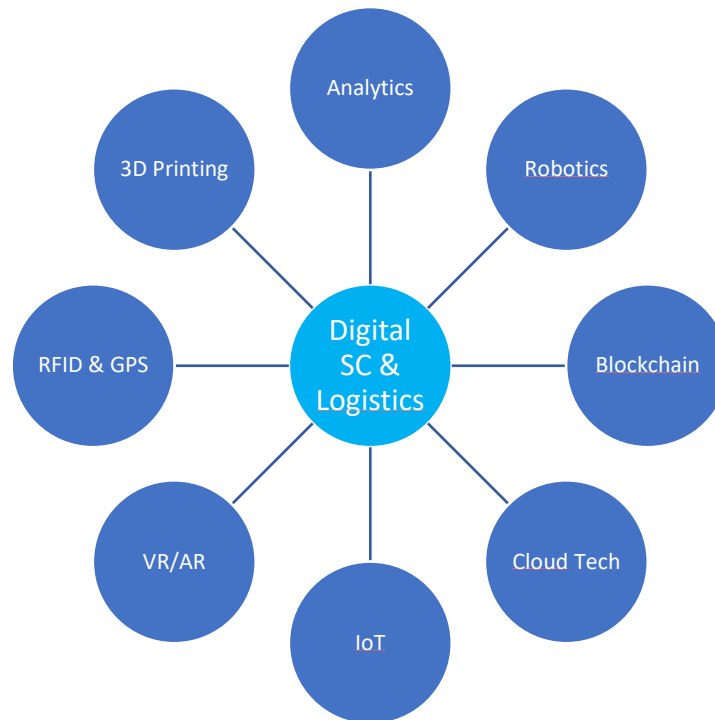
**Figure 22: Digital technology drivers of SC & logistics management. Source: Pettey (2019); Büyüközkan and Göçer (2018).**

### 3.4.4 Possibilities with Digital Twin

Even though technically and organizationally challenging, Dtwin and their applications are growing in the field of SC and logistics (Simchenko et al., 2020, Moshood et al., 2021). Relatively recent innovations, particularly Dtwin, enable the online gathering of enormous volumes of data on supply chains, including the possibility of supply failure and supplier data such as financial condition and manufacturing capacity. SCM systems enable the detection of crucial hot spots as well as early alerts about events that may have a substantial impact on the supply chain (Barykin et al., 2021). Several attempts to incorporate Dtwin in SC operations have been made in recent years by researchers and industry experts, with the support of various approaches, frameworks, and tools. Their impacts have the promise of strengthening the overall value, visibility, dependability, and efficiency of the SC (Park et al., 2020, Zhang et al., 2021, Kamble et al., 2022, Chen and Huang, 2021, Barykin et al., 2020, Abideen et al., 2021, Shevtshenko et al., 2020, Ding, 2019, Wang et al., 2022). Furthermore, Dtwin is making strides into the architectural, engineering, construction, operation, and facility management (AECO-FM) market as part of logistics management, where building information modeling (BIM) has gained tractions since 2018 (Sepasgozar, 2021). Dtwin is gradually adjusting to the industry's internal complications. Nonetheless, it is expected to improve building lifecycle management in the next years, producing value for project and property owners (Sepasgozar, 2021).

A Dtwin model requires multi-level components inside a SC to function and provide insights. A collection and virtual setup of the technologies required for Dtwin in SC is shown in figure 23.
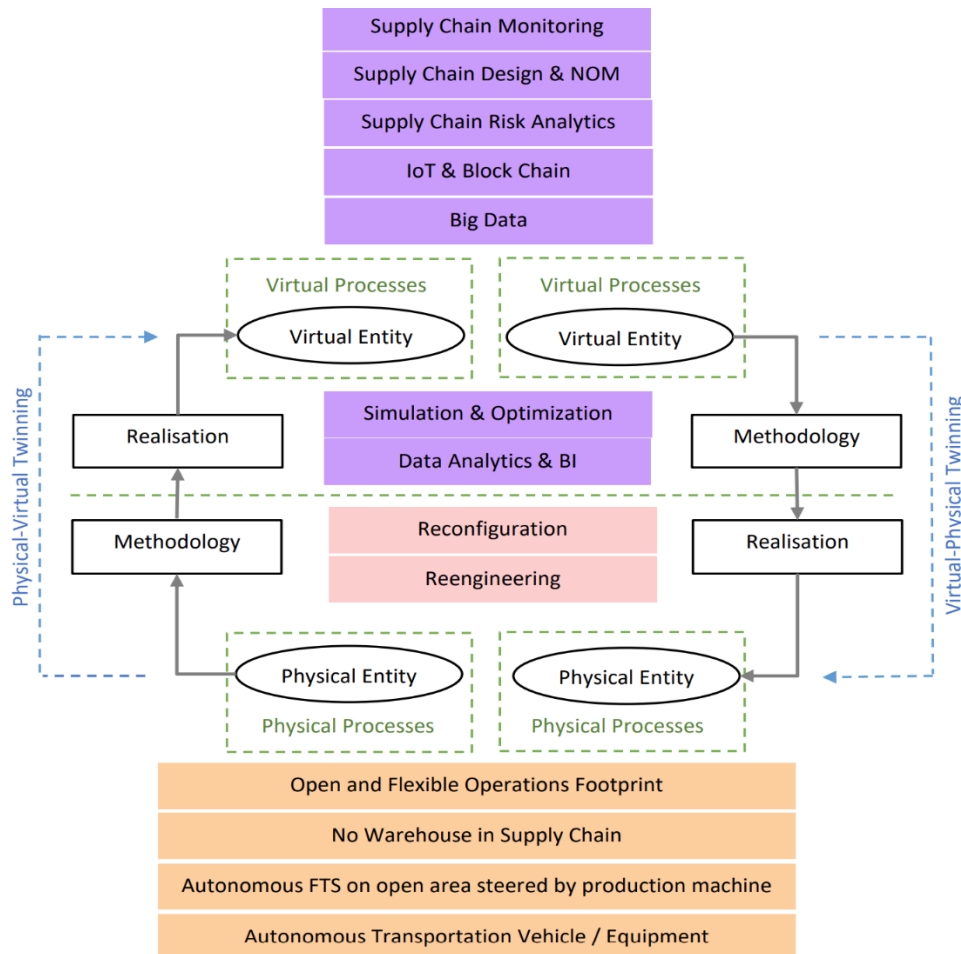
**Figure 23: A framework for incorporating Dtwin in SC. Source: Barykin et al. (2020).**

## 3.5   Project management

This subsection explains the relevance of the scientific study and application of PM, its associated components pertaining to Dtrans and how it is being affected by it.

### 3.5.1   Importance of Project Management

According to the Project Management Institute (PMI), a project is temporary endeavor that is chosen in order to construct a novel product, service, or output (PMI, 2018). It is related to an organization's strategy and thus alignment with it is necessary to achieve desired outcomes (Zwikael and Smyrk, 2019). According to Hussein (2018), project definitions vary based on the variety and multiplicity of the project's aims (Hussein, 2018). Internal development projects (internal projects of an organization) and delivery projects (projects arranged for external clients) are two types of projects (Klakegg, 2015). A project is a tool for achieving goals and objectives and adding value which can be viewed as an element of the whole social perspective (Klakegg, 2015, Kivilä et al., 2017, Samset, 2010) as shown in figure 24.
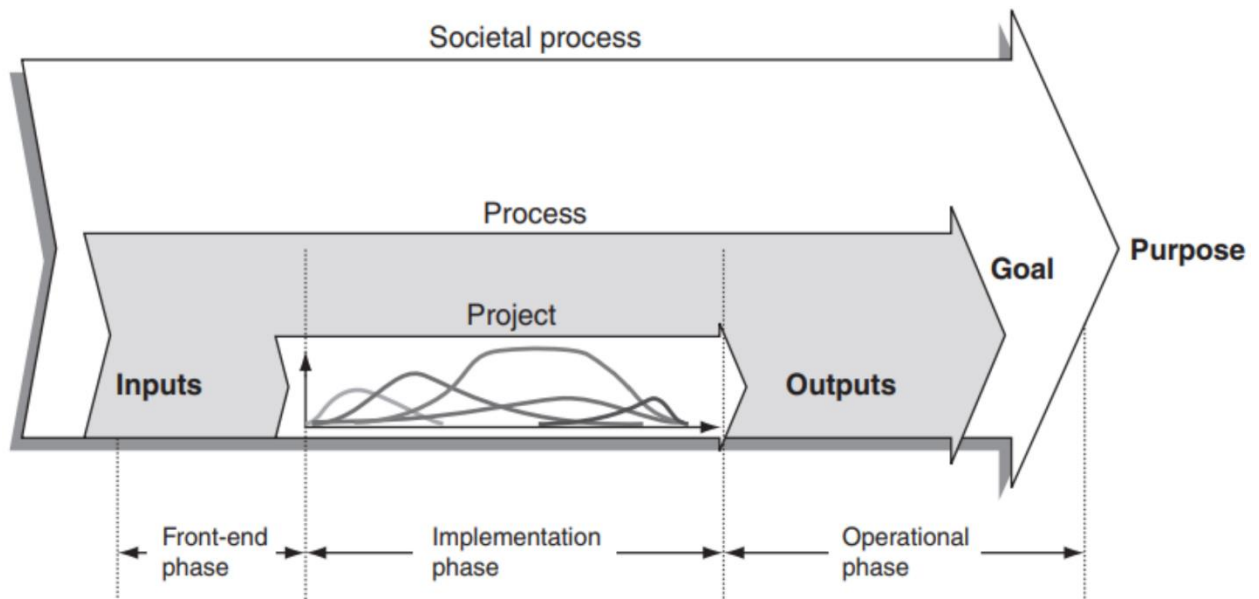
**Figure 24: Project management as a societal process. Source: Samset (2010).**

### 3.5.2 PM Methodologies: Linking Digital Transformation

Waterfall (plan-based, sequential steps), agile (flexible), hybrid (mixture of different methods) are the three most common PM methods (Dehnert and Santelmann, 2021, Hussein, 2018). Complex digital transformation projects need excellent management of processes and socio-technical interactions and thus, needs adaptability, effective leadership, and individual mindfulness (Dehnert and Santelmann, 2021). Furthermore, Ageron et al. (2020) claims that lack of PM best practices can lead to Dtech implementation failures and consequently generating a weaker SC management system (Ageron et al., 2020). One method does not fit all projects, and thus digital project managers need to be adaptable to changes.

# 4 Results

The findings produced from the literature and the interviews with the process/method outlined in the previous chapters are gathered and examined in this chapter in a structured manner, underlining the attempts to answer the research questions.

## 4.1 Literature Study Outcomes

Various Dtrans success factors and measures, consequent effects on BM and SC, and barriers and emerging Dtech in SC and logistics have been identified by means of the literature review. Subsection 4.1.1 and 4.1.2 pertain to RQ1, 4.1.3 and 4.1.4 to RQ2, and 4.1.5, 4.1.6 and 4.1.7 to RQ3, respectively.

### 4.1.1 Digital Transformation Success Factors

Saihi et al. (2022) found 10 major clusters of Dtrans success factors. These clusters have been considered as categories and adapted in table 13 to assemble the identified success factors of Dtrans of firms because the ranking system is verified through a hybrid method (qualitative and quantitative) (Saihi et al., 2023).

**Table 13. Compilation of success factors of digital transformation across industries from the literature review. The numbers in brackets denote the numbers of identified research works.**

| Categories of Success Factors | Constituents of Identified Factors | Relevant References (15) |
|---|---|---|
| **Digital Strategic Alignment (7 mentions)** | a) Digital business strategy development<br>b) Selecting strategically aligned projects<br>c) Aligning business and information systems (IS)/IT strategies<br>d) Clear, well-defined digital vision | a) Sebastian et al. (2017); Osmundsen et al. (2018); Eller et al. (2020)<br>b) Stief et al. (2016)<br>c) Osmundsen et al. (2018); Gurbaxani and Dunkle (2019); Cichosz et al. (2020)<br>d) Morakanyane et al. (2020); Gurbaxani and Dunkle (2019) |
| **Top Management Involvement (2 mentions)** | a) Supportive, committed top management<br>b) Determine digital triggers/initiators, drivers, transformed areas, and impact zones | a) Stief et al. (2016)<br>b) Morakanyane et al. (2020) |
| **Organizational Development and Change Management (5 mentions)** | a) Develop dynamic organizational capacities<br>b) Human resource control<br>c) Run pilot projects<br>d) Establish digital-oriented organization with standard processes | a) Osmundsen et al. (2018)<br>b) Stief et al. (2016)<br>c) Vogelsang et al. (2019)<br>d) Morakanyane et al. (2020); Cichosz et al. (2020) |
| **Management and Leadership Practices (4 mentions)** | a) Well-managed Dtrans tasks through leadership<br>b) Workforce and management engagement<br>c) Resourceful Project Management practices | a) Osmundsen et al. (2018); Cichosz et al. (2020)<br>b) Osmundsen et al. (2018)<br>c) Bhanji et al. (2021); Bousdekis et al. (2020) |

**Table 13: Compilation of success factors of digital transformation across industries from the literature review. The numbers in brackets denote the numbers of identified research works (continued).**

| Categories of Success Factors | Constituents of Identified Factors | Relevant References (15) |
|---|---|---|
| Organizational Culture (7 mentions) | a) Facilitate joint IT-business initiatives within the larger transformation<br>b) Supportive organizational culture<br>c) Foster individual mindfulness and stewardship climate in the organization<br>d) Build product specifications around core customer needs and reliance | a) Haffke et al. (2017)<br>b) Osmundsen et al. (2018); Cichosz et al. (2020); Morakanyane et al. (2020); Vogelsang et al. (2019); Gurbaxani and Dunkle (2019)<br>c) Dehnert and Santelmann (2021)<br>d) Vogelsang et al. (2019) |
| Knowledge Management and Skill Development (5 mentions) | a) Knowledge handling/management, know-hows, and tools<br>b) Continuous employee training and skill development<br>c) Exploit internal and external knowledge | a) Stief et al. (2016); Gurbaxani and Dunkle (2019)<br>b) Eller et al. (2020); Cichosz et al. (2020)<br>c) Osmundsen et al. (2018); Cichosz et al. (2020) |
| Technology Management (6 mentions) | a) Building technical capabilities (e.g., infrastructure, reliability, relevance, adaptability, security)<br>b) Digital services platform adoption<br>c) Automation adoption (e.g., production, process, etc.)<br>d) Experimentation of new tech for customer needs | a) Stief et al. (2016); Vogelsang et al. (2019); Gurbaxani and Dunkle (2019)<br>b) Sebastian et al. (2017)<br>c) Vogelsang et al. (2019)<br>d) Mhlungu et al. (2019) |
| Data Management (3 mentions) | a) Strengthen information system capabilities<br>b) Proper use and handling of data (e.g., completeness, availability, real-time, integration) | a) Osmundsen et al. (2018)<br>b) Vogelsang et al. (2019); Cichosz et al. (2020) |
| Internal Integration (2 mentions) | a) Operational backbone integration<br>b) Customer centricity (e.g., designing offerings, response to changing needs, reengineering, etc.) | a) Sebastian et al. (2017)<br>b) Mhlungu et al. (2019) |
| External Integration (5 mentions) | a) Meeting ESG (Environmental, social and governance) protocols for Dtrans<br>b) Handling legal procedures for technological implementation, e.g., data protection standards<br>c) Build creative partnerships (e.g., external collaborations, employee and partner engagement) | a) Bajic et al. (2021); Johansson et al. (2019)<br>b) Bajic et al. (2021); Bokrantz et al. (2017); Mhlungu et al. (2019)<br>c) Mhlungu et al. (2019); Cichosz et al. (2020) |

## 4.1.2 Determinants of Digital Transformation Progress

From the digital transformation readiness or maturity viewpoint, a set of ten parameters have been developed from the sources that the systematic review yielded. It can be utilized for evaluation of an organization's state when it is planning a holistic Dtrans. They are presented in table 14.

**Table 14. Digital organizational readiness parameters collected from the literature review**

| Serial No. | Digital Readiness Parameters | Representative References (20) |
|---|---|---|
| 01 | Find the organization's strategic necessities and rewards of Dtrans. | Roos and Nilsson (2020); Weiner (2009); Machado et al. (2019b) |
| 02 | Locate the consequent threats and opportunities of Dtrans. | Hermann et al. (2019); Weiner (2009); Machado et al. (2019a, b) |
| 03 | Determine assets, capacities, and expertise for Dtrans. | Kane et al. (2018); Combe (2014); De Sousa Jabbour et al. (2018); Pessot et al. (2020) |

**Table 14: Digital organizational readiness parameters collected from the literature review (continued)**

| Serial No. | Digital Readiness Parameters | Representative References (20) |
|---|---|---|
| 04 | Facilitate leadership and interdisciplinarity for Dtrans. | Colli et al. (2018); Kane et al. (2018); Nosalska et al. (2019) |
| 05 | Set the vision, objectives, and strategy for organizational Dtrans. | De Sousa Jabbour et al. (2018); Kotter (2014); Nosalska et al. (2019); Pessot et al. (2020) |
| 06 | Advocate and empower transparent communication with all parties. | Weiner (2009); Kotter (2014); Geissbauer et al. (2016); Machado et al. (2019a, b); Kane et al. (2018) |
| 07 | Evaluate Dtrans progress (possibly with need-specific KPIs) | Combe (2014); Weiner (2009), Yeow et al. (2018); Issa et al. (2018); Machado et al. (2019a, b); Bosman et al. (2020) |
| 08 | Ensure a proper digital knowledge management system | Pessot et al. (2020); De Sousa Jabbour et al. (2018) |
| 09 | Enable autonomy for stakeholders | De Sousa Jabbour et al. (2018); Kotter (2014); Pessot et al. (2020) |
| 10 | Accelerate the Dtrans process in whole value chains | Colli et al. (2018); Ghobakloo (2018); Pirola et al. (2019) |

No standard established set of Dtrans KPIs or indicators was discovered in the literature review since it is not well-established in most institutions where KPIs are still heavily focused on finances (Machado et al., 2021). Very few research articles mentioned any performance measurements that may be suitable for Dtrans. The mentionable attempts from the literature to suggest digital indicators belong mostly to categories or objectives such as, cost savings, revenues gains, employee engagement, process efficiency, and customer satisfaction/values due to digital means and methods (Levkovskyi et al., 2021, Kuntsman and Arenkov, 2019, Ahmad et al., 2021, de Andrade and Sadaoui, 2017, Singh et al., 2020).

## 4.1.3    Digital Transformation of Business Model

The literature review found several sources pointing directly at digital BM innovations. Table 15 shows how today's BMs are being altered by Dtrans with respect to strategic, value, and technological developments.

**Table 15. Effects of Dtrans on BM innovation across dimensions from literature review. The numbers in brackets denote the numbers of identified research works.**

| BM Dimensions | Concise Descriptions | References (35) |
|---|---|---|
| Strategic Consistency (9 mentions) | 1. Establish digital strategy with plans and goals<br>2. Top management leadership recognition<br>3. Digital culture development | 1. Hess et al., (2016); Verhoef et al., (2019); Schallmo et al., (2019)<br>2. Brenner, (2018); Schneider, (2018); Mihardjo et al., (2019)<br>3. Verhoef et al. (2019); Coreynen et al. (2017); Lenka et al. (2017); Bouwman et al. (2019) |
| Value Creation (24 mentions) | 1. Adjust traditional processes with digital (product/service development)<br>2. Integrate processes: information, hardware and software<br>3. Integrate entire SC through collaboration and trust<br>4. Digital expertise of technology and data<br>5. Change management: job, human-machine interaction, resistance mitigation<br>6. Standardized technology selection and integration<br>7. Capacities for information management (detection, collection, storing)<br>8. Analytics to generate value<br>9. Dynamic managerial and technical capacities<br>10. Partner collaboration<br>11. Value chain network integration along SC | 1. Zheng et al. (2019); Yip et al. (2014)<br>2. Müller et al. (2018); Wang et al. (2016); Liao et al. (2017); Kiel et al. (2017)<br>3. Hahn (2020); Kagermann et al. (2013); Kiel et al. (2017)<br>4. Birkel et al. (2019); Dean and Spoehr (2018); Schneider (2018)<br>5. Birkel et al. (2019); Dalenogare et al. (2018); Dean and Spoehr (2018); Schneider (2018)<br>6. Frank et al. (2019); Kiel et al., (2017); Sung (2018)<br>7. Zheng et al. (2019); Lenka et al. (2017)<br>8. Gauthier et al. (2018); Lenka et al. (2017); Zheng et al. (2019)<br>9. Warner and Wäger (2019); Oesterreich and Teuteberg (2016); Hasselblatt et al. (2018)<br>10. Schneider (2018); Vendrell-Herrero et al. (2018)<br>11. Camarinha-Matos et al., (2019); Horvath and Szabo (2019); Lenka et al. (2017); Verhoef et al. (2019); Witschel et al. (2019) |
| Value Proposition (3 mentions) | Redefine offers to customers through Dtech | Coreynen et al. (2017); Brenner (2018); Schneider (2018) |
| Value Delivery (6 mentions) | 1. Digital CRM processes with customer's BM understanding<br>2. Digital sales approaches<br>3. Digital collaboration/co-creation with customers (B2B, B2C) | 1. Coreynen et al. (2017); Vial (2019); Hasselblatt et al. (2018); Witschel et al. (2019)<br>2. Hasselblatt et al. (2018); Rachinger et al. (2019)<br>3. Coreynen et al. (2017); Hasselblatt et al. (2018); Lenka et al. (2017) |
| Value Capture (6 mentions) | 1. Investment in Dtech implementations<br>2. Recognition of new revenue streams from digital sources<br>3. Financial risk management from digitalization | 1. Birkel et al. (2019); Parida et al. (2019); Müller et al. (2018)<br>2. Schneider (2018); Kotarba (2018); Rachinger et al. (2019)<br>3. Schneider (2018) |
| IT/Tech capacities and data protection (7 mentions) | 1. Upscale and update existing IT infrastructures for Dtrans<br>2. Establish reference standards<br>3. Ensure digital security and integrity | 1. Dalenogare et al. (2018); Saarikko et al. (2017); Verhoef et al. (2019)<br>2. Liao et al. (2017); Oesterreich and Teuteberg (2016); Birkel et al. (2019)<br>3. Horvath and Szabo (2019); Oesterreich and Teuteberg (2016); Birkel et al. (2019) |

### 4.1.4    Digitalization of Supply Chain and Logistics

To connect the digital BM with SC and logistics, several researchers have noted a handful of important phenomena. For instance, it is observed that adopting a collaborative perspective with value chain partners is crucial for integrating systems, processes, and relevant data across SC (Camarinha-Matos et al., 2019, Horvath and Szabo, 2019). Moreover, Industry 4.0 implementation and sustainability performance of SC is positively and intimately impacted by circular BM as well as organizational innovation (Belhadi et al., 2021). Following the BM development, Sundaram et al. (2020) found that the supply chain of the future will combine three important components to lower total business costs and boost productivity: intelligence, interconnection, and instrumentation. The authors also argued that incorporation of Dtrans into BM can help to improve entrepreneurial activities, production gains, revenues, and contribute to general economic growth (Sundaram et al., 2020).

### 4.1.5    Barriers in Today's Supply Chain and Logistics

From the systematic literature review, at least 25 micro types of barriers were identified. These barriers are inclusive of those belonging to sustainable SC and reverse logistics in contemporary industries including *agriculture, manufacturing, construction, healthcare*, and so on. Thus, they are multidimensional and they can be categorized across organizational sections, as presented in table 16.

**Table 16. Barrier or obstacles in SC and logistics management from literature review. The numbers in brackets denote the numbers of identified research works.**

| Barrier Category | Barrier Brief Descriptions | Representative References (19) |
|---|---|---|
| **Management (9 mentions)** | a) Lack of Project Management best practices in SC<br>b) Lack of leadership excellence<br>c) Overall increasing complexity of SC and logistics among parties<br>d) Lack of focus, obligations, and commitment from top executives and shareholders | a) Ageron et al. (2020)<br>b) Manzouri et al. (2010); Kim and Nguyen (2022)<br>c) Kim and Nguyen (2022); Stewart et al. (2016); Narayanan et al., (2018); Khan and Qianli (2017)<br>d) Govindan et al. (2014); Neri et al. (2018); Alzawawi (2014) |
| **Human Resources (4 mentions)** | a) Skilled labor shortage<br>b) Labor intensiveness and workload pressure<br>c) Shortage of technical and behavioral training | a) Kazancoglu et al. (2020)<br>b) Kazancoglu et al. (2020); Stewart et al. (2016)<br>c) Stewart et al. (2016); De Jesus and Mendonça (2018); Narayanan et al., (2018) |
| **Economy & Finance (6 mentions)** | a) High initial expenses (e.g., circular/green systems)<br>b) Lack of fund or capital for investment<br>c) Doubt and/or unclarity about return on investment (ROI) | a) Kazancoglu et al. (2020)<br>b) Stewart et al. (2016); Govindan et al. (2014)<br>c) Stewart et al. (2016); De Jesus and Mendonça (2018); Narayanan et al., (2018); Neri et al. (2018); |
| **Technology & Infrastructure (7 mentions)** | a) Lack of visibility (i.e., proper info sharing system) and tracking (i.e., info collection)<br>b) Deficient research and development (R&D), innovation, and entrepreneurial capacities<br>c) Lack of proper technological infrastructure (e.g., IT) for resource management | a) Manzouri et al. (2010); Kazancoglu et al. (2020)<br>b) Stewart et al. (2016); Gupta and Barua (2018)<br>c) De Jesus and Mendonça (2018); Stewart et al. (2016); AlSanad (2018); Fawcett et al. (2008) |

**Table 16: Barrier or obstacles in SC and logistics management from literature review. The numbers in brackets denote the numbers of identified research works (continued).**

| Barrier Category | Barrier Brief Descriptions | Representative References (19) |
|---|---|---|
| Policy & Regulation (5 mentions) | a) No incentives or support from governing bodies<br>b) Non-conducive legal system (e.g., disregarding improvement possibilities)<br>c) Absence of clear governmental framework enabling best practices | a) Stewart et al. (2016); Khan and Qianli (2017); Hussain et al. (2018)<br>b) AlSanad (2018); Hussain et al. (2018)<br>c) Govindan et al. (2014); Hussain et al. (2018) |
| Organization and Culture (7 mentions) | a) Suboptimal organizational structure<br>b) Subpar internal communication<br>c) Insufficient employee empowerment<br>d) Unclear or ill-defined responsibilities<br>e) Poor functional integration and cooperation leading to resistance<br>f) Performance measurement (KPI) and incentive issues | a) Neri et al. (2018)<br>b) Kazancoglu et al. (2020)<br>c) Stewart et al. (2016); Neri et al. (2018); Fawcett et al. (2008)<br>d) Stewart et al. (2016)<br>e) Stewart et al. (2016); Kim and Nguyen (2022); Hussain et al. (2018)<br>f) Stewart et al. (2016) |
| Market & Network (4 mentions) | a) Lack of collaboration and coordination with suppliers (e.g., regarding pricing, sharing info, and raw materials)<br>b) Insufficient clarity in terms of customer requirements<br>c) Awareness/consciousness or knowledge deficiency among consumers (e.g., benefits, tech features, eco-friendliness of certain products, etc.) | a) Delmonico et al. (2018); Stewart et al. (2016); Kazancoglu et al. (2020)<br>b) Stewart et al. (2016); AlSanad (2018)<br>c) Stewart et al. (2016); AlSanad (2018) |

## 4.1.6 Digital Technologies in Supply Chain and Logistics

A wide range of Dtech and their subordinate functionalities are emerging across the globe to facilitate SC and logistics integration, support, and subsequent competitive edges. From the literature, the objectives of SC Dtech have been arranged into three categories: information exchange, data analysis, and automation, as presented in table 17, with purposes, systems and mentionable technologies they consist of.

**Table 17. Notable present and emerging Dtech in industrial SC accumulated from literature. The number in brackets denote the total number of identified research works.**

| Objectives | SC & Logistics Tasks | Automation and Information Systems | Sets of Digital Technologies | Intersecting Literature List (11) |
|---|---|---|---|---|
| Information Exchange between SC echelons | E-commerce, e-procurement, SC process coordination, communication, and transparency, automated supplier search | Digital signature, Customer Relationship Management (CRM), Supplier Relationship Management (SRM), AMS (Application Management Services), Electronic Data Interchange (EDI) | Blockchain, industrial cloud, social network, digital marketing, cybernetic loop, omnichannel smart fulfillment solution, automated e-sourcing | Pagoropoulos et al. (2017); Bressanelli et al. (2018a); Salminen et al. (2017); Bressanelli et al. (2018b); Somapa et al. (2018); Williams et al. (2013); O´Leary (2017); Gupta (2017) |

**Table 17: Notable present and emerging Dtech in industrial SC accumulated from literature. The number in brackets denote the total number of identified research works. (continued)**

| Objectives | SC & Logistics Tasks | Automation and Information Systems | Sets of Digital Technologies | Intersecting Literature List (11) |
|---|---|---|---|---|
| **Data analysis and presentation** | Real-time scheduling of activities, business process steering, electronic catalog data collection, information systems integration, SC monitoring, product data and event management, predictive analytics and maintenance, data processing | Enterprise Resource Planning (ERP), Transportation Management System (TMS), Real-time planning, supply chain operations reference (SCOR), Standards (e.g., ISO), Product Information Management (PIM), Supply Chain Event Management (SCEM) | AI (artificial intelligence), Big Data, cloud computing, database management system (DBMS), smart warehouse and wearables, quantum computing, Sales and operations planning (S&OP) platforms | Pagoropoulos et al. (2017); Bressanelli et al. (2018a); Salminen et al. (2017); Bressanelli et al. (2018b); Somapa et al. (2018); Williams et al. (2013); O´Leary (2017); Gupta (2017) |
| **Automation of logistics (e.g., processes, assets)** | Digital production processes, digital manufacturing, digital product quality inspection, digital reverse engineering, flexible production automation, virtual models of physical productions | Flexible manufacturing systems (FMS) and factory automation, radio-frequency identification (RFID), automated production lines, warehouse management system (WMS) | Industrial IoT (IIoT), sensors, automated guided vehicle (AGV), virtual, augmented, and mixed reality (VR, AR, MR), intelligent robots, additive manufacturing & 3D-seal, Dtwin | |

In a similar fashion, more and more businesses is embracing Dtech in their SC and logistics operations which is visible from the literature works. The benefits reaped from Dtech and their example functions in SC and logistics within six particular major application domains (derived from Büyüközkan and Göçer (2018) and Pettey (2019)) selected from the review are presented in table 18.

**Table 18. Benefits of digital technologies in SC and logistics from literature**

| Application Domain | Example Functions | Benefits | Representative References |
|---|---|---|---|
| **Robotics in Complex Logistics** | 1. Picking, uploading in warehouses<br>2. Home delivery (including drones) | Faster, safer, and more productive logistics and SC | Ageron et al. (2020); Attaran (2020) |
| **Advanced Analytics** | Logistics and retail optimization | 1. Gain customer and market insights<br>2. Complex process optimization<br>3. Improved strategy & risk handling | Dubey et al. (2017); Gölzer & Fritzsche (2017) |
| **Blockchain Technology** | Complete product lifecycle management | 1. Efficient tracking, recording, and digital asset management<br>2. Improved digital security, SC visibility, and compliance | Somapa et al. (2018); O´Leary (2017); Gupta (2017); Williams et al. (2013) |
| **Additive Manufacturing** | On-site, on-demand manufacturing of parts and products | 1. Minimized inventories and warehousing<br>2. Distributed production<br>3. Efficiency gains (e.g., faster delivery)<br>4. Reduced costs | Attaran (2017); Attaran (2020) |
| **Internet of Things (IoT)** | Field operations and asset management | 1. Improved reliability visibility<br>2. Optimal equipment use and maintenance<br>3. Increased uptime and asset usage | Pettey (2019); Attaran (2020) |
| **Augmented/Virtual Reality (AR/VR)** | 1. Virtual shopping<br>2. Movement tracking in stores and production<br>3. Refine customer experience | 1. Real-time glance at manufacturing facilities<br>2. Improve order picking and detection<br>3. Efficient delivery process<br>4. Improved security | Ageron et al. (2020); Attaran (2020) |
| **RFID & GPS** | 1. Logistic tracking<br>2. Information retrieval<br>3. Reverse logistics<br>4. Supplier relationship management | 1. Improved decision making<br>2. Faster information exchange<br>3. Higher quality<br>4. Efficient processing<br>5. Reduced costs<br>6. Enhanced competitiveness | Reyes et al. (2007) |
| **Cloud Technology** | Digital services along SC | 1. Faster CRM and SRM<br>2. Reduced costs across value chains<br>3. Shorter product design and delivery<br>4. Improved forecasting and sustainability parameters | Attaran (2017); Wei (2021) |

## 4.1.7    Digital Twin: Applications in Supply Chain and Logistics

As a relatively new branch of technology, the research on Dtwin and its applications in SC is growing. Dtwin, along with other technologies, are mentioned in the reviewed literature as being associated with SC and logistics for driving Dtrans process in a firm. The studies that related to transforming the environment of digital firms exhibit diverse implications. Particularly recently, Dtwin has found substantial applications in SCM and logistics, which can increase the total obtained value and satisfaction of stakeholders. Table 19 summarizes the selected part of the reviewed literature on this issue.

**Table 19. Selected literature for Dtwin applications in SC and logistics management**

| Framework | Brief Explanation | Anticipated SC/Logistics Impact | Related References |
|---|---|---|---|
| A universal framework valid for several SC practical systems in the production industry | Partition of a complete SC system into four amalgamated standard groups that can be adopted for a Dtwin | 1. Meeting the research gap of a universal SC Dtwin<br>2. Reduced Dtwin establishment expenses and execution challenges<br>3. Handles challenges of an actual SC with numerous players | Zhang et al., 2021 |
| A cyber-physical (CPS) logistics system's architectural framework of Dtwin for SC control operation | Within a multitier CPS framework, this research proposes a cyber-physical logistics system synchronised with the mediator cyber-physical production systems. The objective of such a multitier architectural framework is to deliver technological functionalities for resilient SC control. | 1. Focusing on the issue with make-to-order (MTO) custom-made production's dynamic variations in SC<br>2. Use of technological abilities in a diverse simulation ecosystem<br>3. Driving resilience in SC control | Park et al., 2022 |
| A Dtwin application framework for green SC | Four-level application framework: physical level, SC digital twin level, analytics level, and implementation level | Curtailing disorder in multifaceted SCs by pinpointing the trends and inefficiencies in real-time and subsequently improving SC performance | Kamble et al., 2022 |
| A framework for data-enhanced Dtwin generation and reinforcement learning | Utilizing real-time data to create data feeds for the simulation model, providing a real-time Dtwin | 1. The Dtwins can emulate several adverse situations and suitable responses given by the personnel to solve them.<br>2. In due course, this pattern can be proficiently gathered, verified, and set over time to develop a reinforced machine learning platform for intelligent decision-making in SC/logistics. | Abideen et al., 2021 |

**Table 19. Selected literature for Dtwin applications in SC and logistics management (continued)**

| Framework | Brief Explanation | Anticipated SC/Logistics Impact | Related References |
|---|---|---|---|
| **Multi-level Digital Twin method to visualize and simulate complete digital business model** | Modeling four layers of a Small and Medium Enterprise (SME) company that authenticates the Multi-level Digital Twin method: business processes, operations, workflow, and work cell operations. The simulation analysis is done to evaluate the effects. The procedures are devised to link and incorporate business process level models with models of operations workflow and work cell steps. | 1. Lessening resource expenses in engineering processes and supply chain throughput time<br>2. Suggesting changes to the physical environment to meet the requirements of numerous detailed orders<br>3. Improved flexibility in manufacturing operations | Shevtshenko et al., 2020 |
| **Novel Dtwin model with three layers (physical, simulation, analysis) of capabilities** | Relation between job shop, procurement, sales, and marketing for the purpose of decision making | 1. Logistics unit systems virtualization<br>2. Averting delays in marketing activities via synchronized marketing resources. | Ding, 2019 |
| **SC Dtwin Architecture on optimization software called Anylogistix and an outline of technologies required** | Dtwins linked with dynamic simulation models in cases of digital logistics, procurement, and SC | SC risk mitigation via<br>1. monitoring numerous failure types<br>2. executing recovery procedure | Barykin et al., 2020, 2021 |
| **"Remanufacturing" (reverse or circular) SC** | A Dtwin for enterprise distribution concept with decision support system filled with data from internal and external sources | 1. Secured blockchain-backed information exchange<br>2. Includes revenue recognition, environmental footprint analysis, and transportation scheduling | Chen and Huang, 2020 |
| **Dtwin SC program (framework) realized by JD.COM - China's biggest retailer in terms of revenue** | Unified end-to-end digital presentation of full SCs through advanced optimization algorithms. | 1. Improved SC responsiveness<br>2. Advanced collaboration<br>3. Elevated agility<br>4. Enhanced information transfer across the board | Wang et al, 2022 |

## 4.2 Interview Outcomes from the Professionals

Interviewees were asked to disclose their own idea of Dtrans. Table 20 summarizes the verbatim definitions of the term Dtrans disclosed by the interviewees who chose to do so.

**Table 20. Definitions of digital transformation according to the interviewees**

| Interviewee Code No. | Definition(s) |
|---|---|
| A1 | "using information as a tool to achieve business goals which an organization puts on. I would not put a lot of emphasis on the tool, but it is the information management that is doing it." |
| A2 | "enabler to manage massive data in any companies above a certain scale" |
| E | "Digital transformation is transforming work processes through digitalization." |
| G | "Digital transformation is about changing work processes to make them more efficient by making people acceptable to changes and integrating changes to the organization using technological processes." |
| H | "Digital transformation is a kind of starting with a understanding the existing processes, which are basically something paper-based, then transforming it to a digital format." |
| I | "a way of using digital tools to streamline your either your internal business or how you interact with your customers." |
| J | "a process that changes the way companies or industries operate through new digital technologies. It could be caused by disruptive solutions challenging the status quo or new regulations." |

The interviewees mostly spoke from their current line of work, but many of them referred to their past experiences as well. The following subsections provide the summaries of their responses. The information is organized according to the groups of organizational parameters mentioned in table 12. Other insights include existing challenges and business success of Dtrans of the interviewed organizations.

### 4.2.1 Organization A

*Industry: Metallurgy. Type of organization: Aluminum Producer. Short description: Organization A is a global actor in the aluminum industry. It was much bigger before, but now aluminum production is its main business. There is another core doing chemical work. It has four different plants, with five in Europe, in three different countries, two in Norway, two in Spain, and one in Iceland. Two professionals (A1 & A2) were interviewed from this company. They provided different perspectives which are discussed separately below.*

**Interviewee A1:** The interview was conducted with the regional manager for the Nordics who has been working for organization A for over a year. They are responsible for operational and maintenance improvement activity or program which consists of work planning and execution of processes, reliability analysis, risk and asset health condition monitoring, equipment engineering, and so on. There is a lot of people working with different things, but it's the reliability that is concerned with logistics and material management which have everything to do with purchasing, organizing stores, processes,

and the last thing is systems which works in between these. And then, within these systems, there are platforms like planning tools, even Microsoft tools like Azure. The interviewee's job is to implement all these programs, according to plans, and put them into operation and then after that follow up so that they are really improving the bottom line. Or if not, then they go back and take corrective actions.

### Group 1: Digital Consciousness

*Digital Incentives*

As a material production company, organization A has employees bound to use certain tools and technologies that are corporate-dictated, i.e., decided by upper management. However, it has improved the efficiency of the processes. *"But the incentive is there, even if I can't tell you the numbers. We can see how fluid the work is now versus when it was on paper,"* the participant remarked.

In terms of data storage, they have virtually everything available in silos (process, logistics, procurement, etc.) which they are now currently working on making available globally across different technology layers. Also, they mentioned that when it comes to observing the changes due to digitalization, it always takes some time, and *"improvement will not be on the digital tool itself but how well these tools are supporting processes which we are changing."*

*Transformation Impact*

According to the regional manager, they have cloud-based performance measurement systems for whole facilities with data quality assurance. There is a hierarchy of metrics that are fully reported by the personnel. For the external organizations, it is embedded in the system in different levels. However, they are still working on KPIs that translates to the needs of Dtrans as the company is taking steps to understand and summarize details into metrics. According to the participant, examples of KPIs would be how number of users and usage increased over the months, and how the different applications and different departments are involved, how they are implemented and how they affect their work across the departments. Another one here is for connected applications, or field applications. *"There is a central engineering department which is almost not using anything (metrics) because they aren't in the field. So they are using just for testing. But, when I see the central maintenance shift is increasing by far 400% in the last month, it's important because those guys goes with their devices in their pockets. So, that's how the KPIs are structured now and they're rolled upwards in a single Power BI page,"* they mentioned.

Furthermore, digitalization has improved the efficiency of the company over using only paper-based solutions. There is no need to go back and forth for finding any data as everything is digitally available.

### Group 2: Digital Implementation

*Digital Technologies*

The participant claimed that they have extensive knowledge and support regarding interpersonal communication with both software and hardware (i.e., messages and mobile devices). Thus, their communication is efficient across internal and external personnel. They mentioned, *"We completely deployed something called "connected workers" across internal and external personnel because we use a lot of contractors, so all of them can log in with their devices and do get their checklist and work, including ours."* Nonetheless, they

are only starting out with *data analytics* (i.e., Power BI). They use *cloud technology* (i.e., Azure), but it is not optimized enough, according to the interviewee. They explained, *"The architecture of the cloud is not optimized. What we need is like every continent with one instance and then the connection on top of it, that is still not there."* Also, they use sensor technology in factories and third-party delivery activities, but not extensively.

*Digital Business Strategy*

When asked about digital strategy, the participant mentioned three actors in action: business strategy, IT and other one is OT or operational technology. OT is taking more and more space and it is between business and IT. According to the participant, in many corporations that they have worked, they observed that IT is losing ground and being more and more infrastructural, while OT is aligning the tools with the business goals. In organization A today, the OT Strategy is being formed according to the business strategy. *"If you can't connect the investment or initiative as to how it saves or make money, because business strategy is about making money, then your initiative, which is IT or OT, does not work. And due to the current economic situation of the world, it would be very difficult to get any approval (from top management)",* they said.

They further explained, *"I feel our implementation is optimal according to the goals. For example, our maintenance has a goal of saving $150 million in 3-5 years. So that's the goal and there's no rush to push the digital tools. But if you go to big tech or consultancy firms, they'll say we're slow and they won't sell their products to us. I could call it "purposeful digitalization". Because there's no point when anybody can buy a cloud service."*

The participant further describes that the corporation has several layers. There's a core team that works with OT (operational technology) and IT. On one side, they have their own resources for doing and organizing the work. And then, the business have agreements with Microsoft, Oracle, and other big software companies that provide the products that they adapt and deploy. Also, they have local subject-matter experts, regional experts, and support teams that basically deploy and execute systems. Therefore, they behave like separate organizations that behaves like a whole chain without anything to do with the production of aluminum.

*Digital Business Model*

Within its business model a aluminum manufacturer, organization A has been monitoring the processes since last year to improve the quality of aluminum and the variety of the products to the customers. According to the interviewee, they are including flexibility and automation within their processes to make them more efficient and effective. They claimed that digital technologies have an impact on the supplier relationship, even though suppliers and customers might value different things. Organization A is innovating in their field: *"There's a new carbon-free technology being released this year which was a huge program. Because we are not just producing aluminum, but also producing the technology to produce aluminum. So many of our competitors are actually buying technology from us to produce aluminum. So, these lines will be fully digitalized,"* they remarked. (N.B., This is an innovation where it produces oxygen as a byproduct while processing aluminum.)

In comparison with their experience with the oil and gas industry, the interviewee was positive about organization A's adaptability to digital market changes. *"But then again, the thing is, it's not about implementing the software – it's the speed of changing your process and bottom line,"* they said. Moreover, they remarked it is difficult to determine the change

speed from the inside of the corporation as digitalization does not affect its tonnage directly but only ensures proper asset management.

### Group 3: Digital Facilitation

*Multidisciplinary Collaboration*

According to the participant, the organization's structure has a Dtrans implementation plan that is central as to whether or not it will succeed. They emphasized the importance of domain expertise, including all relevant stakeholders, software, and other resources. "*Whatever it is, through both the program management, software managers and staff - if you don't have this triangle working together, it will not work. It will fail,*" they remarked, as the management might listen to only one of them and miss the bigger picture. In their opinion, there is no one-size-fits-all situation in this question. Thus, every company needs to find out their way of working before starting with Dtrans. All the strategies go from global to the regional locations. They are defined and supported that way. They start with a target and then go to the process tools. Then in the way they involve with what is found or needed in the organization. It can start with many people in a team, but it can shrink when executing. Therefore, there is a hierarchy in the process. However, some locations are more efficient than others due to internal organizational situation, such as, remoteness or distance from upper management.

*Organizational Culture*

The participant disclosed that when it comes to the digital tools, employees have no choice but to use them as it is dictated by the upper management. The same goes for the management – they are too involved in strategic decisions, so they do not have the room for questioning it.

The participant claimed that the organization is encouraging its employees to be more digital. "*Everybody got these smartphones and iPads delivered to them, even if they didn't need them – it was a big encouragement for the people.*" When there is a resistance or problem, the regional leads, software leads, and locals leads go and try to help or fix them. The employees are also technically savvy, according to the interviewee. Furthermore, for implementing the ERP system, they purposefully aligned the company's core culture with it.

### Other insights

*Existing Challenges*

According to the interviewee A1, some challenges exist in the management of organization A. Their logistical data is collected in the cloud, but there is no "global usage" of the data due to lack of an central management system. According to the interviewee A1, the organization is facing some difficulties to integrate asset and operational/production KPIs with Dtrans. *"Everyone sees things coming, but there are no solutions which have proven themselves in all the levels, in my opinion. You need to have that domain knowledge and you need to have investment adapted to your work and money. So there's no corporate strategy as to how to introduce it beyond proving data and data access framework,"* they remarked.

On the other hand, the planners of the company have struggled because the integration of all these data sources is not always seamless. Delays affect the data quality, and if things go wrong, they lose trust in the planning data. The participant opined, *"For example, you*

*don't want to open your Minibank twice and see different accounts or different amounts of money on it. So, the integration causes issues with data availability and also with information architecture, because when you have such a huge organization and you try to put things together, it's a very complex network and you need to route the data to the right place."* Moreover, suppliers might find it difficult to integrate and maintain with a large number of IT systems that their customers own.

*Business Success of Digital Transformation*

The regional manager said they are growing their capacity to produce aluminum. They claimed that are also saving money by dint of digitalization. Nonetheless, it is not clearly known whether the corporation is growing because of it and they attributed this to their short tenure at the organization. Yet they emphasized, *"But I think the company is moving in the right direction with digitalization. We have improvement in asset management numbers. But today we're working on these metrics and models to connect the introduction of digital tools versus tonnage of production. It's still not there and there's a lot of discussion as to how it should be done."* The participant further mentioned a big investment which was the Oracle Database Management System which has been in use for 8-9 years. But having all this asset management and work data available and accessible in a single system of handling data is supposed to be a huge improvement, because everything else is built on it. Besides, the local system in their Iceland facilities and another small analytical company from Canada provide advanced data analytics. Some smaller investments did not turn out to be successful, but they remarked, *"I don't see many bad solutions, but I do see many bad integrations."*

**Interviewee A2:** The interview was conducted with the material management lead for Organization A working for about one and half a year now, but their entire career in logistics, supply chain, and planning is about 15-16 years. The participant claimed that they developed the material management strategy for the organization globally and implemented in entire Europe.

### Group 1: Digital Consciousness

*Digital Incentives*

The participant is involved with internal maintenance team and not with external customers. However, they believe that the pace of work and interactions have gone up due to Dtrans. *"I think a company or business is like a like a living organism. If you don't change, then you have to die. So this urges you to change yourself or behavior,"* they commented. They think it is normal for businesses to embrace change in order to survive the digital wave.

Like other departments, the materials section collects and keeps relevant information which is critical to material management. Nonetheless, the participant A2 thinks that it is not done at an optimal level because they have the same data in different places (silos) which can lead to communication problems. *"We use the same data. But I only see from a material management point of view, and for example, purchasing is looking at the same data from a purchasing point of view. And, although we are looking at the same data, we are not communicating with each other,"* they remarked.

The interviewee thinks the aluminum industry is not affected by digitalization as much as other industries due to its traditional nature of technology. Then again, they believe that

the right implementation of IT and digital technology is a key enabler for analyzing data and effective communication within and outside of the organization. *"It's because we let the data talk, not ourselves. So, it's a very concrete way of communication,"* they said.

*Transformation Impact*

According to the participant, digital means are a great help to measure, categorize and manage inventory. It helps to keep it at an optimal level (e.g., space and cost saving, obsolete product detection, etc.) where data is shared with the personnel in different departments (e.g., materials, finance, procurement, c-suite, etc.) across the organization. The interviewee mentioned one possible KPI that might relate to Dtrans, and that is, supplier on-time delivery monitoring via digital means. Transparency and sharing of the data are two of the mentionable benefits of Dtrans, according to participant A2.

### Group 2: Digital Implementation

*Digital Technologies*

The interviewee mentioned that they use MS Teams and regular emails. Yammer is used as a means of social network which is transparent and widely used. In plants, people use mobile devices to scan. Organization A does not use machine learning but only Power BI as a data analytics tool which they are working on integrating with a common database. Currently, they are using a Microsoft Azure-based solution (SharePoint) for file sharing. IoT is widely used in plants and warehouses with secured radio-frequency identification (RFID) systems.

*Digital Business Strategy*

The company's IT department and external IT providers are working together complying with their business strategy - said the interviewee. The interviewee clarifies, *"Some business strategies are very advanced according to IT technology as well, but in other parts, we're a little bit behind. It's not bad because we don't always have to be the industry average. It's rather according to our demands, needs, and strategy where and how to get there."* The company is using screens/monitors to measure production every day. The interviewee also thinks the management is quite eager to implement digitalization as fast as possible, even though it takes a certain amount of time to see its effects and sometimes they happen to be impatient. They further talked about the importance of the initial intensive period, resource constraints, and hiring the right talents when new implementing IT solutions. Hiring is especially sensitive in Norway, in their opinion, due to its strong labor laws and unions protecting the employees. However, the IT personnel and the workers need both-way communication for make any implementation fruitful, as the workers generate user information and the IT team uses it to improve the solution which ultimately leads to learning.

*Digital Business Model*

The participant said the product portfolio of the company is increasingly becoming more technologically advanced to produce, even though the volume of aluminum produced might not be increasing so fast. And thus they need more knowledge, new gadgets, new assets, and new machines, for which digitalization is a key enabler.

In terms of supplier relationships, it is inherently hard to agree with each one of them, according to the participant. Thus, when introducing a new strategy or altering existing ones, they have to negotiate with the suppliers that have higher bargaining power and

make the smaller ones use their proposed methods to improve efficiency. Yet, the interviewee claimed that organization A always makes an effort to apply a newly adopted method or tool to another area to discover new possibilities, which makes the company behave like a "living organism".

The company has a blanket purchasing agreement (BPA) with general terms and conditions for specific suppliers. Therefore, they do not have to negotiate every time with the supplier about prices, lead time, and other conditions because they are already defined and stored in the shared system as well. Thus, the contract is done. So it gives us both ways the supplier and us - we can benefit, a lot of cost saving and time saving.

### Group 3: Digital Facilitation

*Multidisciplinary Collaboration*

The participant mentioned they work in a horizontal environment, whereas in some other countries the company have other types of integration. Some locations/countries are lagging behind in terms of digital collaboration maturity while others are trying to lead them to the right direction. "*In multidisciplinary matrix system, it is extremely important to communicate with each other. And it's really hard to make everyone focused in one goal because everyone has different measurements, different KPI, and evaluation tools,*" they said. Thus, different groups and regions have different focuses, but they are dictated by potential ROI and cost savings. Additionally, they believe that there is a high potential for agile cross-functional improvements in their organization.

*Organizational Culture*

When asked about employee digital engagement, the participant claimed them to be sometimes quite conservative about it as changing the little things deep in their minds is hard. Also, new, unproven things are scary and cause complaints from employees. But that is deemed as feedback for improvement. According to the interviewee, young people are more likely to adopt technology than older people as the latter might think old ways produce the same output as the new ones without requiring to go through a learning curve. Nonetheless, they think tech-related learning is necessary and it causes mutual benefits between the organization and the employees.

### Other insights

*Existing Challenges*

The participant thinks the management wants to see results of Dtrans immediately, but it always takes some time before they become obvious. Sometimes organization A is bound to obey a decision from an important supplier side even though they might not really need it. But ideally, any digital decision should be beneficial to both parties.

Furthermore, the participant think that their technology knowledge is suboptimal, especially in the IT area, even though factory automation level is high. Also, they said, "*We have lots of data relevancy issue and people are using different reports each other and we have some trouble communicating each other.*" There exists "silo-thinking" in various departments, for example, miscommunication between finance and maintenance departments. According to the interviewee, it is worse than having no data when no "single source of truth" is present. Moreover, there are issues with coordination of global metrics and country-specific environments.

*Business Success of Digital Transformation*

The participant said the revenue of the company went down due to high material prices during the pandemic. It is still being impacted by the ongoing war in Ukraine that is causing energy price hikes (essential for raw material production). But they believe the possible exponential revenue growth will return when the time comes as their teams are working and developing inside within. Their teams are also working on integrating their ERP solution to the suppliers' to make procurement more efficient.

When setting the annual budget, the company measures the "urgency and the importance" of the projects and then select only a few, according to the participant. Their management determine their success by calculating the ROIs, and thereby pass the knowledge to the organizational development. Furthermore, the interviewee A2 believes that their innovation that produces oxygen in aluminum production is going to be revolutionary. Even though Dtrans may not be as prominent as it is in other industries in generating revenue, they believe that the company still needs to do it with care.

## 4.2.2    Organization B

*Industry: IT & Construction Consultation. Type of organization: IT Consultation. Short description: Organization B is an IT startup founded in 2021. They are only two personnel in the company who have been working with the local government with the policy of some documentation. Their main customers belong to the Norwegian construction industry.*

**Interviewee B:** The interview was conducted with the Chief Executive Officer (CEO) of an IT startup with extensive experience in the construction industry where they worked a carpenter and a foreman. Therefore, their perspective comes from the junction of construction and IT industries.

### *Group 1: Digital Consciousness*

*Digital Incentives*

The interviewee thinks that the startup is getting more customers due to digital technologies, so therefore, their customer base is expanding. They are storing data mostly of the information of the buildings of their customers. *"It's going to be stored on cloud based on a digital twin. So the accessibility is going to be much better due to the technology that is available, and the user friendliness for most people is going to be much easier,"* they said.

The interviewee answered the question of market competitiveness from two perspectives. In their present business, technology is an inherent need. But, in their past experience in the construction industry, they believe that companies that are embracing digital tools and technologies will have a big head start compared to the ones shying away from it.

*Transformation Impact*

The participant believes that the construction industry, especially the small and mid-size companies, does not have a good overview of their KPIs and metrices except for individual projects. However, they believe that things will improve due to digitalization of data. Right now, the industry is getting more and more expensive, but they think Dtrans will be able to flip it the other way around. Furthermore, the digital possibilities will increase which will enable project managers to have more projects. "*But it might give them a tendency to overfill the project with work which can be hitting back on the company because the project management might become actually less active with the project,"* they said. Nonetheless,

they opined that digitalization helps minimize unnecessary waste where *"the positive side is the project management is able to deliver the information such as drawings digitally without going out to the worker and providing them."*

### Group 2: Digital Implementation

*Digital Technologies*

The IT startup is currently using tools like Microsoft Teams and SharePoint on computers and smartphones for direct communication without any pressing need for expansion due to the fact that the organization is currently run by only two persons. They intend to use data analytics in the near future. About cloud technology, they said, *"our platform is going to be based on Azure."* They just started with IoT: *"We've bought 3 complete packages with software and sensors for buildings and to measure different things. And now we are in a process of connecting this one to our scans, which is the digital things that we are working with."*

*Digital Business Strategy*

The participant said their main business depends on the availability of the relevant data (i.e., building info) in various stages of projects. *"And that's all from the operation of a project till the end of the project or the financial part of it and so on. So it's about connecting the data and the information. It's the main source here,"* they said. Moreover, due to being an early-stage startup, their work is quite fast which they claimed to be their main strength.

When asked about digital investments, they said, *"It's divided into two pieces – it's how we're developing things and how we're doing things".* According to them, their projects are split into small pieces each of which gives them direct income. But they do not try to embrace all technologies updates at the same time as it is not feasible. *"So, we bring one part to the company, and bring it out to the customers and we have our income, and then we put it all together"*, they emphasized.

*Digital Business Model*

About the product portfolio, Interviewee B said their accessibility has changed for service work as customers can now input requirements digitally which has given them the chance to customize their services, keep track of time and resources spent, and improve cost-effectiveness in information handling. However, they said, *"I don't think we're providing any better quality than we did a few years ago."*

The participant thinks their relationship with customers and suppliers have improved digitally as they are dealing with corporations in Australia, Canada, and Germany almost every day. *"So, digitalization has definitely broadened our reach to partners and suppliers. Almost the same can be said about customers as we are deleting boundaries with digital transformation. And it's not that we're speaking to the customer in a different way, but it's more and more customers are turning to us",* they explained. They believe that quality has come into the system and not just to the person. Customers can now get a better understanding of the product throughout the development process. Thus, planning and delivery have improved. On the other hand, suppliers can see ahead of time what to do with supplies and plan accordingly. Thus, logistics can be updated live (e.g., scan of a building, BIM, Dtwin, etc.) on both sides.

In terms of innovation, they are replacing traditional boards with digital ones with health, safety, and environmental (HSE) instructions that is required by law. Everyone has a card reader that gives them access to the digital boards, and according to the interviewee, HSE is one of the most important areas of the construction industry. Furthermore, they believe that even though old construction companies are not fast enough to respond to market changes, newer ones with digital approaches will ultimately reap the benefits in the future.

### Group 3: Digital Facilitation

*Multidisciplinary Collaboration*

The interviewee explained, "*In our company, we are only two people here now. So, we don't have any departments. But, you could say that we are dependent on our strategy to use existing technology and bring it to the workflow today. But again, we're using many collaborators which can be thought as many departments. We search for good IT tools and then we bring them together. We're developing them a bit by ourselves, but we maintain a very close cooperation with a company which provides us with some programming and practical help for scanning and so on. We also have a lot of operations both in Norway and outside. But, internally, we don't have departments.*"

*Organizational Culture*

Here, the participant spoke from their experience in the construction sector. They explained, "I think it's got a lot to do with who sees the possibilities and who sees the downsides or the challenges. But I will definitely say that the main rule is that the digital transformation is set by the administration." They emphasized that both sides need to be on the same page to make digitalization actually work. Generally, their experience with encouragement from management has been positive, even though naturally some resistance is expected from workers. The participant also remarked that the workers in the construction industry are less tech-educated than other industries where traditional culture has a huge influence. Nonetheless, they believe that digital project management tools has brought some positive changes with employee information (e.g., routine) and technical knowledge management (e.g., moisture level detection) compared to a pre-digital era.

### Other insights

*Existing Challenges*

According to the interviewee, the benefits of Dtrans is often not so well-communicated by the management to the construction workers which creates gaps in practice and productivity. It is because the workers then fail to see the whole structure and need – they only see more tasks to do (learning and unlearning). Many times new digital implementation is beneficial, but again, there could be many instances where it is unnecessary, according to them. Furthermore, they believe that construction employees become less technologically knowledgeable when only pieces of the problem are taken and the whole system is not connected together.

Moreover, as digital tools creates more productivity, it might give way to overfilling the project management with more tasks and workflow 24/7. "*But, people are available to process only a certain amount of information. And the system is unfortunately not there yet*", they explained. Also, people are interacting more digitally and workers might feel like they are working at two different companies at the same time, which is another downside according to the interviewee.

*"Unfortunately, the big old companies in the construction industry have too much luggage from the past, and that's fundamental problem of the existing companies today. They want to do everything the same way they always did. But they want to do the same thing more easily with technology,"* they said.

*Business Success of Digital Transformation*

The interviewee believes that increased digitalization is helping the business grow as they can now handle more projects at the same time. More precisely, the accessibility to work has increased as their customers can put their work in the digital forums. The participant further believes that the financial system, including taxes, is gaining more value out of Dtrans, and spending more on digital project management tools is helping the revenue growth. The company has so far made an investment in project management tools and a digital input system which has helped them connect all the necessary information.

## 4.2.3    Organization C

*Industry: IT Consulting (Analytics). Type of organization: Predictive Analytics Provider. Short description: Organization C specializes in organizational consulting around Predictive Analytics and Change Management. It was founded in 2013. Since its inception, the organization has been engaged in active digital transformation for their customers to help them move from a traditional paper-based/ spreadsheet/ PowerPoint model to an interactive web-dashboard model for managing risk. They did not have to engage in an internal digital transformation as they had been already actively using a digital model.*

**Interviewee C:** The interviewee C is the founder and president of organization C with extensive experience of providing digital services to customers.

### *Group 1: Digital Consciousness*

*Digital Incentives*

The participant said, "Based on the predicate that our organization has always been a digital-based technology organization, we have seen customer behavior increase after implementation or adoption of our solutions. The adoption rate varies from customer to customer but usually follows a path of skepticism." They described it as follows: first, resistance from potential customers, i.e., reluctance to adopt a new solution, then, acceptance, i.e., realizing the solution's effectiveness based on results, then, adoption, i.e., implementing in operations, and finally, reliance, i.e., continual use and seeking support from organization C.

The interviewee claimed that all of their digital technologies include data storage (including: active databases, database archives, digital notes, images, and videos). It is a core competency to all of their consultative solution offerings.

Organization C has benefitted from not having had to transition from manual to digital technology offerings. According to the participant, their competitiveness has been very strong in the market based on their tribal knowledge of the subject matter, innovation in the solution offerings, and superior web-visualization tools that create "extraordinary value" for their customers.

*Transformation Impact*

The participant claimed that all digital transformation activities begin and end with the evaluation of value that is created. *"If a new technology will create superior value then we*

will transition to it. If the value is unclear we will engage in offline experiments to test," they said. Metrics include: process time, accuracy, resiliency, efficacy. *"We measure external organizations on the same metrics we use for internal."*

One example they provided is the selection of a platform for web-visualization. *"We evaluated and ran side-by-side tests of the Saleforce-owned "Tableau" platform and a proprietary platform provided by an independent company (portal). In this evaluation both provided benefits and also had limitations. We are able to deploy either (or both) solutions for our customers depending on their user base. Tableau has a by-seat pricing model of $500 (USD) per user while the other solution offers an unlimited user enterprise license. There are use cases for both. We have deployments that include both solutions."* The interviewee denied any chance of harm done by digitalization as risk mitigation is performed proactively and any deficiencies are treated as learning opportunities with service level agreements for time, business continuity, and disaster recovery.

Furthermore, they claimed their impact to be immutable and critical to core business philosophy of their organization. But depending on the external organization, the customers may see the solution as being a threat or they may embrace and rely on their guidance solutions without a doubt.

### Group 2: Digital Implementation

*Digital Technologies*

Organization C primarily uses Teams for corporate interpersonal communications. *"We may also use GoToMeeting or MS Outlook depending on the use case and the team's access to a reliable internet source,"* they mentioned. They ensure communications via smartphones, tablets and laptops. According to the interviewee, data analytics are at the core of their company offerings. They use a variety of tools: Databases, Spreadsheets, Programming (Visual Basic, C#, Python), Web-Dashboards (based on Angular technology) for visualization. These are "mission critical" for the company. All web visualization/ interactive models are cloud hosted through a third-party. They provide a customer-facing visualization to asses risk and have insights to action.

Additionally, their solution offering do not require connected sensor technologies. *"We rely on "disconnected" Operational Technology data (e.g. Oil Sample Analysis results) that is transformed and merged with IT Data (e.g. Work Orders, Call Notes, Root Cause Analysis)"*, they explained.

*Digital Business Strategy*

About their digital business strategy, they said, *"Our business strategy and IT strategy are aligned and co-dependent. The connectivity cannot be separated."* All of their customers already have multiple, internal digital initiatives, models, and data stores that are often times at odds because they have difficulty within their different business groups identifying a "single-version of truth" as their models are mostly housed in isolated data silos. The participant claimed that when correctly implemented, the organization C models help to synthesize and confederate the customer's data into the closest proximity of a "single-version of truth". *"Adoption is similar but the customer reactions are mixed depending on the internal politics and executive sponsorship. The reactions range from feeling threatened, loss of control, resistance to change, fear of losing control to gratitude and reliance on an integrated model"*, they added.

*Digital Business Model*

*"Our service portfolio has grown with our ability to implement solutions that scale from a smart phone, to a tablet to a laptop/PC. We are device agnostic."* They claimed that since their beginning, their relationship with their customers and suppliers have been established on digital means. They shared multiple stories that brought significant values to both customer and supplier sides.

When asked about business model innovation, they said, *"Innovation is directly tied to our corporate tenet of "creative destruction". Our current product solutions are effective, however, we are working behind the scenes to develop even more advanced solutions that will replace the production models."*

According to the participant, Organization C departed from the industry trend of pricing based on the value created for the customers. This is one that has been used by multiple companies. "*We offer fixed pricing over multiple years that is based on our costs plus internal profit percentage."* This provides a competitive advantage. Furthermore, Organization C has team members who are subject matter experts in their fields (both industrial and technical). "*We do not program code in a vacuum or build solutions without a problem to solve. Our business engagement model is one that includes onsite participation working in an industrial environment",* they said. Example: Onsite, they work directly with the maintenance or reliability and/or mechanical teams to perform equipment inspections, root cause analysis, and warranty overwatch. They claimed that customers ask them to expand their offerings into other areas of their business as well as participate in their internal communications or roadmaps.

### Group 3: Digital Facilitation

*Multidisciplinary Collaboration*

*"There is no distinction between employees and management as all team members may operate in multiple capacities at the same time depending on the business need. Everyone has an equity stake in the organization . As President, I do have the final say or veto power if needed, however, I rarely invoke an overriding decision after a challenge process has been initiated and completed",* they explained. The team knows to expect and embrace the challenge process from a proactive / positive angle. It is core to our culture.

*Organizational Culture*

The interviewee said that there is no distinction between employees and management as all team members may operate in multiple capacities at the same time depending on the business need. Everyone has an equity stake in the organization. *"As President, I do have the final say or veto power if needed, however, I rarely invoke an overriding decision after a challenge process has been initiated and completed"*, they explained. The team knows to expect and embrace the challenge process from a proactive angle which is core to their culture. There is no resistance but only suggestions on new technologies that may provide greater long-term value for the organization. Any non-digital roles (e.g. legal, payroll, finance, HR) have been outsourced. The internal team is 100% engaged in continuous education and subject matter expertise, according to the participant.

About digital technology adoption concerns, they said, *"One consideration we use when selecting public-facing or secured web-visualization is around the host companies' internal policies. Some providers want access to the proprietary data. In these instances, we will*

*not enter into an agreement or business partnership. The data belongs to the organization and our customers."*

**Other insights**

*Existing Challenges*

As a digital-born company helping other with advanced digital solutions, this organization faces less challenges than any organization with a traditional history. However, one noticeable thing is that they do not have any dedicated KPIs for measuring their customer's digital maturity or transformation. Besides, the interviewee implied that some of their customers might be skeptical of their provider's solutions, especially during the early stages of implementation.

*Business Success of Digital Transformation*

Revenue growth has occurred organically and grows year over year with long-term contracts or engagements, according to the interviewee. "*We won't enter into a new project unless the following elements are present and agreed upon: dedicated resources, timelines, scope, metrics",* they emphasized*.* They do not engage in value-based pricing as their core tenets reflect the fact that the return on investment (ROI) belongs to the client. They believe their business has grown via word of mouth, publications like case studies (e.g. Forbes.com, Railway Age, industry publications) as well as conference presentations (either as the presenter or participant on a panel). *"We continue to be cash positive profitable with no outside investments or debt. Our current customer retention rate is 100% up to 10 years in committed, sole source contracts"*, they mentioned.

Their primary example of growth is the ability to provide their customers with insights to action that provide a 360 degree view of the risk or opportunity. They explained, *"Not only do we predict future events, we offer prescriptions for intervention with advanced digital solutions (e.g. checklists, inspection steps, compliance, outcomes, comparisons to like-assets or failure modes across our customer ecosystem)"*. This model results in their ability to be viewed as an investment with a high ROI in a short amount of time. They implied, *"We will not engage with customers that see our solutions as a "cost"".*

The company invested significant sums into their third-party vendors for web-visualization. Their ROI was 6-12 months (7 years ago). *"We believe that our partnerships have created an "unfair" advantage in the market as we are capable of scaling and implementation at a rate that exceeds any competition, at a lower price point",* they remarked.

According to the interviewee, Organization C is growing and has grown year-over-year because of their digital offerings and expert insights. They further said, "*People and technology are mutually required for success. The organization could not succeed without either. I am unable to provide a percentage of expansion estimate as it has not been measured separate from our core solutions."*

### 4.2.4   Organization D

*Industry: Academia. Type of organization: University. Short description: Organization D is a university in Norway with dedicated digital estate management.*

**Interviewee D:** The interviewee D is a manager for the digital properties department in the university. Their role is to support mostly the Estates Department with the digital solutions. All the systems are their responsibility. The interviewee also implement new systems and digitize existing processes in the department. "So basically we're a service

organization for the rest of the departments, working with the digitization mostly. Before this, I've been working with several IoT suppliers, ERP solutions, both as a consultant and a project manager for customers implementing these systems. So I've been working with the implementing applications last 30 years, more or less," they said.

### *Group 1: Digital Consciousness*

*Digital Incentives*

The participant said the digital customer behavior has sped up, but at the same time with all the different channels and technologies available, it has become a very fragmented picture. *"It's hard to choose technology that you can integrate into your business conduct in a controllable manner,"* they said. They think the maturity is very good. It's increasing very fast, and people are integrating or implementing technology very fast as well, especially on personal data such as Facebook and TikTok.

According to the participant, it is easy to gather and store usage data from different individual sources (e.g., building energy consumption, environmental climate, devices, etc.), but it is hard to track and combine who are using it. Also, it is hard to gain user trust regarding data collection (e.g., GDPR). They further think that the competitiveness of the market has not increased significantly because *"there's a lot of systems and technology available out there, but the knowledge of using it correctly is not very high."*

*Transformation Impact*

The companies (construction and IT) the interviewee worked for had not any structured digital KPIs. When transformation is done correctly, it brings advantage to the organization: *"For instance, we have a new facility management system implemented. And that has definitely made us aware of all the tasks that need to be done, all the assets that we have to maintain, and a very good overview of our buildings and digital twin models."* But when the information in the system is wrong or not complete, the clients completely lose interest or trust in the system, and that means they stop using it. It requires hard work to regain their trust in the system, according to the interviewee. They also remarked that the successes are fortunately exposed to the outside world a lot more than the failures: *"But we need to work a lot with both the internal and the external effects of the system implementation."*

### *Group 2: Digital Implementation*

*Digital Technologies*

The interviewee has had a long experience with interpersonal communication tools like messenger apps and handhelds. About data analytics, they said, "Relevant data is quite important, but not in all settings, though. We use Power BI and we also use other analysis tools, machine learning and AI on our Microsoft Azure platform. If you keep it within the relevant sphere and within knowledgeable people and as long as you handle the data that you get out of it in a proper manner, it's very useful. But it should not be exposed to the public." They claimed other cloud tools are not as versatile as Azure, even though it is expensive. Their experience with IoT suggests that they can store data, but has a high risk of being siloed as it is difficult to integrate.

*Digital Business Strategy*

Unfortunately, it is not always integrated sufficiently, as it is often unclear how to align the business with the IT infrastructure, and there exists organizational barriers: "*Implementing a system IT-wise is very easy with all the cloud services especially, but implementing them in the organization is the hard part. And we do not give that enough attention in my view. So it's basically an organizational change project more than IT project most of the times.*" According to the personnel, the implementation is quite fast, but a company has to face the aforementioned barriers anyway as people need time to change their behavior. "*We can buy licenses for a new system and education and also learning the new system we're using, but we don't set aside the budget resources for the organizational change itself*", they commented.

*Digital Business Model*

The product and service portfolio have evolved, according to the interviewee. They have the same data accessible for all departments which is a huge improvement in terms of efficiency, communication and trust. Yet that depends on how they use the implemented system. It has changed the way people work from day to day. Customers are getting more consistent information and standardization of internal processes is also beneficial. About supplier relationships, they said, "*I worked with a couple of production companies implementing a larger production system and it of course, the order or the stocking was made a lot easier and more predictable. So you saved a lot of money with just-in-time production for instance.*" But that requires the knowledge of production needs at a given time. It is about data quality: "*When the data quality increases, the efficiency is increased as well.*"

The interviewee mentioned their experience with IT innovation. "*There's a lot of technical innovation out there, but the real benefit is when you manage to integrate this (API) in your existing systems or make a common platform for all those systems, because individually they're just a new silo of information and technology that might be efficient in one very narrow activity*", they said, referring it as a difficult task. In their opinion, the innovation process is rather step-by-step or iterative. They are working with university facility (room/space improvement projects) management that are evolving and giving new possibilities. According to the participant, the organizational reactions to digital market changes is not optimal: "*So the reaction must be to take more time, to hold a little bit, and involve the organization earlier so that the organization understands and implements it as an organizational change as much as a technology change.*"

### Group 3: Digital Facilitation

*Multidisciplinary Collaboration*

"*To try to fix the organizational challenges, we have a we have put together task forces with representatives from different departments that are actually part of the project or the implementation of a new system. But we have done so post-implementation, so we do it in order to fix the organizational changes more or less*", the participant said. It is an incremental process along with data management. They also believe that they are on the right track with organizational changes to make it more agile and cross-functional.

*Organizational Culture*

The interviewee has noted positive attitude among employees with digital means. But about the management, they said, "*It's a resource question, so unless you can convince management that this will have a positive effect on business or the task that we are set to*

*do, they're quite skeptical of it."* They also remarked, *"My main critique also is that digitalization is not integrated enough in the organizational development. It's very often highlighted as a as a separate task, so we have the digitalization as one task and the organizational development as another task."* Nonetheless, they have seen many skilled people on a personal level.

### Other insights

*Existing Challenges*

The interviewee claimed that the hard part is to find professional use of digital technologies and to control the data. Moreover, sometimes companies have a business strategy that just that mentions digitalization, but it does not say how to digitalize in a relevant manner.

*Business Success of Digital Transformation*

About the organizations interviewee D has worked with, they said, *"When successful, yes, the revenue and efficiency, and so the bottom line has increased. Sometimes also top line because increased sales and increased exposure to the customers and potential customers."* Moreover, they said the organizations are not encouraging the employees enough to make use of digital tools. Also, they tend ignore their existing culture for digitalization.

## 4.2.5    Organization E

*Industry: Oilfield services. Type of organization: Subsea engineering. Short description: Organization E designs and constructs energy infrastructure while also offering a variety of goods and consulting services to low-carbon and renewable energy projects.*

**Interviewee E:** The participant is a digital advisor in the Dtrans team at organization E, working since July 2022.

### Group 1: Digital Consciousness

*Digital Incentives*

*"I would say that we definitely face the challenge when introducing digital technologies for communication. And it sounds easy, but you have to get used to new ways of working, which is always a challenge"*, interviewee E said.  The department they are working at is quite young, but the digital progress is what they are hopeful about regardless of any resistance.

For data storage, they are using their in-built cloud technology as well as Azure Data Factory. They are building digital applications with their own partner company. The uses of such digital applications are tracked and stored. Yet, they mentioned that they are dependent on the partner company for storing which delimits data availability.

Even though competition in the market has increased around the world, the interviewee claimed they are in a good position to lead, especially in Norway: *"Organization E is a pioneer in introducing and offering digital tools to oil and energy projects. And so they have developed these tools for internal purposes, but they could be scaled."*

*Transformation Impact*

As a digital advisor, the participant is responsible for tracking digital progress. *"It's quite hard and much challenging. As I said, these tools are new. Again, the KPI's that you're*

*defining are does not have a background necessarily, and there are many partners involved. They don't necessarily reach an agreement on what KPIs are proper to follow,"* they explained. They learn as they go and they have KPIs within projects, adoption rate, and operations. *"If a designer is using a tool that's used for designers, then we want to see less and design change request or DCR's in a later stage of the projects. So if the design is done properly, then there won't be request to redo the design which comes of course at a later time. And that's why I say it's gradual."*

About digitalization benefits, they claimed it improved communication and collaboration. Also, risks are minimized due to less design changes and waste reduction. Organization E is working with partner companies quite effectively according to the participant: *"The company that we're working with for developing the digital tools has been part of organization E first. And so they were one company, I would say, now that they are sister companies. Many of them have been working in organization E for several years. So they know the company and processes quite well."* They have been working together to develop tools that can scaled to other companies and projects as well. It has helped them financially and with market positioning.

### *Group 2: Digital Implementation*

*Digital Technologies*

According to the participant, the corporation is using messenger apps for interpersonal communications very effectively. They do not use mobile devices for work purposes. They extensively use data tools (Excel and Power BI). Furthermore, they use Azure Data Factory while they are in the process of transferring the existing data. IoT is only used in yards.

*Digital Business Strategy*

*"Organization E is trying to excel and be relevant through digitalization, which is developed by IT department. So the recent business cases that they have, or their upcoming vision for the coming years is based on IT, are not primarily in oil and gas anymore. So they want to be more into offering digital tools, which is unlike what we did in the past. So yeah, I definitely agree. This two (business and IT) are very closely linked"*, they remarked. They further emphasized their passion and competence for digital tools and technologies with allocated funds, resources, and digital representatives in different segments that generates business development ideas.

*Digital Business Model*

"I would say organization also actively consulting some projects into how to be digital and how to save as much money as possible," they said about their service portfolio. Also, they believe their relationship with customers has improved, and suppliers are interested in their share in digital services as it brings better values all around.

Innovation is mostly done at their yards, according to the interviewee, such as building the first welding robot in Norway. It is a project-based approach. Even though oil and gas projects are slow in execution, it is necessary to be reactive when some applications only target specific phases of a project. *"So if you're not adaptive enough, if you're not fast enough then you lose that phase of the project and you basically use lose the project totally. So I would say that the development plan of the applications and the development plan of the project are quite aligned right now"*, they explained. They need to respond to

changes required in specifications rather than market needs, e.g., even pushing a software development project.

### Group 3: Digital Facilitation

*Multidisciplinary Collaboration*

The company is using both individual and multidisciplinary digital tools for work that are widely used. Furthermore, the participant mentioned, *"I think every team is trying to link themselves to agile methodology and agile ways of working there implementing digital kanban."* They believe procurement department is more prone to cooperation due to its importance, complexity of operations, and close contact with suppliers.

*Organizational Culture*

*"There is another initiative as "everyday digital" that's going on for the employees where they are asked to digitalize whatever they did with the tools that they're provided with plus the digital tools that everybody used in the company. By digital tools. I'm referring to the digital tools that organization E developed for the projects. And the second would be communicational tools",* they said about the employees. Employees can request digital tools to the administration. On the other hand, managers are encouraged to be as digital as possible even if they lack experience initially. Everyone is quite tech-inclined and open to change, according to the interviewee. Furthermore, the existing culture somewhat influenced digital tool adoption as they run surveys for estimating employees' preferences and develop tools project-based to mitigate problems.

### Other insights

*Existing Challenges*

The participant mentioned their dependency on partner companies and negotiation problems that diminishes data availability or accessibility. Moreover, there can be challenges in understanding each other, and hard to agree on the same point which may lead to delays.

*Business Success of Digital Transformation*

"Revenues necessarily have not grown, but the costs have been less," said the interviewee, about their transformational success claiming at least 25% savings in labor costs. *"By using digital tools we were able to cut down some unnecessary man hours and shorten the projects periods or timeline and save a lot in material waste"*, they added. Furthermore, they said, *"There's a quite large type of investment on the digital tools. The investment is mainly on the tools development and maintaining. So that's where it goes, not necessarily used on the projects or employees but mainly on the application development."* Nonetheless, not all app developments are successful, even though that depends on whether or not a project is looked upon as a success. Trial and error is a part of it. The participant attributed 50% of their potential growth to Dtrans even though they are still dedicated to older projects. *"Oil and gas projects take a very long time to deliver, but it's growing and the vision for 2025 onwards is that 2/3 of the revenue should come from digital transformation"*, they added.

## 4.2.6    Organization F

*Industry: Commodities. Type of organization: Wholesaler. Short description: Organization F is a private distributor of fruits, vegetables, and flowers.*

**Interviewee F:** The participant is the IT Leader (Project Management Office) of a grocery wholesaling business in Norway. They are responsible for full project and portfolio management and delivery with in-house integration and data science teams.

### Group 1: Digital Consciousness

*Digital Incentives*

According to the interviewee, they are a B2B company and most customers are interested in their internal digital solutions that has shown good adoption rate and efficiency so far. They mostly store transactional data. They are working on a centralized data warehouse that captures and stores everything. About the market competitiveness, they said, *"It has increased, yes. But I'm not sure if we can compete at a higher level. At the moment, we're keeping up with the competition."*

*Transformation Impact*

There is no specific measures used for Dtrans, only KPIs related to individual projects. On the benefit side, ecommerce solutions implemented have benefited the organization by improving efficiency, according to the participant.

### Group 2: Digital Implementation

*Digital Technologies*

The participant claimed their personnel got accustomed to the Teams app quite extensively during the pandemic. Mobile devices are used in operations and warehouse, but not in offices. They have a dedicated data science team with machine learning expertise, but still they believe they have a long way to go in this area. The organization is currently dependent on cloud and on-premise data center solutions. In some transportations from abroad, they are using GPS systems.

*Digital Business Strategy*

*"The digital strategy has been created based on the on the business strategy, so there is definitely a link there",* they emphasized. *"From an IT perspective, we have capabilities and we are doing quite a lot, I would say, especially in this data science area. But it is quite a long way to mature the organization in order to actually implement, adopt and work differently. Yeah, things like trusting data, solutions, and others,"* they explained. Besides, they claimed digitalization resource allocation mainly happens through projects across the board with no multidisciplinary cooperation.

*Digital Business Model*

Due to being a commodity wholesaler, there is not much scope for product and portfolio modification or innovation, according to the interviewee. Digital visualization tools have helped them understand their needs better along with customer behavior. Any new idea or problem-solving is done through projects, e.g., implementing new ERP solutions. Nonetheless, the interviewee believes that the market itself is not changing that much.

### Group 3: Digital Facilitation

*Multidisciplinary Collaboration*

"There is no multidisciplinary teams, at least not today. Even though it's has been discussed, but that's probably many years into the future. So the collaboration is mainly

through projects", interviewee F said. Only some IT-related involvement are by nature multidisciplinary with business and IT tightly working together, e.g., they are implementing Dynamics 365 as an ERP application. Also, there are differences (between parts of the organization) in speed, ambition level, and maturity.

*Organizational Culture*

Employee digital involvement varies widely with some expected resistance to digital introductions, according to the interviewee. The management is encouraging interpersonal communication via digital means and generation of insights with visualization tools (e.g., reporting). Data science teams are working alongside.

*"In parts of the organization, it's a bit stuck with the old ways of working, especially with long-tenured people"*, they said. Thus, IT-solutions are not pushed instantaneously as cultural issues are considered. IT-solutions are only delivered according to business needs.

### Other insights

*Existing Challenges*

The data is stored in different solutions and databases today, and at the moment they do not have a central data warehouse that captures everything. Furthermore, there is room for improvement also on the management level in order to think differently, form different ways of working, and also hire the right type of profiles, according to interviewee F. The revenue also has not been growing in the last few years, claimed the participant. There are many investments that have not been utilized in a very good way. And so the potential is there, but more is needed in order to bring out the efficiencies", said the interviewee.

*Business Success of Digital Transformation*

According to the employee, digital promotions have helped increase sales. Digital transformation investments has been in the data science area with some ROI, e.g., cost savings and streamlining.

## 4.2.7    Organization G

*Industry: Registrar and classification. Type of organization: Auditor. Short description: Organization G is auditor in assurance and risk management across multiple industries (maritime, oil and gas)*

**Interviewee G:** The interviewee is a Dtrans consultant in the Digital Solutions Department. They have been working for organization G since August 2022.

### Group 1: Digital Consciousness

*Digital Incentives*

About the customer behavior, they said, *"Yes, it accelerated because we have continuously been producing services and products in the digital domain. And whenever we have a digital product that reduces the workload, the turn out time of the service or even the difficulty of the service decreases whenever we have a product of this sort which does this, people are more receptive and the client pays also increases."* Usually, all the metrics they use depend on individual projects. Data availability is quite fast in their opinion and their market competitiveness is growing gradually due to innovation.

*Transformation Impact*

The interviewee did not mention any specific measures of Dtrans that they know of, citing it as a management function. They mentioned a positive example of digitalized "compliance process of class vessels". *"They started to do this remote inspection of vessels so they don't have to send a surveyor to the ship to see what it does or to check its status. What they do now is they have a digital platform where they can survey the machine. So it has reduced costs for us and the vessel owner"*, they explained. They did not think of any harm digital initiatives have done, at least not directly. *"We are enjoying this transformation"*, they added saying that they comply with clients first before diving into it.

### Group 2: Digital Implementation

*Digital Technologies*

The interviewee claimed that they are using messenger apps for social relationships rather than professional with extensive mobile device usage. They own advanced analytics systems in their maritime standards and digital solutions departments. They have their own Dtwin system with cloud computing services, and they handle sensor systems (IoT) for their customers.

*Digital Business Strategy*

The participant claimed there is a strong, visible, and ambitious connection between the company's IT and business strategies. About implementation rate, they said: *"I would say there are two categories. One is if you consider stuff like analytics, machine learning, artificial intelligence or something that is pretty stable in the research and application domain. And something that is very innovative, that is a new thing that you're trying to develop, which doesn't exist anywhere else, then we take time to think about it. Then we take time to form the framework around in which we have to do that."* Even though the departments may not observe each other's solutions, they are developing new things according to the company's strategy.

*Digital Business Model*

The interviewee claimed that the product and service offerings have evolved since they joined the company. For instance, they mentioned their implemented data platform which integrated legacy systems. *"You know complete data value chain. This is just one example and our platform consists of more than 500 services. All of them are digitalized, which were in silos before sitting in different departments and organizational units"*, they explained. Moreover, they said their customer relationship has improved over time: *"Usually, improving communication and efficiency is a targeted value of digital transformation. Also, efficient workflows and less lead times."* Their innovation approach goes project-based or alternatively, it can cause a BM innovation through internal corporate programs or case competitions.

### Group 3: Digital Facilitation

*Multidisciplinary Collaboration*

The company has several departments and subdepartments. There is a hierarchy and the employees do not collaborate on a daily basis other than projects that requires so, according to the participant. However, they mentioned, *"It's an open organization - you can contact anyone, and you can reach out to anyone regarding anything you want."* The teams are not usually cross-functional except the digital solutions team where people from

other departments work with them. Some departments are traditionally independent, e.g., piping/pipeline-related work that requires specialized skills, according to interviewee G.

*Organizational Culture*

The management is involved in digitalization as far as the interviewee is concerned, and they claimed that the employees are very good at adopting technologies and using technologies in their work processes. They have not noticed any resistance to digital adoption from their side. "The organizational culture is pretty much aligned with this digital transformation culture", they said from the perspective of the digital solutions department of the company. They use digital tool from the smallest level to the biggest level, such as from individual idea generation with digital mind mapping to technological development projects. Yet, the interviewee acknowledged that it takes time to recognize and accept changes because they work with standards.

**Other insights**

*Existing Challenges*

According to the interviewee, some segregation between the departments exists at least to some degree. Furthermore, they claimed that the company rushed into AI regulations which they did not prepare for beforehand.

*Business Success of Digital Transformation*

The participant mentioned an ongoing project that translates to "digitalization of maintenance" which they hope will bring about reduced costs and labor. The interviewee recognized the importance of Dtrans in business success as well, saying, *"I think 60 to 70% - all of our acquisition, merger, and everything are related to the digital technologies or technological companies or so."*

## 4.2.8    Organization H

*Industry: Academia. Type of organization: University. Short description: Organization H is a public technological research university in the Netherlands.*

**Interviewee H:** The interviewee H is an assistant professor of Civil Engineering at a university in the Netherland. They have experience consulting with the construction industry stakeholders across Europe, but they refrained from answering any rating questions due to their no direct involvement in the industry.

**Group 1: Digital Consciousness**

*Digital Incentives*

"In the context of the construction industry, there are multiple stakeholders and it's a bit more complex," they said. These businesses are working with digital versions of physical assets. The owners are getting the chance to do predictive analysis in building operations, including energy management. Also, building information modeling (BIM) is used. *"It's about the product that they're delivering to the customers, so it's mostly done from the owner's perspective during the construction design phase,"* they commented.

The industry is also storing data of buildings and contracts in standardized (e.g., ISO) formats with increased online platform usage, they claimed. They also claimed that collaboration level among parties has increased due to digitalization.

*Transformation Impact*

Even though there are metrics for other areas (e.g., sustainability, quality), there is currently none for Dtrans, the interviewee said. They emphasized that some people in the industry simply lack the skills needed to realize or see the benefits of Dtrans, to some extent because of the fact that it might cause some initial delays in projects.

### Group 2: Digital Implementation

*Digital Technologies*

*"I think the most significant one so far has been the mobile devices. It has been percolating and there's a lot of collaboration changes that has come with instant messaging tools primarily"*, they remarked. Every business they have worked with have at least matured in this technology. Some construction businesses have gone a bit further and use apps and handheld tabs to record progress.

*Digital Business Strategy*

The interviewee claimed that businesses are starting to establish the link between IT and business and recruiting dedicated professionals in digital designations, especially since 2020. *"They are working together along with the product ecosystems"*, they said, even though business strategy is still dominating the scenario.

*Digital Business Model*

The interviewee claimed that the product and service offerings has changed for some companies due to digital technologies, enlarging their digital portfolios. However, about supplier and customer relationships, they said, *"I don't think there is a significant change in the relationship because it's mostly end product based."* But they believe that digital technology has improved assurance in larger projects. Also, digital project tracking tools have improved efficiency and made progress towards achieving circular economy goals. Digital dashboards are the only innovation they mentioned, while noting that their market adaptability is slower compared to other industries.

### Group 3: Digital Facilitation

*Multidisciplinary Collaboration*

The interviewee claimed that many companies still think emails and digital formats (e.g., PDF) are what all Dtrans is about. Yet they said, "In the design phase there are kind of like model-based collaboration currently and a little bit more in terms of like project management phases, a little bit more collaboration using tools such as Power BI to get insights." It also depends on how much integration there exists. *"If you ask whether collaboration is more or less, I'd say it remains almost the same. But what has changed is the visibility of the data, so it has become a bit more transparent process. So you get to understand or what has happened more efficiently"*, they opined.

*Organizational Culture*

About the organization culture, interviewee H claimed that it is dependent on the number of stakeholders as the hierarchy changes with the numbers involvement. For project management in construction, the decisions are made with the main contractors and people have to start partnering with each other once the project begins. Companies are also inclined to go digital with their everyday tasks, e.g., digital dashboards.

When asked about the digital vs old culture, they said, *"No, they still look back because construction is a very old discipline."* Also, the profit margin is very minute compared to other industries and the complexity is increasing. *"Since the complexity is increasing and a lot of stakeholders other, they cannot make a decision directly based on digital,"* they said.

### Other insights

*Existing Challenges*

According to the interviewee, currently it is not possible to correlate the competitiveness of the market with the level of digitalization (construction industry). Businesses are still behind when combining IT strategy with business strategy.

*Business Success of Digital Transformation*

According to the interviewee, there are many instances and case studies where digital transformation has brought benefits. Yet, it is only a part of the whole picture and, *"correlation doesn't mean causation"*.

## 4.2.9    Organization I

*Industry: IT. Type of organization: SaaS. Short description: Organization I provides IoT, business intelligence, and analytics services as comprehensive SaaS solutions for connectivity, control and optimalization of facilities.*

**Interviewee I:** The interviewee is the newly appointed CEO of organization I with a long background in other organizations.

### Group 1: Digital Consciousness

*Digital Incentives*

The interviewee claimed that the pandemic over the last 2-3 years has caused a digital boom in all of their business connections in Norway and abroad. *"First of all, we have a cloud solution where we of course store customer data related to their IoT infrastructure. "When it comes to internal processes, we have a CRM solution and a finance solution where we of course store customer information related to this. And of course, there are support tools,"* they explained. They further claimed that the market (IT) is quite "hot" right now, with tons of startups competing in the same space while energy costs and environmental concerns are growing.

*Transformation Impact*

There are no well-defined metrics for Dtrans, but customer side has benefited from it, according to the interviewee. *"I think one of the improvements is that I'm getting feedback from the customers that it's quite a lot clearer,"* they mentioned. Also, employees know their roles and responsibilities better. Furthermore, they are leading innovation: *"We are actually kind of in front of the wagon instead of constantly being chased by our customers. We are actually leading our customers instead of being chased by them,"* they emphasized.

### Group 2: Digital Implementation

*Digital Technologies*

About the use of Dtech, the interviewee said, *"We are a very proficient organization with digital, being an IT organization."* Every personnel is using mobile communications as they

are also developing apps for such devices. They also provide data analytics solutions which they have recently started working on. Cloud services with Industrial IoT (IIoT) is their specialized set of solutions for industrial purposes.

*Digital Business Strategy*

They claimed their business and IT strategy go hand in hand due to the technical nature of their business structure. They adopted modern ways of doing business such as growth hacking, customer interaction-based solutions, etc. as an integral part of their business. In terms of speed, they said they have to consider the existing BM and profitability, and therefore, it needs to be a cultural change. Thus, the transformation speed is "not too fast". Their internal stakeholders seems to be keen on implementing tools along with the cultural change within their strategy.

*Digital Business Model*

*"We are kind of like a core part of digitalizing our customers and they see us as kind of fundamental to their changes"*, interviewee I claimed. Due to their short tenure at organization I, they have not noticed any relationship changes on customer or supplier side. The company makes integrated solutions that can be operated by single personnel to control several different locations at the same time, bringing the value of efficiency. They are also consistently innovating with their own cloud technology as a platform company, introducing new services to customers. The platform itself is also continuously being maintained and improved. According to the interviewee, they are doing it both step by step as well as project-based. With their AI and machine vision tech and related innovation teams, they believe they are on the right path to react to market changes and challenges on the right time.

### Group 3: Digital Facilitation

*Multidisciplinary Collaboration*

The participant elaborated: "We reorganized the company when I joined implementing the typical structure of a source company. So with a development organization, a product management organization, customer success/sale and revenue operations, we are trying to kind of work interdisciplinary across these, since historically everybody was doing everything." Thus, they are collaborating by making necessary changes and clearly defined responsibilities in different areas with a tight set of interactions between processes. Development and PM have found their interests the fastest, and product development branch have been keen on working with the new structure and thus moved along quickly as well.

*Organizational Culture*

According to the interviewee, cultural changes take place over a long period of time. With a quite tech-savvy workforce, they have not noticed any resistance to adopt new tools among the employees. Management is actively encouraging them as well as testing out new tools for suitability. They are taking their time to drive the cultural change and developing interactive tools for the benefit of the customers.

### Other insights

*Existing Challenges*

According to the participant, the company is still finding its way into a more agile style of working. Although roles are more clearly defined now, old ownerships can be hard to give up. Even though slowly, the interviewee believes that we are going in the right direction.

*Business Success of Digital Transformation*

*"It's difficult to kind of pin it on digitalization. But if you look at the last couple of years of development, we have been a "gazelle" – one of the fastest-growing companies,"* they said. Then, they provided successful project examples (i.e., aquaculture, and building tech) with their implemented Dtech and software. Even though organization I had a difficult year in 2022, the interviewee believes that they are going to meet their budget this year (2023) and they have had close to 50% growth in 2023. *"Both digital transformation and modern business model are part of it",* they explained.

## 4.2.10    Organization J

*Industry: Architecture, Engineering and Construction (AEC). Type of organization: SaaS provider. Short description: Organization J is a startup in Norway providing Dtwin-related services to ensure a circular construction industry.*

**Interviewee J:** The interviewee J is the CTO of organization J involved in planning the technical development of solutions and software products. They also work with conceptual development and UX/UI for their solutions.

### *Group 1: Digital Consciousness*

*Digital Incentives*

Regarding customer behavior, they said they relied on the same digital technologies since startup. As the solutions are in early stages of development there are no numbers that could signify this. About the data issue, they explained, *"We have recently developed a backend system with a database that can store data from reuse mapping reports, photos and BIM objects for each material that are created on the basis of the information available. We are in dialog with other actors in the industry to coordinate and exchange data, but our data will remain unavailable until we have a fully functional system."*

According to the interviewee, the market of the recycling or reuse industry is relatively small and malleable, but only in the last couple of years several new companies have emerged. New technologies and tools for mapping on site and improved data templates have created competition among the digital markedplaces for reused materials. *"There is still no other actor who solves the issues in the way we do, taking it a step further by forwarding the materials as BIM objects to synchronized plugins for BIM software,"* they added.

*Transformation Impact*

According to the participant, measuring Dtrans will be an important aspect for the future during commercialization, but currently they are not there. They have plans for developing such measures, e.g., towards customers, this could relate to user mass and demographics (how many developers and architects/technical consultants), user activity (what type of materials, how many and when is it applied in the building process). They added, *"We have been involved in test and development projects where primitive versions of our system have been tested out and proved through feedback to be more efficient for architects when*

*it comes to evaluating available reuse materials and digitizing them for design application in the 3D model."*

### *Group 2: Digital Implementation:*

*Digital Technologies*

About the use of Dtech, the interviewee J said they are using messenger apps and Notion (planning) app for versatile uses. They have started using Azure Server System for cloud data management. There are working on their tech domains as they are growing their business as it is core to their BM.

*Digital Business Strategy*

*"The business and IT strategy is in our case very interconnected as it determines what kind of people we hire and who we can deliver our services to. That is because part of our services relates to providing plugins for already existing software,"* the interviewee remarked about their business and IT strategy. They further added, *"Our value propositions and visions are aiming to exactly cause digital transformation in how reused building components are distributed, conveyed and implemented in new building projects. We have a multidisciplinary Board of Members within the fields of sustainable architecture, business development, sales, marketing and technical development. In addition to this we are now about to invite several actors from the real estate and architecture industry to a Strategic Partnership to make sure that we are solving real problems for real customers when we develop our solutions."*

*Digital Business Model*

According to the participant, the company currently rely on the same digital technologies as always since its foundation. *"We are attractive to customers (developers and architects) because we provide new digital technologies to the market. These have remained the same since we started the company. We are currently not in active dialogue with suppliers"*, they explained. In their case digital marketplaces and external material owners outside the building projects will be the suppliers.

*"We make it easier for bigger real estate developers to manage and distribute their building mass of potential materials for reuse into new building projects"*, they said. The architect gets access to the developers inventory through a plugin to BIM (Building Information Modeling software), where they can search and model with the materials. Altogether this saves time and makes it easier for the project team to implement reused materials in large scale building projects, and eventually for the developer to save CO2 emissions. The company could in the future be a marketing channel for the suppliers of reused materials on the open market into the architects digital medium.

*"We innovate by challenging traditional conceptions through new digital solutions. We ensure the quality of the development we do by engaging in test projects for bigger clients (e.g., government agencies), conducting interviews with our intended customer base and by doing user testing. This will ultimately result in our own line of applications, web based and plugins for existing BIM software. Our company was created because the market specifically asked for new and improved solutions for managing and designing with reused materials. For that reason I strongly believe we will be adaptable towards changes also in the future"*, the interviewee explained their innovation policy.

### *Group 3: Digital Facilitation:*

*Multidisciplinary Collaboration*

The participant claimed that their structure is very horizontal and dynamic being an early-phase startup. *"Currently, we are four employees, all educated architects with different specializations and programming skills. We collaborate within several fields like business strategy, sales and client interaction and product development, but each of us have core responsibilities,"* they added. Since they are a small team, it is easy to prioritize and coordinate whenever needed.

*Organizational Culture*

The participant on their culture: *"We do not so much engage in the digital transformation ourselves within the organization, but provide this to our customers, being real estate firms and architectural offices. The first being users of our system for management of their material mass and ongoing building projects and the second being users of our design tools as consultants on behalf of the developer. Both are equally important in order for the system to work and provide value."* They claimed that their potential customers are very pleased with their prospects and they are inherently a tech-savvy team.

About technology, they explained, *"Certain digital technologies have been prioritized based on prior knowledge, user mass, online documentation and scalability. In this case digital technologies refer to programming tools and design software (BIM)."*

**Other insights**

*Existing Challenges*

As a young startup, organization J still needs to improve their infrastructure in some technological domains (e.g., data analytics).

*Business Success of Digital Transformation*

According to interviewee J, the startup has been operative for nearly two years with a steady revenue growth. They explained, *"For our case as early stage tech startup we have gradually gone from having fundings and scholarships as our income sources to projects. We are internally not at a stage where we can say that this is caused by digital transformation processes. We have not done any investments related to digital transformation ourselves."* The company is at a stage of growth as it is expanding to have all necessary competence in-house, and is preparing for an investment seed round. This will make it possibly to further develop its solutions for digital transformation at a higher pace.

## 4.3  Key Comments and Highlights on Digital Transformation

The interviewed persons indicated the significance of Dtrans that ranges across multiple organizational dimensions, including positive and negative effects. The noteworthy ones are compiled as the following direct quotes and/or interpretations with the respective participant codes in brackets.

- No universal metrics: Except for organization G which creates digital solutions and standards in-house, all other interviewed organizations (A, B, C, D, E, F, H, I, J) lack either clear data or separate record on the percentage of contribution of Dtrans in their organization growth or success due to underdeveloped KPIs or lack of initiative for creating such a framework altogether. Thus, whether a Dtrans effort is making or saving money needs to be connected to the respective business strategy

(A1). Impatience among the management team regarding Dtrans outcomes is also present (A2).

- Suboptimal cross-functional integration (A1, A2): Externally, it might be difficult to reach agreement with stakeholders, especially suppliers, regarding digitalization (A2).
- Reaction to change: *"People are naturally resistant to the change"* with the older people more prone to it (A2, E, F). *"Depending on the external organization, they may see the solution as being a threat or they may embrace and rely on our guidance or solutions"* (C).
- Means of communication: "*They only communicate digitally. So, I think that's another downside"* (B). On the other hand, when implemented properly, it improves supply and production processes and gains customer trust (D). The recent corona pandemic is likely to have influenced people and organizations to be more inclined to digital means of communication (F, H, I).
- Digitalization with specific goals: *"Purposeful digitalization"* (A1), i.e., having clear goals about process improvements and then set the digitalization strategy and plan accordingly. In reality, organizations might do the opposite: *"They're emphasizing on process and need. And then they go to the tool. But normally in this big data hype and digitalization, hype is done wrongly and opposite. People go and buy the tool or take big consultancy without having clear goals on it"* (A1).
- Higher efficiency and effectiveness in complex processes: "*You can see the efficiency – you can see improvements in execution of the works because they don't need to use any printing or paper"* (A1). *"Digitalization is an effective way to manage the complex aspects of your company – being it inventory or asset or whatever"* (A2). "*It will totally flip the game – today the digital tools are helping us, and tomorrow we'll be helping the digital tools"* (B)*.
- Improved handling of customer and supplier requirements: More efficient information exchange during project phases means improved customization (B).
- Improved logistics: Digital information management (Dtwin, BIM, CAD, etc.) can improve planning, work, and delivery more efficient both on customer and supplier sides (B), plus they might come with sustainability benefits (J).
- Data availability: All interviewed organizations store their relevant data, but many keep them in silos of databases which they are either working on connecting or need to connect globally across their organizations for a more fluid experience (A1, A2, F). Data is also difficult to handle and control (D), even when managed by a partially/wholly-owned partner company (E).
- Data technology as a key enabler of organizational improvement: Proper data management creates the foundation for effective business analytics and communication (A2). *"People and technology are mutually required for success"* (C).

## 4.4 Rating Interviewed Organizations on Digital CSF and Success

Based on the findings from Osmundsen et al. (2018) and Morakanyane et al. (2020), the seven CSFs laid the foundation of the interview questionnaire formation as discussed in the . The answers from the interviews were analyzed to rate the organizational Dtrans

CSFs between 1 to 5 with an increment of 0.5 (used whenever hinted by any interviewee). The scoring degree scale is showed and explained in table 21 for understanding the level of performance of a particular organization in the criteria.

**Table 21. Explanation of the rating system in the interview questionnaire analysis**

| Rating | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Degree | Very Low | Low | Moderate | High | Very High |
| Brief Explanation | The organization has not advanced in this area and/or has not made any plans. | The organization is progressing in this area and/or has made such plans. | The organization is in the middle-of-the-road on its quest of maturity in this area. | The organization is maturing and planning to expand further in this area. | The organization is matured in this area and competitive in the respective market. |

Among the 11 interviews, 10 of them provided relevant information that made them eligible for rating across the seven CSFs selected for interview questionnaire formation. The only exception is the university professor (organization H) whose experience inherently does not relate to business success. That is why they refrained from rating any question. It is worth mentioning that even though Organization D is a university, the interviewee spoke from their previous experience in IT and digitalization consultancy. Therefore, they rated the questions based on it. Organization A had two participants whose average ratings have been taken into consideration. The seven CSFs identified and their associated breakdown of ratings based on the interview answers are presented in table 22. The CSF ratings are the mean values of the criteria constituting the CSFs.

**Table 22. Arrangement of ratings or scores per interviewed organization**

| Critical Success Factor (CSF) Criteria for Organizational Digital Transformation | | Interviewed Personnel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A1, A2 | B | C | D | E | F | G | I | J |
| CSF 1: Utilization of Digital Technologies (SMACIT) | Social | 5, 5 | 5 | 5 | 4 | 4 | 4 | 3.5 | 4 | 4 |
| | Mobile | 5, 5 | 5 | 5 | 5 | 3 | 2 | 5 | 5 | 2 |
| | Analytics | 2, 4 | 1 | 5 | 4 | 4 | 3 | 4 | 2 | 1 |
| | Cloud | 3, 5 | 1 | 5 | 4 | 3 | 3 | 5 | 5 | 3 |
| | IoT | 3, 4 | 2 | 1 | 3 | 4 | 2 | 5 | 5 | 1 |
| **CSF 1 Ratings** | | **4.1** | **2.8** | **4.2** | **4** | **3.6** | **2.8** | **4.5** | **4.2** | **2.2** |
| CSF 2: Digital Incentives | Customer behavior progression | 1, 2 | 4 | 3 | 3.5 | 3 | 3 | 4 | 5 | 1 |
| | Data availability | 3, 3 | 5 | 5 | 3 | 1 | 3 | 4 | 4 | 3 |
| | Market competitiveness | 2, 2 | 3.5 | 4 | 2 | 3 | 3 | 3 | 5 | 4 |
| **CSF 2 Ratings** | | **2.167** | **4.167** | **4** | **2.83** | **2.33** | **3** | **3.67** | **4.67** | **2.67** |

**Table 22. Arrangement of ratings or scores per interviewed organization (continued)**

| Critical Success Factor (CSF) Criteria for Organizational Digital Transformation | | Interviewed Personnel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A1, A2 | B | C | D | E | F | G | I | J |
| CSF 3: Digital Business Strategy | Placement of IT & business strategy | 4, 3 | 4 | 5 | 1 | 4 | 4 | 5 | 5 | 5 |
| | Dtrans implementation speed | 3, 4 | 5 | 3 | 3 | 5 | 4 | 4 | 3 | 3 |
| | Allocation of resources for Dtrans purposes | 4, 4 | 3.5 | 5 | 3 | 5 | 2 | 3 | 4 | 4 |
| | Management of transformation | 3, 4 | 3 | 4 | 3 | 4 | 2 | 3 | 3.5 | 3 |
| **CSF 3 Ratings** | | **3.625** | **3.875** | **4.25** | **2.5** | **4.5** | **2.75** | **3.75** | **3.875** | **3.75** |
| CSF 4: Digital Business Model | Novel value propositions (product /service) | 3, 3 | 3.5 | 4 | 3 | 3 | 1 | 4 | 5 | 5 |
| | Novel value networks | 3, 3 | 4 | 5 | 3 | 3 | 1 | 3 | 4 | 3 |
| | Innovation | 3, 4 | 4 | 5 | 2 | 4 | 2 | 2 | 5 | 4 |
| **CSF 4 Ratings** | | **3.167** | **3.833** | **4.67** | **2.67** | **3.33** | **1.33** | **3** | **4.67** | **4** |
| CSF 5: Multidisciplinary Collaboration | Agile organizational structure | 5, 2 | 1 | 5 | 4 | 4 | 3 | 4 | 4 | 4 |
| | Diversified functions/teams | 4, 3 | 2 | 4 | 4 | 4 | 2 | 3 | 2 | 4 |
| **CSF 5 Ratings** | | **3.5** | **1.5** | **4.5** | **4** | **4** | **2.5** | **3.5** | **3** | **4** |
| CSF 6: Favorable Organizational Culture | Employee involvement | 4, 4 | 2 | 5 | 4 | 4 | 3 | 4.5 | 2 | 3 |
| | Management involvement | 3, 4 | 4 | 5 | 3.5 | 4 | 3 | 4.5 | 4 | 3 |
| | Employee digital attitude | 5, 3 | 2 | 5 | 4 | 4 | 2 | 4.5 | 5 | 5 |
| | Aligning tech adoption with preexisting culture | 5, 3 | 5 | 5 | 2 | 1 | 3 | 5 | 2 | 1 |
| **CSF 6 Ratings** | | **3.875** | **3.25** | **5** | **3.375** | **3.25** | **2.75** | **4.63** | **3.25** | **3** |
| CSF 7: Identify Transformation Impact | Internal impact | 4, 4 | 3 | 5 | 3 | 4 | 3 | 4 | 4 | 2 |
| | External impact | 2.5, 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 2 |
| | Detect transformation Impact regions | 4, 4 | 2 | 4 | 1 | 3 | 2 | 2 | 1 | 2 |
| **CSF 7 Ratings** | | **3.583** | **2.67** | **4** | **2.33** | **3.67** | **3** | **3.33** | **3** | **2** |
| Business Success | Dtrans ROI | 3.5, 4 | 4 | 5 | 3.5 | 3 | 3 | 3 | 4 | 2 |
| | Firm growth | 2, 2 | 3.5 | 5 | 3.5 | 3 | 1 | 4 | 4 | 2 |
| **Perceived Dtrans Success Rating** | | **2.875** | **3.75** | **5** | **3.5** | **3** | **2** | **3.5** | **4** | **2** |

The overview of CSF and perceived Dtrans success ratings of the organizations in the table above are visualized and summarized below.

**CSF 1: Digital Technologies**

## Digital Technology
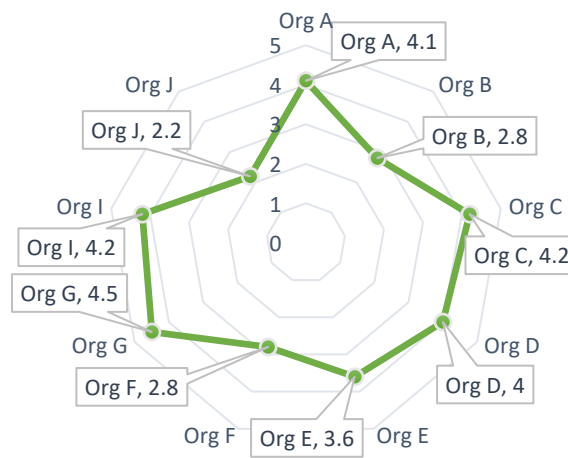


**Figure 25. Radar chart depicting Dtech utilization rating per organization**

The above figure shows **Organization G** performed the best on the "Utilization of Digital Technologies" (SMACIT), mainly due to being extensive uses of Dtech across their business. On the other hand, **Organization J** performed the lowest because of their startup scenario still lacks the adoption of all Dtech under discussion.

**CSF 2: Digital Incentives**

## Digital Incentives
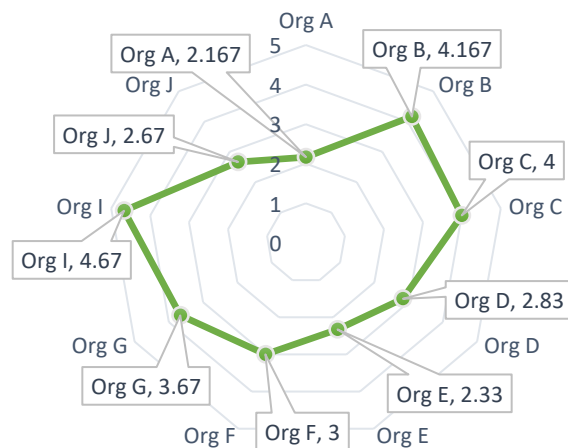


**Figure 26. Radar chart depicting digital incentives rating per organization**

The above figure shows **Organization I** ranked the highest on incentivizing its personnel to adopt digital means. Being a software provider, they are completely reliant on digital means which explains it. On the other hand, **Organization A** ranked the lowest as it belongs to the traditional metallurgy industry where processes are not as digitalized compared to younger industries like software.

**CSF 3: Digital Business Strategy**
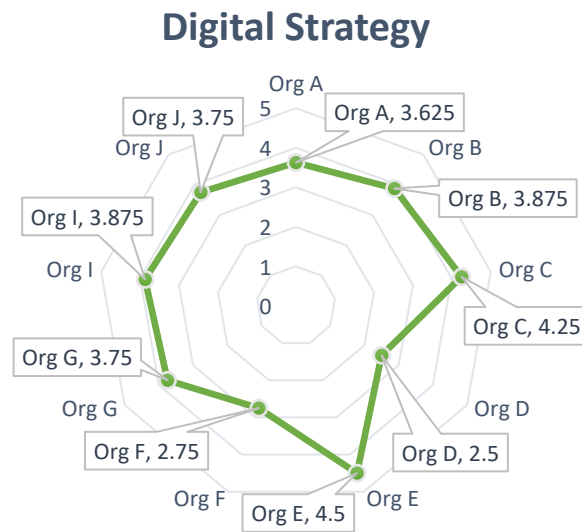
## Digital Strategy



**Figure 27. Radar chart depicting digital business strategy development rating per organization**

The above figure shows **Organization E** scored the highest in setting a digital strategy as they need to provide digital and physical assets and solutions to their customers.  On the other hand, **Organization D,** from the perspective of the construction industry, scored the lowest as traditional ties run deep in the industry.

**CSF 4: Digital Business Model**

## Digital Business Model



**Figure 28. Radar chart depicting digital BM development rating per organization**

The above figure shows **Organization C and I both** ranked the highest on developing a proper digital BM because they are both software and/or analytics-oriented firms with inborn digital plans. On the other hand, being a conventional B2B business, **Organization F** ranked the lowest as they are less reliant to digitalization models than modernized firms.

81

**CSF 5: Multidisciplinary Collaboration**

## Multidisciplinary Collaboration
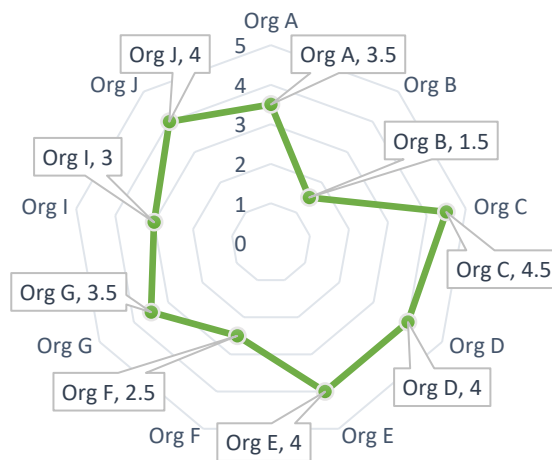


**Figure 29. Radar chart depicting multidisciplinary collaboration rating per organization**

The above figure shows **Organization C** excelled at cooperating within its different functions. On the other hand, **Organization B** ranked the lowest as they are yet to venture into such dimensions due to being a company run by two persons currently.

**CSF 6: Favorable Organizational Culture**

## Organizational Culture
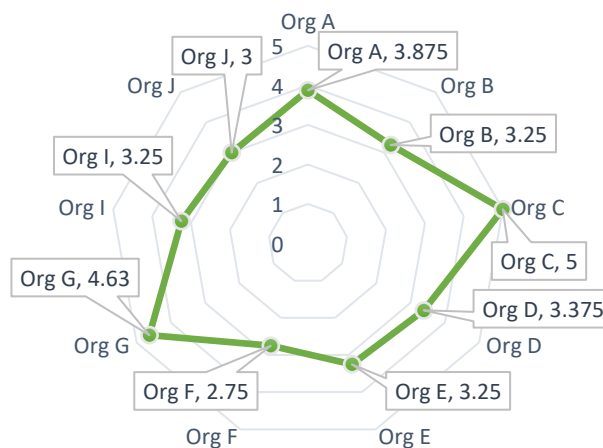


**Figure 30. Radar chart depicting favorable organizational culture rating per organization**

The above figure shows **Organization C** apparently excels in cultivating a all-round digital culture due to their technical nature. On the other hand, **Organization F** lags behind the ratings due to their conventional work culture.

**CSF 7: Identify Transformation Impact**
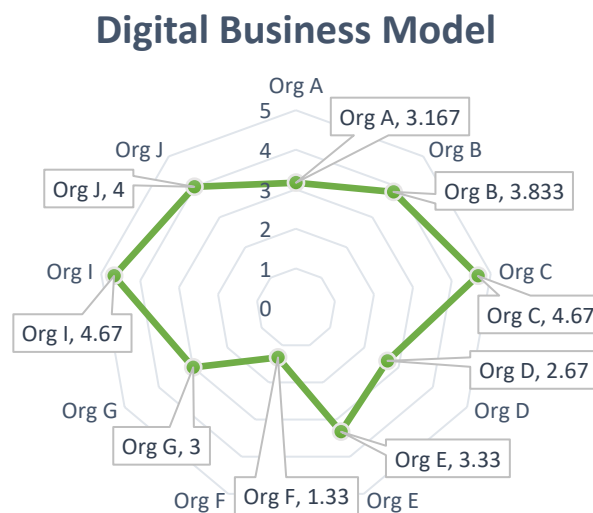
## Transformation Impact
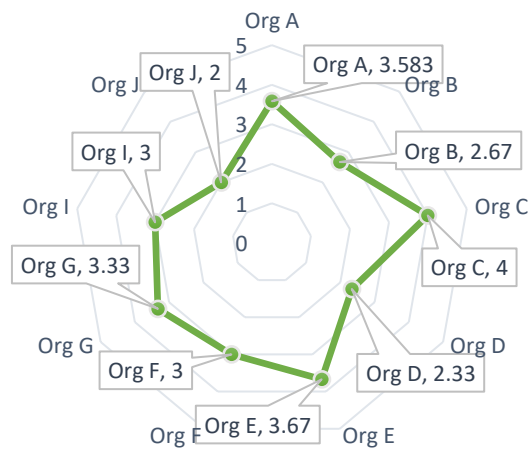


**Figure 31. Radar chart depicting Dtrans impact detection rating per organization**

The above figure shows **Organization C** ranked the highest on detecting their transformational impact as they are extensively reliant on Dtech for measuring their processes. On the other hand, **Organization J** ranked the lowest as their initial stage of business do not any any measures whatsoever, but they have plans to do so.

**Perceived Digital Business Success of Interviewed Organizations**

## Perceived Digital Success
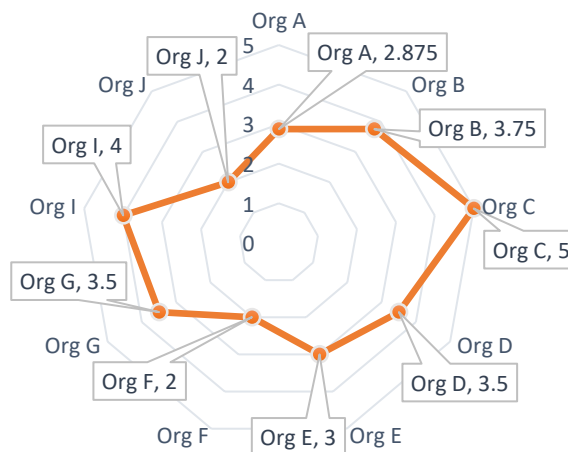


**Figure 32. Radar chart of total perceived Dtrans success ratings of the interviewed organizations**

Based on the two parameters, digital ROI and firm growth, a perceived success rating was generated for each organization as given in table 22. **Organization C** got the highest rating on perceived Dtrans success which can be attributed to their digitally transformed business since startup, yielding benefits for all the parties involved. On the other hand, **organization F and J** performed the lowest. For organization J being an early-phase startup, it is yet unknown whether they will improve. For organization F, it is due to the

market conditions (i.e., grocery industry) that delimit their innovation and digitalization capacities.

## 4.5   Financial Performance of the Organizations

Financial performance, specifically the revenue data of the organizations interviewed, was searched in their annual reports available in the websites of the respective organizations. Whenever annual reports unavailable, publicly available financial information sites (e.g., Yahoo Finance, Google Finance, MSN Money) were search for relevant data that contain financial information of publicly traded companies. For Norwegian organizations, Proff, a utility service for the Norwegian business sector, was used that provides up-to-date in-depth information about Norwegian companies (https://www.proff.no/). The exempted are organizations D and H due to being not for profit, B and J for being early-stage startups, and C for data unavailability. After searching for the revenue data for the most recent five fiscal years, it was found between 2017 – 2022. It is presented in figure 33.
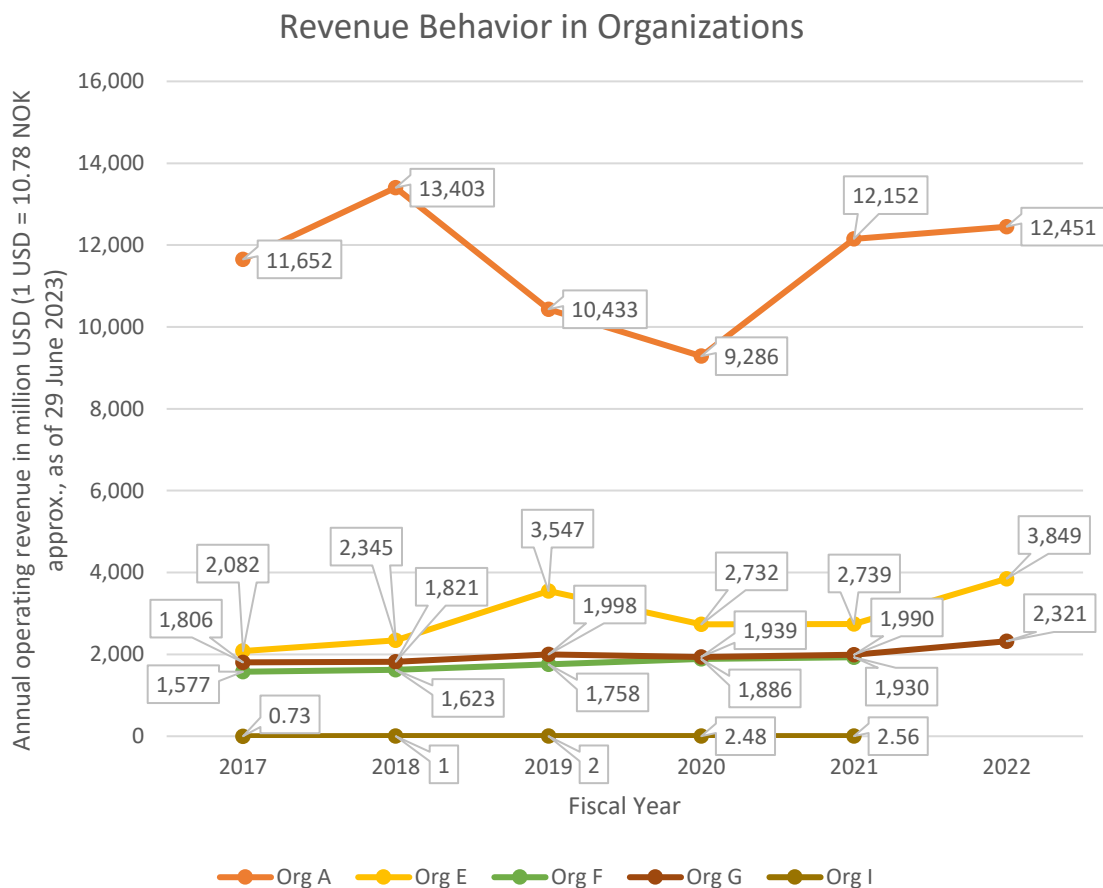


**Figure 33. Revenue performance trends of interviewed organizations over 5-6 most recent available fiscal years (Organization A, E, F, G, I)**

The following observations and comments are mentionable about the chart:

- The graphical presentation reveals that the claims made by the interview participants of Organization A, E, E, F, G, I aligned with what the financial data portrayed.
- The revenue curve of organization I (an IT firm) is showing steady growth over the years, which is well-aligned with the claim of the interviewee.

- During the pandemic in 2020, Organizations A, E, G took a slump in their revenues compared to the previous year, but organizations F and I continued to grow.
- According the 2022 annual report of organization G, they own an independent digital cloud platform that has gained market share over the last five years. It states that their revenue went up 11.5% from the previous year with USD 116 million contribution – courtesy of new digital solutions.

No official financial data dedicated to digital activities were found for other organizations, nonetheless.

# 5 Discussion

The primary objective of this research study was to find the answers to the RQs posed in the introduction by means of a literature review and a set of professional interviews. This section discusses all the observable findings combining both sources of information. Any opinions disclosed by the interviewees are indicated by their participant/organization codes in parentheses.

## 5.1 Digital Transformation Success Factors

The main RQ along with RQ1 asked about the possible means that make Dtrans successful and impactful. The literature review identified ten categories of success factors of Dtrans that included both human and infrastural elements (Saihi et al., 2023). Furthermore, the CSF given by Osmundsen (2018) and Morakanyane (2020) was combined with the framework given by Vial (2019) to formulate the interview questions as discussed earlier. In figure 34, an aggregate or cumulative CSF ratings of all the interviewed organizations have been visualized in a stacked bar chart. As seen from table 22, organization C performed the best among them due to their digital nature of business. Organization F performed the lowest due to their conventionalism in business.
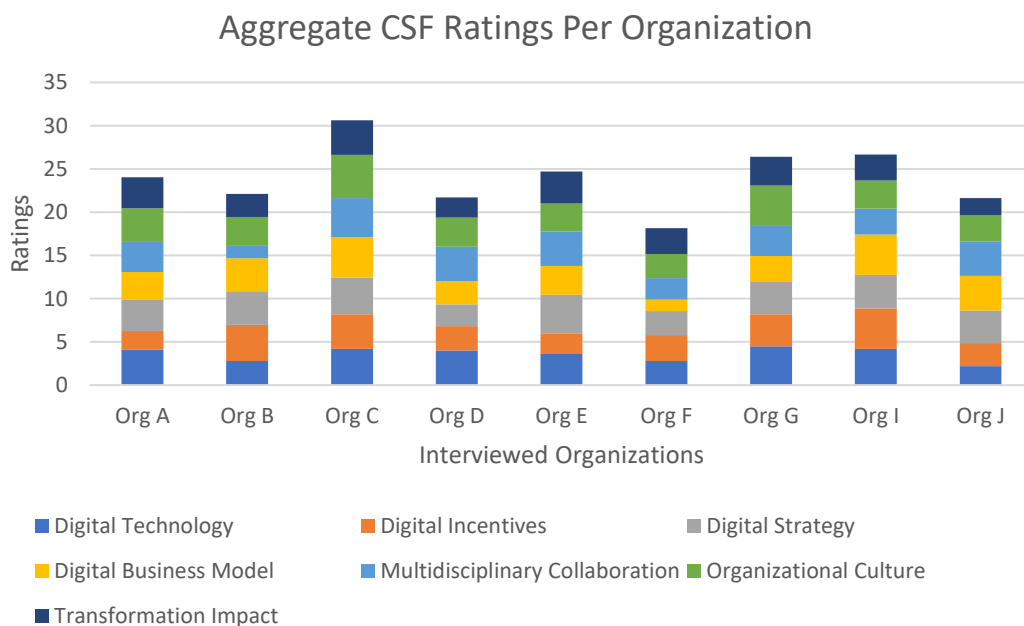


**Figure 34. Stacked chart showing aggregate Dtrans CSF scores of the interviewed organizations**

Also, the aggregate perceived digital success ratings of those organizations have been visualized in figure 35. As the interview questions inquired about Dtrans investments and firm growth, the interviewees provided their perceptions as ratings. Again, organization C tops with the highest cumulative rating, while organization F scores the lowest due to lack of initiatives. Organization J is scoring equally low due to their current early startup phase. These figures reveals the growing importance of Dtrans management in general.
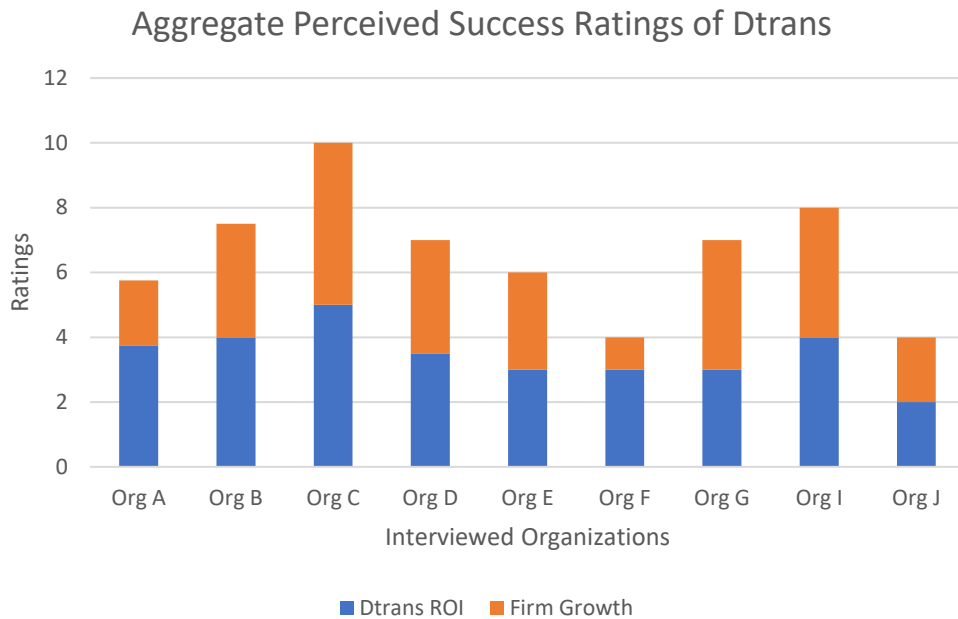
Figure 35. Stacked chart showing aggregate perceived success scores of Dtrans based on digital ROI and perceived growth of the interviewed organizations

Data integration was found to be a critical reason for digital success (Vogelsang et al., 2019, Cichosz et al., 2020) which is well-aligned with the opinions of some the interviewees (A1, D). Such integration of data silos is a apparently a dominant problem in organizations (A1, A2, F). Meanwhile data is hard to manage and control (D), especially in the age of AI innovation and regulations that are hard to anticipate (G). Furthermore, it is notable that organizations with relatively higher perceived digital success ratings (figure 34 and figure 35) have either a solid foundation in digitalization or they adopted digital means from the very beginning of their journeys.

For older organizations, high initial transition time to digital solutions might also be discouraging for Dtrans undertakings (H). Employees might feel threatened if external and/or digitalization efforts from the top management are imposed, and they consequently might focus on productivity rather than getting accustomed to digital means (A1). Hence, leaders need to help employees to minimize resistance to changes (A1). Furthermore, it is important to consider the organizational culture that predates the digitalization because it seems to have a psychosocial impact on the employee and management behaviors which tend to struggle with changing dynamics (A2, B). Dtrans is therefore further considered as technological as it is cultural (A2, I). Thus, managers to think and act differently from usual or traditional practices to improve Dtrans control (F).

People and technology are interdependent and must be mutually cooperative to achieve desired outcomes (C). Thus, any change must be treated as an organizational change as much as a technology change (D). For this reason, companies should not ignore their core existing cultures (D).

## 5.2   Measuring Digital Transformation Progress

The RQ1 further delved into the measures and progress of Dtrans of organizations. Researchers have suggested to measure it across dimensions like strategic necessities, opportunities, assets, capacities, culture, and value chains (Roos and Nilsson, 2020,

Weiner, 2009, Machado et al., 2019b, Hermann et al., 2019, Kane et al., 2018, Combe, 2014, De Sousa Jabbour et al., 2018, Pessot et al., 2020, Colli et al., 2018, Ghobakloo, 2018, Pirola et al., 2019). Yet, Dtrans measures are deprived of standardization (Machado et al., 2021).

From the interviews, it is worth noting that not all organizations across the industries (IT, universities, construction, consulting) are involved in Dtrans on an equal basis, nor can they be measured with the same metrics. Table 23 categorizes the interviewed organizations based the interpreted digital readiness parameters identified from the literature (table 14), which have been evaluated in terms of the perceived CSFs ratings (table 22). The observed average of the CSFs related a readiness parameter has been considered to rate it within low, medium, or high. Organization C ranks high overall across the seven parameters due to being a digital-born organization offering high-level analytical products and services.

**Table 23. Linking the digital readiness or maturity parameters from literature (table 14) with the interviewed organizations' observed CSF performance levels (table 22)**

| Digital Readiness or Maturity Parameters | Related CSF | Readiness/Maturity Level of Organizations (A, B, C, D, E, F, G, I and J) | | |
|---|---|---|---|---|
| | | *Low* | *Medium* | *High* |
| 1. Identify strategic necessities | CSF3, CSF4, CSF1 | D, F | A, G, J | B, C, E, I |
| 2. Locate threats and opportunities | CSF2, CSF7, CSF4 | A, D, E, J | B, F, G | C, I |
| 3. Determine assets, capacities, and expertise | CSF1, CSF3 | B, J, F | A, D, E | C, G, I |
| 4. Facilitate leadership and interdisciplinarity | CSF3, CSF5 | B, F | A, G, I | C, D, E, J |
| 5. Set the vision, objectives, and strategy | CSF3, CSF4 | D, F, J | A, B, G | C, E, I |
| 6. Advocate and empower transparent communication | CSF6, CSF3 | F, J | B, D, E, I | A, C, G |
| 7. Evaluate Dtrans progress (KPIs) | CSF7 | B, D, J | F, G, I | A, C, E |
| 8. Ensure digital knowledge management systems | CSF3, CSF2 | A, E | D, F, G, J | B, C, I |
| 9. Enable autonomy for stakeholders | CSF4, CSF5 | B, F | A, G, I | C, D, E, J |
| 10. Accelerate the Dtrans process | CSF7, CSF6 | D, B | A, E, F, G | C, I, J |

Most interviewees recognized Dtrans or digitalization is positively correlated with organizational efficiency (A1, A2, B, C, D, H, I). Even though the recent revenue trends (figure 33) matched with the claims of the interviewees, there is no way to attribute it to Dtrans without proper measures. Only one possible KPI was mentioned by the interviewees (A2) that might relate to Dtrans, and that is, supplier on-time delivery monitoring via digital means. It validates the claim of KPI deficit and this particular metric is merely relatable to logistics. Besides, lack of any particular digital vision, clear data or idea on the percentage of contribution of Dtrans in their organization growth or success due to underdeveloped KPIs, or lack of initiative for creating such a framework altogether were identifiable in some organizations (A1, H).

A compilation of possible KPIs for a customer-oriented digital business has been suggested based on the findings from the reviewed literature in figure 36. It provides the measures along the four dimensions introduced by Kaplan and Norton (Kaplan and David, 1992).
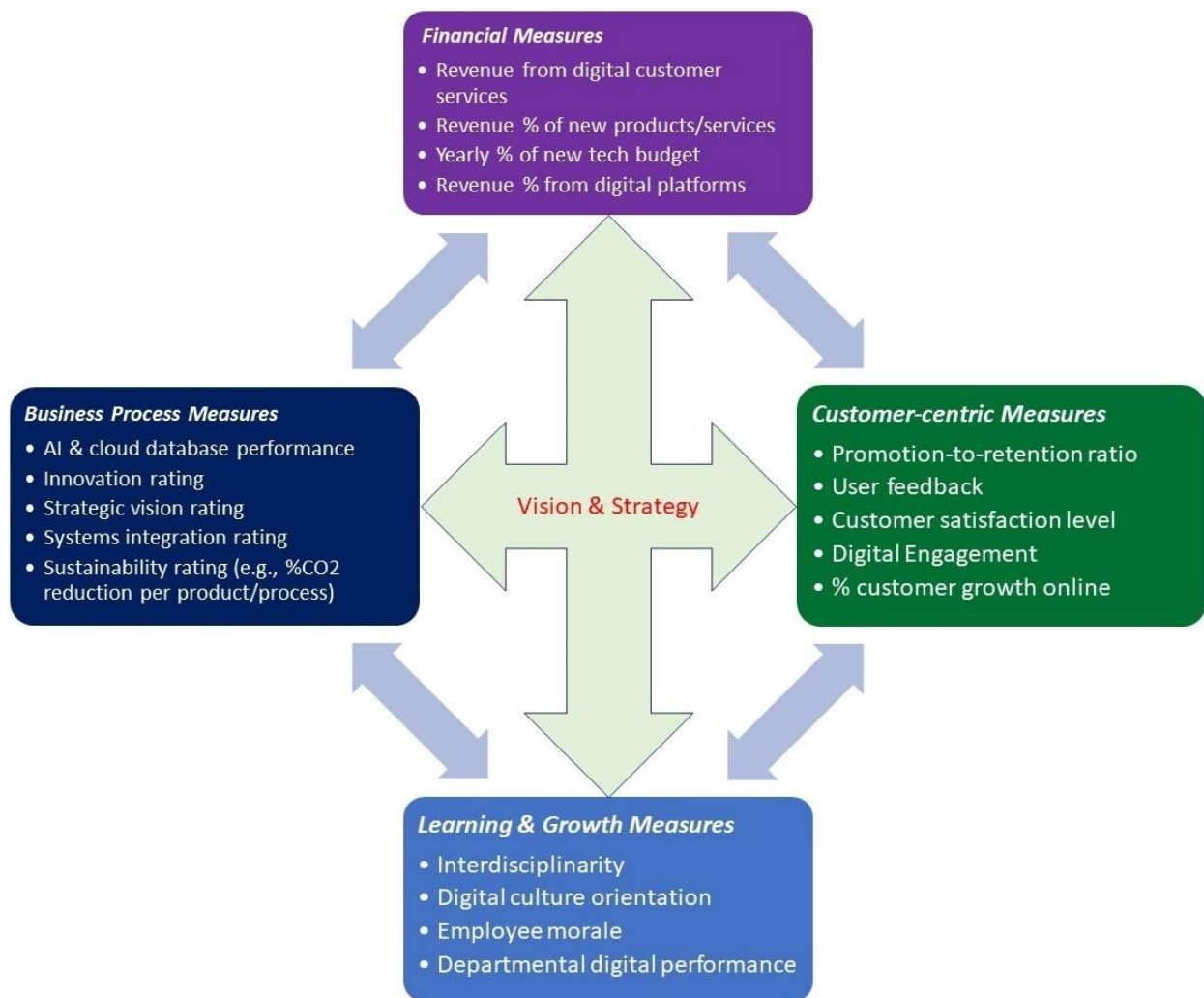
**Figure 36. Balanced Scorecard with suggested KPIs for measuring organizational digital performance. Source: own creation inspired by literature review and Kaplan and Norton's (1992).**

## 5.3  Digital Business Model

The RQ2 basically queried how BM and Dtrans impact each other along the value chain system. From the literature review, it is clear that the value creation part is the most extensive and resource-intensive as it is the driver of any BM that leads desired outcomes (table 15). It can be mainly attributed to its capacity building, transition management, and compliances with customer and legislative requirements (Zheng et al., 2019, Müller et al., 2018, Wang et al., 2016, Liao et al., 2017, Kiel et al., 2017, Hahn, 2020, Kagermann et al., 2013, Birkel et al., 2019, Dean and Spoehr, 2018, Schneider, 2018, Dalenogare et al., 2018, Frank et al., 2019, Lenka et al., 2017, Gauthier et al., 2018, Warner and Wäger, 2019, Oesterreich and Teuteberg, 2016, Hasselblatt et al., 2018, Vendrell-Herrero et al., 2018, Camarinha-Matos et al., 2019, Horvath and Szabo, 2019).

The interrelation of BM with SC and logistics from the literature review revealed that necessary collaborations (Camarinha-Matos et al., 2019, Horvath and Szabo, 2019), technological management with innovation (Belhadi et al, 2021), and entrepreneurial nourishment (Sundaram et al., 2020) remain at the core of SC and logistics digitalization. On the negative side, it might be worth noting that the literature on digital BM reveals multidimensional challenges that comes with Dtrans as well (e.g., knowledge and

integration gap, increasing complexities, etc.) (Schneider, 2018, Vendrell-Herrero et al., 2018, Kiel et al., 2017) that needs to be addressed.

From the organizational interviews, it was noted that paradigm shifts in businesses might happen due to digitalization, such as shifting core focus from traditional operations to more digital services (E). Virtually all interviewees recognized that innovation happens through emerging needs, projects, or through both. Proper digitalization improves production efficiency and customer trust. That includes connecting distributed information on common platforms which is a difficult task due to inexperience among companies (D).

Based on the literature review of BM and its value networks, a suggested framework of Dtrans of BM has been created and presented in figure 37. It suggests how an organization can propose, create, capture and deliver value to its stakeholders in its technological transformational stages (i.e., digitization, digitalization, and Dtrans).
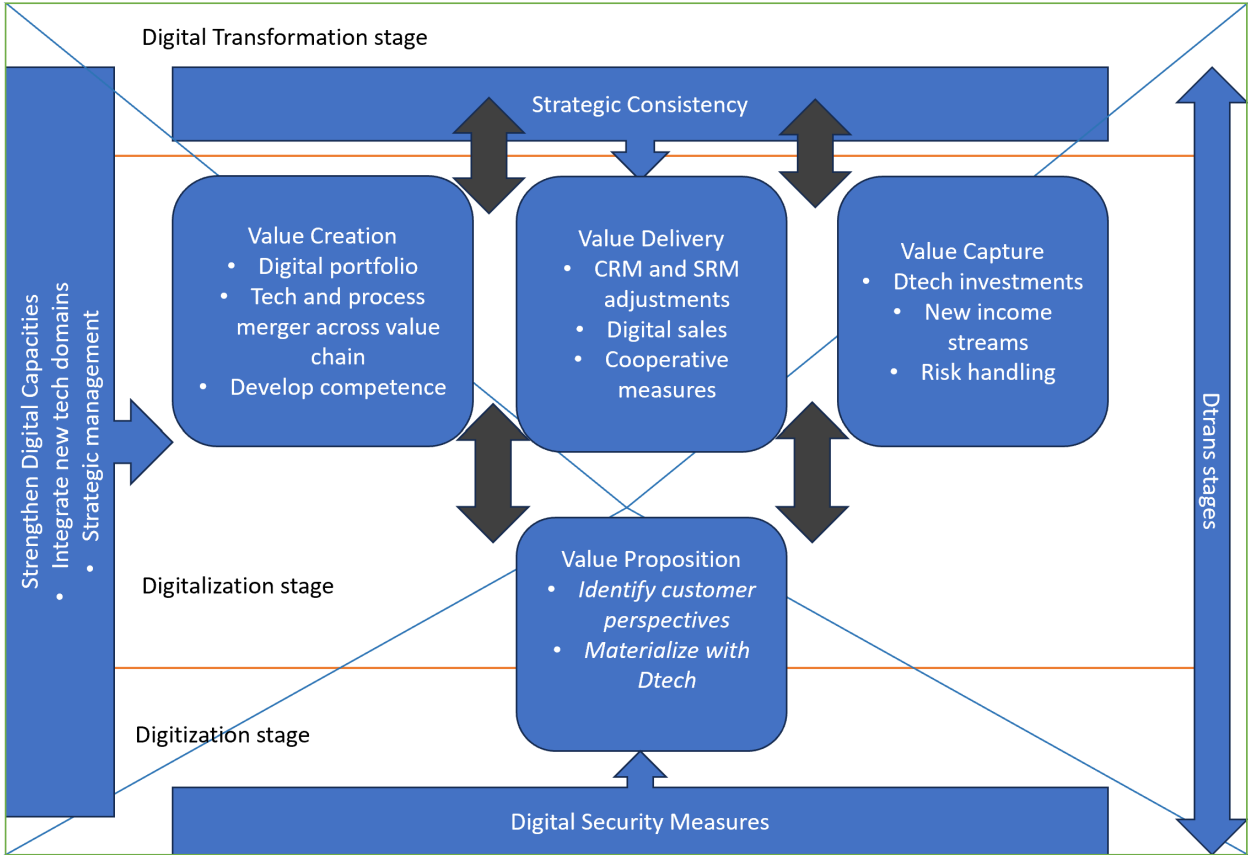


**Figure 37. A possible Dtrans of a BM with the interrelated value dimensions. Source: own creation inspired by literature review (table 15) and interviews.**

## 5.4  Supply Chain and Logistics Challenges

The RQ3 inquired which obstacles are mentioned in the literature of SC and logistics management. Lack of best management practices as well as human resource deficiencies can harm organizations (Ageron et al., 2020, Manzouri et al., 2010, Kim and Nguyen ,2022, Kim and Nguyen, 2022, Stewart et al., 2016, Narayanan et al., 2018, Khan and Qianli, 2017, Govindan et al., 2014, Neri et al., 2018, Alzawawi, 2014). Moreover, infrastructural and cultural issues are found to be present in organizations that are involved in SC and logistics management (Stewart et al., 2016, De Jesus and Mendonça, 2018, Narayanan et al., 2018). Externally, non-favorable governmental policies without incentives and

disruptive market situations can negatively impact organizations and their value chains (AlSanad, 2018, Hussain et al., 2018, Govindan et al., 2014).

On top of that, lack of visibility in SC is found as a major problem as causes demand and supply gaps which is propagated by suboptimal IT infrastructure integration and resource management (Manzouri et al., 2010, Kazancoglu et al., 2020, Stewart et al. ,2016, Gupta and Barua, 2018, De Jesus and Mendonça, 2018). In the same tune, possible SC coordination problems due to variations between global and regional metrics was mentioned by one of the interviewees (A2).

Figure 38 shows a depiction of the major SC and logistics obstacles categories identified from literature and interviews.
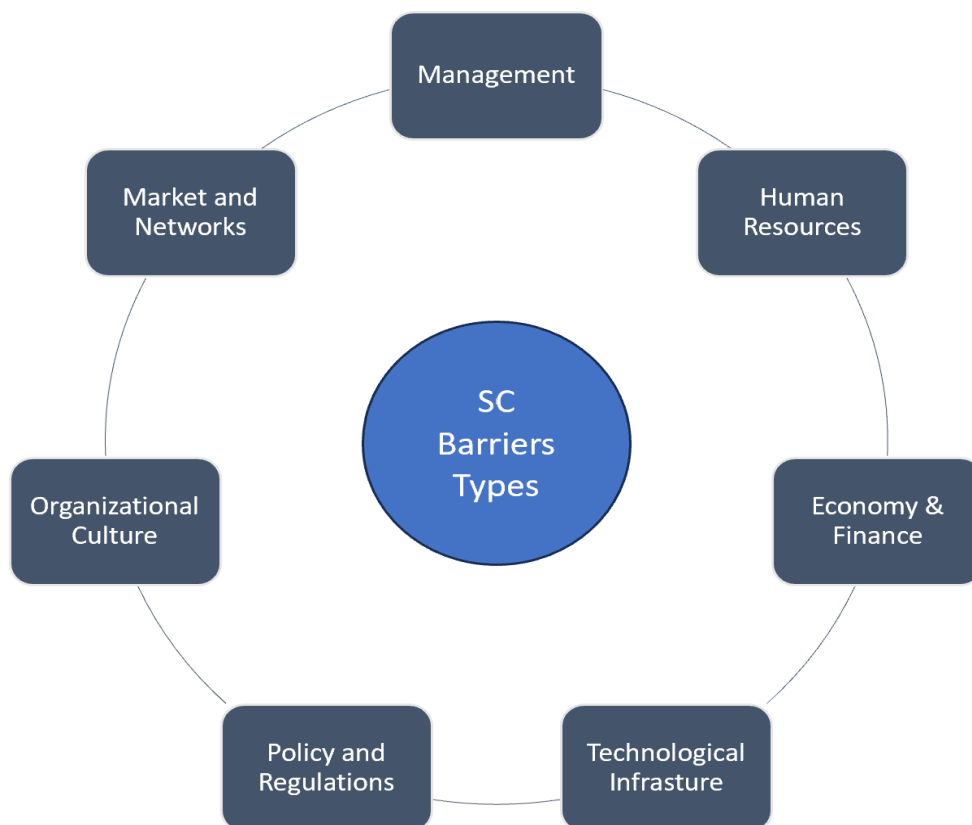


**Figure 38. Model showing major categories of SC and logistics barriers. Source: own creation based on literature (table 16) and interview findings.**

## 5.5   The Role of Digital Technologies and Digital Twin

Going further with the pursuit of answering RQ3, the literature search showed many existing and potential uses of Dtech and Dtwin in improving SC and overcoming its challenges. Dtech like blockchain and cloud computing are enabling a myriad of fast and efficient services to suppliers and customers alike (Gupta, 2017). These are minimizing SC disruptions and saving money for the stakeholders along the value chains. Moreover, the use of data analytics combined with RFID and IoT is helping companies track their parameters better (Gölzer & Fritzsche, 2017, Pettey, 2019, Attaran, 2020). AR/VR is changing customer behavior and influencing the subsequent SC (Ageron et al., 2020, Attaran, 2020).

The identified literature and the interviews (Organization D, G, J actively using Dtwin) link the possibilities of Dtwin in overcoming barriers and challenges in SC and logistics management. Dtwins are effective in increasing SC resilience by increasing transparency and hence improving synchronization across levels. Real-time material flow becomes easier to visualize and implement with the aid of analytics as the information gap reduces, reducing the bullwhip effect (Barykin et al., 2021).

Furthermore, when supplied with the correct data and processed by sophisticated AI tools and algorithms, Dtwin appears to have a great potential for replacing and/or adding to human decision-making (Chen and Huang, 2021, Park et al., 2020). Additionally, Dtwin has a notable effect on SC visibility (Moshood et al., 2021). These can provide considerable risk reduction opportunities in logistics and SC, enhancing stakeholder satisfaction across all SC echelons and providing avenues to innovation in previously inaccessible regions. The interviewees hinted the advantage of SC resiliency with such services (A1, A2).

Nonetheless, it should be noted that some challenges exist regarding the implementation of Dtwin. The literature identified several cultural and technical challenges in the implementation of DX, including knowledge transfer, accurate representation of physical copies, data reliability from numerous sensors, high setup costs, digital security, and reliance on external technology providers (Moshood et al., 2021). Yet, it has a high potential in achieving SC resilience and efficiency in order to meet the growing demands and subsequent challenges in the future (Simchenko et al., 2020).

A three-pillar digital SC achievement scheme has been suggested in figure 39 based on the findings.
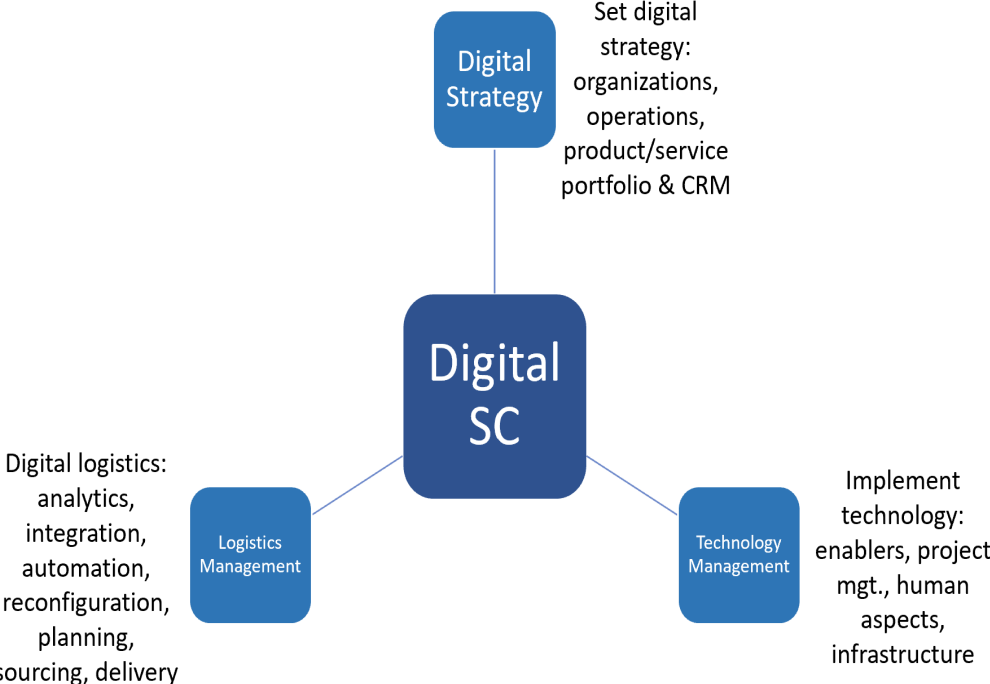


**Figure 39. A triangular foundation of a digital SC management scheme. Source: own creation based on literature review.**

## 5.6 Digital Transformation: Implications for Project Management

The intention of this research was to study the effects of Dtrans and establish connections with BM, SC and Dtech. Nonetheless, RQ1 also indicated the perspective of PM from the angle of Dtrans. PM is an effective means to an organization's strategic end (Zwikael and Smyrk, 2019), and therefore a strategic move like Dtrans naturally involves project-based approaches with strategic resource allocation (Osmundsen, 2018, Morakanyane, 2020). It is suggested by both literature and interviews conducted (organization E, G). Moreover, digital project tracking tools have improved efficiency and made progress towards achieving circular economy goals (H). New technologies for mapping and data templates have increased competition in the recycling/reuse of materials in the construction industry (J), improving the dynamics of its growing reverse logistics.

From the interviews and literature study, it is clear that Dtrans is about organizational as well as a technical changes that entail change of infrastructure, mindset and behavior. More IT and business integration and digital roles are coming up since 2020 (the pandemic) (H). Digital leaders need to be individually mindful of their projects and people in order to make them successful where they need to cultivate a stewardship climate in their organizations for value creation purposes (Dehnert and Santelmann, 2021). Possible data security concerns and subsequent consequences of digitalization are mentioned by interviewees (C), (D) which must be taken into consideration, especially by IT-related PM. Thus, the project managers of the future need to have extensive knowledge and expertise of this ongoing digital paradigm and integrate them within the traditional iron triangle (schedule scope, budget) (PMI, 2018) and hybrid principles of PM (Dehnert and Santelmann, 2021).

# 6 Conclusion

The magnitude of Dtrans and its associated fields continue to grow as the economies of world is rushing to keep up with each other. Despite this fast progress and potential benefits, many organizations still struggle to manage their transformation evenly. This phenomenon inspired this work of research that combined systematic literature search and interview techniques to identify the impact of Dtrans on industrial business models as well as subsequent barriers and solutions facing SC management. Based on this premise, three RQs were formulated, where RQ1 inquired Dtrans success factors, RQ2 sought its impact on BM, and subsequently, RQ3 intended to identify the SC and logistics challenges and address them with Dtech.

From the literature review, various success factors were identified, encompassing areas like organizational strategy, management and leadership, culture, knowledge and skills, technology, data, as well as internal and external integrations. It is observable that these factors have several constituents that interact with each other to drive Dtrans within a given business enterprise. The interviews and the literature review showed that cultural factors are the most significant ones, while internal integration might be one organizations struggle the least with. Nonetheless, less highlighting does not imply that such factors are insignificant because they were not specifically mentioned anywhere. Digital readiness or maturity parameters were searched as a part of RQ1 and a suggested model was formed in table 14 that might help organizations track their progress in the early phases of transformation. After searching and interviewing, no specific set of KPIs were found that could be identified as a standard for all-purpose Dtrans.

In a similar fashion, the literature review for RQ2 found that organizations need to be strategically consistent to be able to handle stakeholder value dimensions. Across the four value functions (creation, proposition, capture, delivery), many digital occurrences were identified that is changing the traditional shape and idea of BM. Value creation yielded the highest research information upon literature search as well as interview data extractions. Yet, other parameters remain inseparable from the ideal BM. Due to the high technological adoption within recent BM innovations, it is further impacting the SC value paths.

On the other hand, SC and logistics are known for their coordination issues. RQ3 intend to dive deep into this area, and consequently recognized numerous barriers across organizational attributes. Organizational culture and management were seen as the areas with biggest problems. To address such issues, uses of emerging Dtechs have been revealed by the literature review and interviews, spanning across automation, data analytics, AR/VR, cloud computing, and so forth. Even though the adoption level varies, the use of Dtwin in SC and logistics is promising as it especially suited to handle ever-growing complexities of global SC with multiple kinds of technological measures.

From the interviews, it seems the businesses and organizations still have a long way to go with Dtrans where particular areas might need more attention than the others. Even though the benefits of Dtrans are relatively more recognizable now than they were a decade ago, managers and employees of businesses need to tackle several categories of organizational barriers to actually harvest them. The firms that have a long legacy prior to Dtrans need to be especially mindful when planning their digital strategy compared to firms

that are born digital. On top of that, the literature suggests that best PM practices needs to be integrated into Dtrans. Or else, incompetency in PM might cause barriers to achieving desired outcomes which might even SC issues in the long run.

Even though the pandemic influenced virtually all people to heavily rely on digital means of work and communication, the interviews infer that this reliance is being cemented over time. Therefore, it will be necessary for businesses and institutions to forge improvements that meet human and business needs. Therefore, Dtrans must be planned and conducted in a way that optimizes all possible parameters regarding people, resources, environment, and profitability. For an organizational culture that nourishes technical excellence, every stakeholder needs to be on the same page when it comes to Dtrans initiatives.

In conclusion, this research study started from the literature search of organizational success factors and measures of Dtrans, digital BM innovation, and tackling SC barriers with the help Dtech like Dtwin. Additionally, it addressed the role of PM in Dtrans and its significance; achieving the purpose of the thesis in a scientific and systematic manner.

# 7 Recommendations for the future

The research work substantially identified several factors that help a Dtrans process win, its impact on BM improvement, and achievable SC advantages with technology. However, the findings from this research endeavor clearly suggest that organizations still need to address their issues from more than one perspective, whether human or technical. Therefore, the foundation built in the master's thesis can be further stretched into several different research directions as follows:

- *Improved questionnaire with analytical approaches:* Encompassing more subtleties of the RQs, the research work can be executed from the perspective of a different sector.
  This can be industry-specific, e.g., logistics or even more specific within an area, e.g., warehouse and/or facility management with a new or an improved set of questionnaire. Qualitative (e.g., qualitative comparative analysis) or quantitative approaches (e.g., regression analysis) can be adopted to verify the findings of the research.
- *"Purposeful digitalization"* (addressed by interviewee A1): This can examine how companies can align their BM with actual necessities with their digital growth strategies (either customer base, product and service portfolio, or both) and find out any potential gaps and complexities that need to be solved for progression.
- *Sustainability and Digital Transformation:* The complex infrastructure linking the two areas can be studied, or any of its selected parts. A framework needs to be developed for such a case.
- *Reverse/green logistics and SC centering a certain industry*: As the topic is gaining momentum in the academia, the study can continue to identify deeper connections among SC actors, technology, environmental concerns, and its effects on larger society.
- *Value-driven digital project management:* How managers and other stakeholders can come out of the project "iron triangle" and generate socio-economic/ESG values over a longer period of time.
- *Explainable AI:* This relates to the broad study of ethics. It is intended to improve accountability in AI usage where the ever-increasing concerns with AI in a particular context (e.g., third-party logistics) can be studied.
- *Cybersecurity challenges in Digital Transformation:* This is a known issue worldwide within the IT domain which can be studied from organizational and social perspectives.
- *Change management issues*: As Dtrans itself is a long-term change management concern and managerial impatience around it is cited by the interviewees (A2), questions like why ROIs of Dtrans in many companies are low, what that has to do with time, i.e., how long they should wait for the expected results, and such, need to be explored.
- *Digital governmental policy:* How to integrate digital means better in legislation, state-backed projects and governmental bodies in order to benefit the public can be investigated technically.

In addition, any practical experience or experimentation in or around Dtech (e.g., Dtwin/BIM) can be an unique opportunity to dive deep into a narrow and novel research point of Dtrans. It can also be industry-specific which means a single point of a wider research domain will get a superior attention.

# References

ABIDEEN, A. Z., SUNDRAM, V. P. K., PYEMAN, J., OTHMAN, A. K. & SOROOSHIAN, S. 2021. Digital Twin Integrated Reinforced Learning in Supply Chain and Logistics. *Logistics,* 5.

AGERON, B., BENTAHAR, O. & GUNASEKARAN, A. 2020. Digital supply chain: challenges and future directions. *Supply Chain Forum: An International Journal,* 21**,** 133-138.

AGRAWAL, P. & NARAIN, R. Digital supply chain management: An Overview. IOP Conference Series: Materials Science and Engineering, 2018. IOP Publishing, 012074.

AHMAD, A., ALSHURIDEH, M., AL KURDI, B., ABURAYYA, A. & HAMADNEH, S. 2021. Digital transformation metrics: a conceptual view. *Journal of management Information and Decision Sciences,* 24**,** 1-18.

ALIEVA, J. & POWELL, D. J. 2022. The significance of employee behaviours and soft management practices to avoid digital waste during a digital transformation. *International Journal of Lean Six Sigma*.

ALSANAD, S. 2018. Barriers to implementation sustainable cement manufacturing in Kuwait. *European Journal of Sustainable Development, 7***,** 317-317.

ALZAWAWI, M. Drivers and obstacles for creating sustainable supply chain management and operations. ASEE Zone Conference Proceedings, 2014. 1-8.

ARENKOV, I., TSENZHARIK, M. & VETROVA, M. Digital technologies in supply chain management. International Conference on Digital Technologies in Logistics and Infrastructure (ICDTLI 2019), 2019. Atlantis Press, 448-453.

A Taxonomy of 24 Digital Transformation KPIs - The Digital Transformation People. The Digital Transformation People. Retrieved from https://www.thedigitaltransformationpeople.com/channels/delivery/a-taxonomy-of-24-digital-transformation-kpis/

ATTARAN, M. 2017. The rise of 3-D printing: The advantages of additive manufacturing over traditional manufacturing. *Business Horizons,* 60**,** 677-688.

ATTARAN, M. 2020. Digital technology enablers and their implications for supply chain management. *Supply Chain Forum: An International Journal,* 21**,** 158-172.

AZHARI, P., FARABY, N., ROSSMANN, A., STEIMEL, B. & WICHMANN, K. 2014. Digital Transformation Report 2014: neuland GmbH. *Editora: WirtschaftsWoche.*

BAJIC, B., RIKALOVIC, A., SUZIC, N. & PIURI, V. 2021. Industry 4.0 Implementation Challenges and Opportunities: A Managerial Perspective. *IEEE Systems Journal,* 15**,** 546-559.

BARRICELLI, B. R., CASIRAGHI, E. & FOGLI, D. 2019. A Survey on Digital Twin: Definitions, Characteristics, Applications, and Design Implications. *IEEE Access,* 7**,** 167653-167671.

BARTUNEKL, J. M. 1993. Scholarly Dialogues and Participatory Action Research. *Human Relations,* 46**,** 1221-1233.

BARYKIN, S. Y., BOCHKAREV, A. A., DOBRONRAVIN, E. & SERGEEV, S. M. 2021. The place and role of digital twin in supply chain management. *Academy of Strategic Management Journal,* 20**,** 1-19.

BARYKIN, S. Y., BOCHKAREV, A. A., KALININA, O. V. & YADYKIN, V. K. 2020. Concept for a supply chain digital twin. *International Journal of Mathematical, Engineering and Management Sciences,* 5**,** 1498.

BELHADI, A., KAMBLE, S., GUNASEKARAN, A. & MANI, V. 2021. Analyzing the mediating role of organizational ambidexterity and digital business transformation on industry 4.0 capabilities and sustainable supply chain performance. *Supply Chain Management: An International Journal,* 27**,** 696-711.

BERGHAUS, S. & BACK, A. Stages in digital business transformation: Results of an empirical maturity study. MCIS 2016 Proceedings, 2016. Association for Information Systems

BHANJI, S., SHOTZ, H., TADANKI, S., MILOUDI, Y. & WARREN, P. Advanced Enterprise Asset Management Systems: Improve Predictive Maintenance and Asset Performance by Leveraging Industry 4.0 and the Internet of Things (IoT). ASME/IEEE Joint Rail Conference, 2021. American Society of Mechanical Engineers, V001T12A002.

BIRKEL, H., VEILE, J., MÜLLER, J., HARTMANN, E. & VOIGT, K.-I. 2019. Development of a Risk Framework for Industry 4.0 in the Context of Sustainability for Established Manufacturers. *Sustainability,* 11.

BOKRANTZ, J., SKOOGH, A., BERLIN, C. & STAHRE, J. 2017. Maintenance in digitalised manufacturing: Delphi-based scenarios for 2030. *International Journal of Production Economics,* 191**,** 154-169.

BOSMAN, L., HARTMAN, N. & SUTHERLAND, J. 2019. How manufacturing firm characteristics can influence decision making for investing in Industry 4.0 technologies. *Journal of Manufacturing Technology Management,* 31**,** 1117-1141.

BOUSDEKIS, A., APOSTOLOU, D. & MENTZAS, G. 2020. Predictive Maintenance in the 4th Industrial Revolution: Benefits, Business Opportunities, and Managerial Implications. *IEEE Engineering Management Review,* 48**,** 57-62.

BOUWMAN, H., NIKOU, S. & DE REUVER, M. 2019. Digitalization, business models, and SMEs: How do business model innovation practices improve performance of digitalizing SMEs? *Telecommunications Policy,* 43.

BRENNER, B. 2018. Transformative Sustainable Business Models in the Light of the Digital Imperative—A Global Business Economics Perspective. *Sustainability,* 10.

BRESSANELLI, G., ADRODEGARI, F., PERONA, M. & SACCANI, N. 2018a. Exploring How Usage-Focused Business Models Enable Circular Economy through Digital Technologies. *Sustainability,* 10.

BRESSANELLI, G., ADRODEGARI, F., PERONA, M. & SACCANI, N. The role of digital technologies to overcome Circular Economy challenges in PSS Business Models: an exploratory case study. Procedia Cirp, 2018b. 216-221.

BÜYÜKÖZKAN, G. & GÖÇER, F. 2018. Digital Supply Chain: Literature review and a proposed framework for future research. *Computers in Industry,* 97**,** 157-177.

CAMARINHA-MATOS, L. M., FORNASIERO, R., RAMEZANI, J. & FERRADA, F. 2019. Collaborative Networks: A Pillar of Digital Transformation. *Applied Sciences,* 9.

CHEN, Z. & HUANG, L. 2021. Digital twins for information-sharing in remanufacturing supply chain: A review. *Energy,* 220.

CHOPRA, S. & MEINDL, P. 2007. Supply chain management. Strategy, planning & operation. *Das summa summarum des management.* Springer.

CICHOSZ, M., WALLENBURG, C. M. & KNEMEYER, A. M. 2020. Digital transformation at logistics service providers: barriers, success factors and leading practices. *The International Journal of Logistics Management,* 31**,** 209-238.

COLLI, M., MADSEN, O., BERGER, U., MØLLER, C., WÆHRENS, B. V. & BOCKHOLT, M. Contextualizing the outcome of a maturity assessment for Industry 4.0. Ifac-papersonline, 2018. 1347-1352.

COMBE, M. Change readiness: Focusing change management where it counts. 2014. Project Management Institute.

COREYNEN, W., MATTHYSSENS, P. & VAN BOCKHAVEN, W. 2017. Boosting servitization through digitization: Pathways and dynamic resource configurations for manufacturers. *Industrial Marketing Management,* 60**,** 42-53.

CRAANE, B., DIJKSTRA, P. U., STAPPAERTS, K. & DE LAAT, A. 2012. Methodological quality of a systematic review on physical therapy for temporomandibular disorders: influence of hand search and quality scales. *Clinical oral investigations,* 16**,** 295-303.

CRESWELL, J. W. 2014. Qualitative, quantitative and mixed methods approaches. Sage.

DALENOGARE, L. S., BENITEZ, G. B., AYALA, N. F. & FRANK, A. G. 2018. The expected contribution of Industry 4.0 technologies for industrial performance. *International Journal of Production Economics,* 204**,** 383-394.

DE ANDRADE, P. R. M. & SADAOUI, S. Improving business decision making based on KPI management system. 2017 IEEE International Conference on Systems, Man, and Cybernetics (SMC), 2017. IEEE, 1280-1285.

DE JESUS, A. & MENDONÇA, S. 2018. Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy. *Ecological Economics,* 145**,** 75-89.

DE SOUSA JABBOUR, A. B. L., JABBOUR, C. J. C., FOROPON, C. & GODINHO FILHO, M. 2018. When titans meet – Can industry 4.0 revolutionise the environmentally-sustainable manufacturing wave? The role of critical success factors. *Technological Forecasting and Social Change,* 132**,** 18-25.

DEAN, M. & SPOEHR, J. 2018. The fourth industrial revolution and the future of manufacturing work in Australia: challenges and opportunities. *Labour & Industry: a journal of the social and economic relations of work,* 28**,** 166-181.

DEHNERT, M. & SANTELMANN, B. 2021. Are individual mindfulness and stewardship climate success factors for digital transformation projects? *2021 IEEE 23rd Conference on Business Informatics (CBI).*

DELMONICO, D., JABBOUR, C. J. C., PEREIRA, S. C. F., DE SOUSA JABBOUR, A. B. L., RENWICK, D. W. S. & THOMÉ, A. M. T. 2018. Unveiling barriers to sustainable public procurement in emerging economies: Evidence from a leading sustainable supply chain initiative in Latin America. *Resources, Conservation and Recycling,* 134**,** 70-79.

DENSCOMBE, M. 2017. *EBOOK: The good research guide: For small-scale social research projects*, McGraw-Hill Education (UK).

DESHMUKH, A. J. & VASUDEVAN, H. 2014. Emerging supplier selection criterion in the context of traditional vs green supply chain management. *International Journal of Managing Value and Supply Chains,* 5**,** 19.

DING, Y. 2019. Brief Analysis About Digital Twin Supply Chain Model and Application. *Industrial Engineering and Innovation Management,* 2**,** 14-23.

DUBEY, R., GUNASEKARAN, A., CHILDE, S. J., PAPADOPOULOS, T., LUO, Z., WAMBA, S. F. & ROUBAUD, D. 2019. Can big data and predictive analytics improve social and environmental sustainability? *Technological Forecasting and Social Change,* 144**,** 534-545.

ELLER, R., ALFORD, P., KALLMÜNZER, A. & PETERS, M. 2020. Antecedents, consequences, and challenges of small and medium-sized enterprise digitalization. *Journal of Business Research,* 112**,** 119-127.

FAVORETTO, C., MENDES, G. H. D. S., FILHO, M. G., GOUVEA DE OLIVEIRA, M. & GANGA, G. M. D. 2021. Digital transformation of business model in manufacturing companies: challenges and research agenda. *Journal of Business & Industrial Marketing,* 37**,** 748-767.

FAWCETT, S. E., MAGNAN, G. M. & MCCARTER, M. W. 2008. Benefits, barriers, and bridges to effective supply chain management. *Supply Chain Management: An International Journal,* 13**,** 35-48.

FRANK, A. G., DALENOGARE, L. S. & AYALA, N. F. 2019. Industry 4.0 technologies: Implementation patterns in manufacturing companies. *International Journal of Production Economics,* 210**,** 15-26.

FRANKENBERGER, K., WEIBLEN, T., CSIK, M. & GASSMANN, O. 2013. The 4I-framework of business model innovation: A structured view on process phases and challenges. *International journal of product development,* 18**,** 249-273.

GAUTHIER, C., BASTIANUTTI, J. & HAGGÈGE, M. 2018. Managerial capabilities to address digital business models: The case of digital health. *Strategic Change,* 27**,** 173-180.

GEISSBAUER, R., VEDSO, J. & SCHRAUF, S. 2016. Industry 4.0: Building the digital enterprise - PwC 2016 Global Industry 4.0 Survey. PwC.

GHOBAKHLOO, M. 2018. The future of manufacturing industry: a strategic roadmap toward Industry 4.0. *Journal of Manufacturing Technology Management,* 29**,** 910-936.

GHOBAKHLOO, M. 2020. Industry 4.0, digitization, and opportunities for sustainability. *Journal of Cleaner Production,* 252.

GÖKALP, E. & MARTINEZ, V. 2021. Digital transformation maturity assessment: development of the digital transformation capability maturity model. *International Journal of Production Research,* 60**,** 6282-6302.

GÖLZER, P. & FRITZSCHE, A. 2017. Data-driven operations management: organisational implications of the digital transformation in industrial practice. *Production Planning & Control,* 28**,** 1332-1343.

GOVINDAN, K., KALIYAN, M., KANNAN, D. & HAQ, A. N. 2014. Barriers analysis for green supply chain management implementation in Indian industries using analytic hierarchy process. *International Journal of Production Economics,* 147**,** 555-568.

GREEN, B. N., JOHNSON, C. D. & ADAMS, A. 2006. Writing narrative literature reviews for peer-reviewed journals: secrets of the trade. *Journal of Chiropractic Medicine,* 5**,** 101-117.

GRIEVES, M. 2014. Digital twin: manufacturing excellence through virtual factory replication. *White paper,* 1**,** 1-7.

GUPTA, H. & BARUA, M. K. 2018. A grey DEMATEL-based approach for modeling enablers of green innovation in manufacturing organizations. *Environ Sci Pollut Res Int,* 25**,** 9556-9578.

GUPTA, M. 2017. *Blockchain for Dummies-IBM. ,* Hoboken, New Jersey, John Wiley & Sons, Inc.

GURBAXANI, V. & DUNKLE, D. 2019. Gearing up for successful digital transformation. *MIS Q. Executive,* 18**,** 6.

HAFFKE, I., KALGOVAS, B. & BENLIAN, A. 2017. The transformative role of bimodal IT in an era of digital business.

HAHN, G. J. 2019. Industry 4.0: a supply chain innovation perspective. *International Journal of Production Research,* 58**,** 1425-1441.

HASSELBLATT, M., HUIKKOLA, T., KOHTAMÄKI, M. & NICKELL, D. 2018. Modeling manufacturer's capabilities for the Internet of Things. *Journal of Business & Industrial Marketing,* 33**,** 822-836.

HERMANN, M., BÜCKER, I. & OTTO, B. 2019. Industrie 4.0 process transformation: findings from a case study in automotive logistics. *Journal of Manufacturing Technology Management,* 31**,** 935-953.

HESS, T., MATT, C., BENLIAN, A. & WIESBÖCK, F. 2016. Options for formulating a digital transformation strategy. *MIS Quarterly Executive,* 15.

HIZAM-HANAFIAH, M., SOOMRO, M. & ABDULLAH, N. 2020. Industry 4.0 Readiness Models: A Systematic Literature Review of Model Dimensions. *Information,* 11.

HORVÁTH, D. & SZABÓ, R. Z. 2019. Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities? *Technological Forecasting and Social Change,* 146**,** 119-132.

HUCKSTEP, R. 2016. Insurance of Things–how IoT shows prevention is better than cure for Insurers. *InsurTech Weekly,* 39.

HUSSAIN, M., AJMAL, M. M., GUNASEKARAN, A. & KHAN, M. 2018. Exploration of social sustainability in healthcare supply chain. *Journal of Cleaner Production,* 203**,** 977-989.

HUSSEIN, B. 2018. *The road to success: narratives and Insights from real-life projects*, Fagbokforlaget.

ISHAQ BHATTI, M., AWAN, H. M. & RAZAQ, Z. 2013. The key performance indicators (KPIs) and their impact on overall organizational performance. *Quality & Quantity,* 48**,** 3127-3143.

ISSA, A., HATIBOGLU, B., BILDSTEIN, A. & BAUERNHANSL, T. Industrie 4.0 roadmap: Framework for digital transformation based on the concepts of capability maturity and alignment.  Procedia Cirp, 2018. 973-978.

JOHANSSON, N., ROTH, E. & REIM, W. 2019. Smart and Sustainable eMaintenance: Capabilities for Digitalization of Maintenance. *Sustainability,* 11.

KAGERMANN, H., WAHLSTER, W. & HELBIG, J. 2013. Recommendations for implementing the strategic initiative INDUSTRIE 4.0. *Final report of the Industrie.*

KAMBLE, S. S., GUNASEKARAN, A., PAREKH, H., MANI, V., BELHADI, A. & SHARMA, R. 2022. Digital twin for sustainable manufacturing supply chains: Current trends, future perspectives, and an implementation framework. *Technological Forecasting and Social Change,* 176**,** 121448.

KANE, G. C., PALMER, D., PHILLIPS, A. N., KIRON, D. & BUCKLEY, N. 2018. Coming of age digitally. *MIT Sloan Management Review*.

KAPLAN, R. S. 2009. Conceptual foundations of the balanced scorecard. *Handbooks of management accounting research,* 3**,** 1253-1269.

KAPLAN, R. S. & DAVID, P. 1992. "The Balanced Scorecard—Measures That Drive Performance,". *Harvard business review,* 70**,** 71-79.

KAZANCOGLU, I., KAZANCOGLU, Y., YARIMOGLU, E. & KAHRAMAN, A. 2020. A conceptual framework for barriers of circular supply chains for sustainability in the textile industry. *Sustainable Development,* 28**,** 1477-1492.

KHAN, S. A. R. & QIANLI, D. 2017. Impact of green supply chain management practices on firms' performance: an empirical study from the perspective of Pakistan. *Environmental Science and Pollution Research,* 24**,** 16829-16844.

KIEL, D., MÜLLER, J. M., ARNOLD, C. & VOIGT, K.-I. 2017. Sustainable industrial value creation: Benefits and challenges of industry 4.0. *International journal of innovation management,* 21**,** 1740015.

KIM, S.-Y. & NGUYEN, V. T. 2020. Supply chain management in construction: critical study of barriers to implementation. *International Journal of Construction Management,* 22**,** 3148-3157.

KIVILÄ, J., MARTINSUO, M. & VUORINEN, L. 2017. Sustainable project management through project control in infrastructure projects. *International Journal of Project Management,* 35**,** 1167-1183.

KLAKEGG, O. J. 2015. In pursuit of relevance and sustainability. *Open Economics and Management Journal,* 2.

KLOS, C., SPIETH, P., CLAUSS, T. & KLUSMANN, C. 2022. Digital Transformation of Incumbent Firms: A Business Model Innovation Perspective. *IEEE Transactions on Engineering Management***,** 1-17.

KORACHI, Z. & BOUNABAT, B. 2019. Integrated methodological framework for digital transformation strategy building (IMFDS). *International Journal of Advanced Computer Science and Applications,* 10.

KORPELA, K., HALLIKAS, J. & DAHLBERG, T. 2017. Digital supply chain transformation toward blockchain integration.

KOTTER, J. 2014. *Accelerate: Building strategic agility for a faster-moving world* Boston, MA, Harvard Business School Press.

KRAUS, S., JONES, P., KAILER, N., WEINMANN, A., CHAPARRO-BANEGAS, N. & ROIG-TIERNO, N. 2021. Digital transformation: An overview of the current state of the art of research. *Sage Open,* 11**,** 21582440211047576.

KRISTOFFERSEN, E., BLOMSMA, F., MIKALEF, P. & LI, J. 2020. The smart circular economy: A digital-enabled circular strategies framework for manufacturing companies. *Journal of business research,* 120**,** 241-261.

KUMAR, R. 2018. *Research methodology: A step-by-step guide for beginners*, Sage.

KUNTSMAN, A. & ARENKOV, I. A. 2019. Method for assessing effectiveness of company digital transformation: integrated approach. *IBIMA Business Review,* 2019**,** 24.09.

LENKA, S., PARIDA, V. & WINCENT, J. 2017. Digitalization capabilities as enablers of value co-creation in servitizing firms. *Psychology & marketing,* 34**,** 92-100.

LEVKOVSKYI, B., HINRICHS, M., BETZWIESER, B. & UTESCH, M. C. Companies in Transition: Understanding how the Digital Transformation Affects Business Processes and Their Key Performance Indicators.  AMCIS, 2021.

LIAO, Y., DESCHAMPS, F., LOURES, E. D. F. R. & RAMOS, L. F. P. 2017. Past, present and future of Industry 4.0 - a systematic literature review and research agenda proposal. *International Journal of Production Research,* 55**,** 3609-3629.

MACARTHUR, E. 2013. Towards the circular economy. *Journal of Industrial Ecology,* 2**,** 23-44.

MACHADO, C. G., WINROTH, M., ALMSTRÖM, P., ERICSON ÖBERG, A., KURDVE, M. & ALMASHALAH, S. 2021. Digital organisational readiness: experiences from manufacturing companies. *Journal of Manufacturing Technology Management,* 32**,** 167-182.

MACHADO, C. G., WINROTH, M., CARLSSON, D., ALMSTRÖM, P., CENTERHOLT, V. & HALLIN, M. Industry 4.0 readiness in manufacturing companies: challenges and enablers towards increased digitalization. Procedia CIRP, 2019b. 1113-1118.

MACHADO, C. G., WINROTH, M., CARLSSON, D. & CENTERHOLT, V. Digitalization for sustainable production: exploring the use of digital maturity models. 6th EurOMA Sustainable Operations and Supply Chains Forum, 18-19 March, 2019, Gothenburg, Sweden, 2019a.

MANZOURI, M., RAHMAN, M. N. A., ARSHAD, H. & ISMAIL, A. R. 2010. Barriers of supply chain management implementation in manufacturing companies: a comparison between Iranian and Malaysian companies. *Journal of the Chinese Institute of Industrial Engineers,* 27**,** 456-472.

MCCARTHY, P., SAMMON, D. & ALHASSAN, I. 2021. Digital Transformation Leadership Characteristics: A Literature Analysis. *Journal of Decision Systems***,** 1-31.

MCKINSEY. 2023. *New leadership for a new era of thriving organizations* [Online]. Available: https://www.mckinsey.com/capabilities/people-and-organizational-performance/our-insights/new-leadership-for-a-new-era-of-thriving-organizations?cid=alwaysonpub-pso-mck-2304-i37a-fce-mip-oth&sid=pso-POST_ID&linkId=218713688 [Accessed 11 July 2023 2023].

MEIER, H., LAGEMANN, H., MORLOCK, F. & RATHMANN, C. Key Performance Indicators for Assessing the Planning and Delivery of Industrial Services. Procedia CIRP, 2013. 99-104.

MHLUNGU, N. S., CHEN, J. Y. & ALKEMA, P. 2019. The underlying factors of a successful organisational digital transformation. *South African Journal of Information Management,* 21**,** 1-10.

MIHARDJO, L., SASMOKO, S., ALAMSJAH, F. & ELIDJEN, E. 2019. Digital leadership role in developing business model innovation and customer experience orientation in industry 4.0. *Management Science Letters,* 9**,** 1749-1762.

MORAKANYANE, R., O'REILLY, P., MCAVOY, J. & GRACE, A. Determining digital transformation success factors. The 53rd Hawaii International Conference on System Sciences. Hawaii International Conference on System Sciences, 2020.

MORRIS, P. W. & JAMIESON, A. 2005. Moving from corporate strategy to project strategy. *Project Management Journal,* 36**,** 5-18.

MOSHOOD, T., NAWANIR, G., SOROOSHIAN, S. & OKFALISA, O. 2021. Digital Twins Driven Supply Chain Visibility within Logistics: A New Paradigm for Future Logistics. *Applied System Innovation,* 4.

MÜLLER, J. M., BULIGA, O. & VOIGT, K.-I. 2018. Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0. *Technological Forecasting and Social Change,* 132**,** 2-17.

NA, C., CHEN, X., LI, X., LI, Y. & WANG, X. 2022. Digital Transformation of Value Chains and CSR Performance. *Sustainability,* 14.

NARAYANAN, A. E., SRIDHARAN, R. & RAM KUMAR, P. N. 2019. Analyzing the interactions among barriers of sustainable supply chain management practices. *Journal of Manufacturing Technology Management,* 30**,** 937-971.

NERI, A., CAGNO, E., DI SEBASTIANO, G. & TRIANNI, A. 2018. Industrial sustainability: Modelling drivers and mechanisms with barriers. *Journal of Cleaner Production,* 194**,** 452-472.

NOSALSKA, K., PIĄTEK, Z. M., MAZUREK, G. & RZĄDCA, R. 2019. Industry 4.0: coherent definition framework with technological and organizational interdependencies. *Journal of Manufacturing Technology Management,* 31**,** 837-862.

NYAGADZA, B. 2022. Sustainable digital transformation for ambidextrous digital firms: systematic literature review, meta-analysis and agenda for future research directions. *Sustainable Technology and Entrepreneurship,* 1.

O'LEARY, D. E. 2017. Configuring blockchain architectures for transaction information in blockchain consortiums: The case of accounting and supply chain systems. *Intelligent Systems in Accounting, Finance and Management,* 24**,** 138-147.

OESTERREICH, T. D. & TEUTEBERG, F. 2016. Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the construction industry. *Computers in Industry,* 83**,** 121-139.

OSMUNDSEN, K., IDEN, J. & BYGSTAD, B. Digital Transformation: Drivers, Success Factors, and Implications.  MCIS, 2018. 37.

PAGE, M. J., MCKENZIE, J. E., BOSSUYT, P. M., BOUTRON, I., HOFFMANN, T. C., MULROW, C. D., SHAMSEER, L., TETZLAFF, J. M., AKL, E. A., BRENNAN, S. E., CHOU, R., GLANVILLE, J., GRIMSHAW, J. M., HROBJARTSSON, A., LALU, M. M., LI, T., LODER, E. W., MAYO-WILSON, E., MCDONALD, S., MCGUINNESS, L. A., STEWART, L. A., THOMAS, J., TRICCO, A. C., WELCH, V. A., WHITING, P. & MOHER, D. 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ,* 372**,** n71.

PAGOROPOULOS, A., PIGOSSO, D. C. & MCALOONE, T. C. The emergent role of digital technologies in the Circular Economy: A review.  Procedia cirp, 2017. 19-24.

PAHLEVAN-SHARIF, S., MURA, P. & WIJESINGHE, S. N. R. 2019. A systematic review of systematic reviews in tourism. *Journal of Hospitality and Tourism Management,* 39**,** 158-165.

PARK, K. T., SON, Y. H. & NOH, S. D. 2020. The architectural framework of a cyber physical logistics system for digital-twin-based supply chain control. *International Journal of Production Research,* 59**,** 5721-5742.

PATEL, R. & DAVIDSON, B. Forskningsmetodikens grunder. Att planera, genomföra och rapportera en undersökning. 2003.

PATTNAIK, D. 2018. Digitalization in the midst of Digital Division in India. *Pacific Business Review International,(Indexed in Thomson Reuters, UGC, ISI, ICI, RIF),* 10.

PATTON, M. Q. 1990. *Qualitative evaluation and research methods*, SAGE Publications, inc.

Pettey, C. (2019). *Gartner Top 8 Supply Chain Technology Trends for 2019*. Gartner, Inc. Retrieved July 7, 2023, from https://www.gartner.com/smarterwithgartner/gartner-top-8-supply-chain-technology-trends-for-2019

PESSOT, E., ZANGIACOMI, A., BATTISTELLA, C., ROCCHI, V., SALA, A. & SACCO, M. 2020. What matters in implementing the factory of the future. *Journal of Manufacturing Technology Management,* 32**,** 795-819.

PIROLA, F., CIMINI, C. & PINTO, R. 2019. Digital readiness assessment of Italian SMEs: a case-study research. *Journal of Manufacturing Technology Management,* 31**,** 1045-1083.

PLAZA-ÚBEDA, J. A., ABAD-SEGURA, E., DE BURGOS-JIMÉNEZ, J., BOTEVA-ASENOVA, A. & BELMONTE-UREÑA, L. J. 2020. Trends and new challenges in the green supply chain: The reverse logistics. *Sustainability,* 13**,** 331.

PMI 2018. *A guide to the project management body of knowledge,* Newtown Square, Pennsylvania, USA, Project Management Institute.

PREM, E. A digital transformation business model for innovation.  ISPIM Innovation Symposium, 2015. The International Society for Professional Innovation Management (ISPIM), 1.

PwC, "Industrie 4.0: Chancen und Herausforderungen der vierten industriellen Revolution," PwC, 2014.

QI, Q., TAO, F., HU, T., ANWER, N., LIU, A., WEI, Y., WANG, L. & NEE, A. Y. C. 2021. Enabling technologies and tools for digital twin. *Journal of Manufacturing Systems,* 58**,** 3-21.

RACHINGER, M., RAUTER, R., MÜLLER, C., VORRABER, W. & SCHIRGI, E. 2019. Digitalization and its influence on business model innovation. *Journal of Manufacturing Technology Management,* 30**,** 1143-1160.

RAMESH, N. & DELEN, D. 2021. Digital Transformation: How to Beat the 90% Failure Rate? *IEEE engineering management review,* 49**,** 22-25.

REYES, P. M., FRAZIER, G. V., PRATER, E. L. & CANNON, A. R. 2007. RFID: the state of the union between promise and practice. *International Journal of Integrated Supply Management,* 3**,** 192-206.

ROOS, J. & NILSSON, V. O. 2020. Driving organizational readiness for change through strategic workshops. *International Journal of Management and Applied Research,* 7**,** 1-28.

ROSSMANN, A. 2018. Digital maturity: Conceptualization and measurement model.

SAARIKKO, T., WESTERGREN, U. H. & BLOMQUIST, T. 2017. The Internet of Things: Are you ready for what's coming? *Business Horizons,* 60**,** 667-676.

SAIHI, A., BEN-DAYA, M. & AS'AD, R. 2023. Underpinning success factors of maintenance digital transformation: A hybrid reactive Delphi approach. *International Journal of Production Economics,* 255.

SALMINEN, V., RUOHOMAA, H. & KANTOLA, J. Digitalization and Big Data Supporting Responsible Business Co-evolution. 2017 Cham. Springer International Publishing, 1055-1067.

SAMSET, K. 2010. *Early project appraisal: making the initial choices*, Springer.

SANDKUHL, K., SHILOV, N. & SMIRNOV, A. 2020. Facilitating digital transformation: success factors and multi-aspect ontologies. *International Journal of Integrated Supply Management,* 13**,** 376-393.

SAVIĆ, D. 2019. From Digitization, through Digitalization, to Digital Transformation. 43/2019**,** 36-39.

SCHALLMO, D., WILLIAMS, C. A. & LOHSE, J. 2019. Digital strategy—integrated approach and generic options. *International Journal of Innovation Management,* 23**,** 1940005.

SCHNEIDER, P. 2018. Managerial challenges of Industry 4.0: an empirically backed research agenda for a nascent field. *Review of Managerial Science,* 12**,** 803-848.

SCHWERTNER, K. 2017. Digital transformation of business. *Trakia Journal of Sciences,* 15**,** 388-393.

SEBASTIAN, I., ROSS, J., BEATH, C., MOCKER, M., MOLONEY, K. & FONSTAD, N. 2017. How big old companies navigate digital transformation. *MIS quarterly executive,* 16**,** 197-213.

SEPASGOZAR, S. M. E. 2021. Differentiating Digital Twin from Digital Shadow: Elucidating a Paradigm Shift to Expedite a Smart, Sustainable Built Environment. *Buildings,* 11.

SHEVTSHENKO, E., MAHMOOD, K., KARAULOVA, T. & RAJI, I. O. Multitier digital twin approach for agile supply chain management. ASME International Mechanical Engineering Congress and Exposition, 2020. American Society of Mechanical Engineers, V02BT02A012.

SIMCHENKO, N., TSOHLA, S. & CHUVATKIN, P. 2020. Effects of Supply Chain Digital Twins in the Development of Digital Industry. *International Journal of Supply Chain Management,* 9**,** 799-805.

SINGH, P., GHOSH, S., SARAF, M. & NAYAK, R. A Survey Paper on Identifying Key Performance Indicators for Optimizing Inventory Management System and Exploring Different Visualization Tools. 2020 4th International Conference on Intelligent Computing and Control Systems (ICICCS), 2020. IEEE, 627-632.

SOMAPA, S., COOLS, M. & DULLAERT, W. 2018. Characterizing supply chain visibility – a literature review. *The International Journal of Logistics Management,* 29**,** 308-339.

SPREMIC, M. 2017. Governing digital technology–how mature IT governance can help in digital transformation? *International Journal of Economics and Management Systems,* 2.

Statista. Global Digital Transformation Spending 2026. Statista. Retrieved from https://www.statista.com/statistics/870924/worldwide-digital-transformation-market-size/

STEWART, R., BEY, N. & BOKS, C. Exploration of the Barriers to Implementing Different Types of Sustainability Approaches. Procedia CIRP, 2016. 22-27.

STIEF, S. E., EIDHOFF, A. T. & VOETH, M. 2016. Transform to succeed: An empirical analysis of digital transformation in firms. *International Journal of Economics and Management Engineering,* 10**,** 1833-1842.

SUNDARAM, R., SHARMA, D. & SHAKYA, D. 2020. Digital transformation of business models: A systematic review of impact on revenue and supply chain. *International Journal of Management,* 11.

SUNG, T. K. 2018. Industry 4.0: A Korea perspective. *Technological Forecasting and Social Change,* 132**,** 40-45.

TAICHMAN, D. B., BACKUS, J., BAETHGE, C., BAUCHNER, H., DE LEEUW, P. W., DRAZEN, J. M., FLETCHER, J., FRIZELLE, F. A., GROVES, T. & HAILEAMLAK, A. 2016. Sharing clinical trial data: a proposal from the International Committee of Medical Journal Editors. *Annals of internal medicine,* 164**,** 505-506.

TAO, F., LIU, W., ZHANG, M., HU, T., QI, Q., ZHANG, H., SUI, F., WANG, T., XU, H. & HUANG, Z. 2019. Five-dimension digital twin model and its ten applications. *Computer integrated manufacturing systems,* 25**,** 1-18.

TARAN, Y., BOER, H. & LINDGREN, P. 2015. A business model innovation typology. *Decision Sciences,* 46**,** 301-331.

ÜLKÜ, M. A. & HSUAN, J. 2017. Towards sustainable consumption and production: Competitive pricing of modular products for green consumers. *Journal of Cleaner Production,* 142**,** 4230-4242.

VADANA, I.-I., KUIVALAINEN, O., TORKKELI, L. & SAARENKETO, S. 2021. The Role of Digitalization on the Internationalization Strategy of Born-Digital Companies. *Sustainability,* 13.

VENDRELL-HERRERO, F., PARRY, G., BUSTINZA, O. F. & GOMES, E. 2018. Digital business models: Taxonomy and future research avenues. *Strategic Change,* 27**,** 87-90.

VERHOEF, P. C., BROEKHUIZEN, T., BART, Y., BHATTACHARYA, A., QI DONG, J., FABIAN, N. & HAENLEIN, M. 2021. Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research,* 122**,** 889-901.

VIAL, G. 2019. Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems,* 28**,** 118-144.

VOGELSANG, K., LIERE-NETHELER, K., PACKMOHR, S. & HOPPE, U. 2019. Success factors for fostering a digital transformation in manufacturing companies. *Journal of Enterprise Transformation,* 8**,** 121-142.

VON LEIPZIG, T., GAMP, M., MANZ, D., SCHÖTTLE, K., OHLHAUSEN, P., OOSTHUIZEN, G., PALM, D. & VON LEIPZIG, K. Initialising Customer-orientated Digital Transformation in Enterprises. Procedia Manufacturing, 2017. 517-524.

WANG, L., DENG, T., SHEN, Z.-J. M., HU, H. & QI, Y. 2022. Digital twin-driven smart supply chain. *Frontiers of Engineering Management***,** 1-15.

WANG, S., WAN, J., LI, D. & ZHANG, C. 2016. Implementing Smart Factory of Industrie 4.0: An Outlook. *International Journal of Distributed Sensor Networks,* 12.

WARNER, K. S. R. & WÄGER, M. 2019. Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal. *Long Range Planning,* 52**,** 326-349.

WEI, J., LIU, Y., WANG, L. & SUN, X. 2021. Research on evaluation of manufacturing cloud service oriented to environmental benefits of supply chain. *Environmental Science and Pollution Research,* 28**,** 59473-59485.

WEINER, B. J. 2009. A theory of organizational readiness for change. *Implementation Science,* 4**,** 67.

WENGLER, S., HILDMANN, G. & VOSSEBEIN, U. 2021. Digital transformation in sales as an evolving process. *Journal of Business & Industrial Marketing,* 36**,** 599-614.

WESTERMAN, G., BONNET, D. & MCAFEE, A. 2014. *Leading digital: Turning technology into business transformation*, Harvard Business Press.

What Is Digital Transformation? Definition and Examples. What Is Digital Transformation? Definition and Examples. Retrieved from https://airfocus.com/glossary/what-is-digital-transformation/

WILLIAMS, B. D., ROH, J., TOKAR, T. & SWINK, M. 2013. Leveraging supply chain visibility for responsiveness: The moderating role of internal integration. *Journal of Operations Management,* 31**,** 543-554.

WITSCHEL, D., DÖHLA, A., KAISER, M., VOIGT, K.-I. & PFLETSCHINGER, T. 2019. Riding on the wave of digitization: insights how and under what settings dynamic capabilities facilitate digital-driven business model change. *Journal of Business Economics,* 89**,** 1023-1095.

WOHLIN, C. 2014. Guidelines for snowballing in systematic literature studies and a replication in software engineering. *Proceedings of the 18th International Conference on Evaluation and Assessment in Software Engineering - EASE '14.*

YEOW, A., SOH, C. & HANSEN, R. 2018. Aligning with new digital strategy: A dynamic capabilities approach. *The Journal of Strategic Information Systems,* 27**,** 43-58.

ZAOUI, F. & SOUISSI, N. Roadmap for digital transformation: A literature review. Procedia Computer Science, 2020. 621-628.

ZHANG, J., BRINTRUP, A., CALINESCU, A., KOSASIH, E. & SHARMA, A. 2021. Supply chain digital twin framework design: an approach of supply chain operations reference model and system of systems. *arXiv preprint arXiv:2107.09485*.

ZHENG, P., WANG, Z., CHEN, C.-H. & PHENG KHOO, L. 2019. A survey of smart product-service systems: Key aspects, challenges and future perspectives. *Advanced Engineering Informatics,* 42.

ZWIKAEL, O. & SMYRK, J. R. 2019. *Project management: A benefit realisation approach*, Springer.

# Appendix A: Interview Questions

**A. Introduction**

1.  What is your role and what line of work do you do in your organization? How long have you been working there? Could you also please define digital transformation in own words?

**B. Digital Transformation**

**B1 Digital Technologies**

2.  Is your organization using digital tools and technologies in the following areas? If so, could you provide an example for each? Could you rate the use of these technologies in your organization on a scale of 1 to 5? Why did you choose this score?

    i.      Interpersonal Communications (e.g., messenger)

    ii.     Mobile Devices (i.e., handheld computers, e.g., smartphones, tablets, etc.)

    iii.    Data Analytics

    iv.     Cloud Technologies (e.g., publicly available services like Azure, AWS, GCP, etc.)

    v.      Internet of Things (IoT) (e.g., connected sensor technology)

**B2 Digital Incentives**

3.  Would you say that the customer behavior change has slowed, remained constant, or increased since the introduction of digital technologies in your organization?

4.  Do the digital technologies in your organization keep data? If so, what kind of data is stored? Please give examples. Could you rate the availability of the data of your organization between 1 to 5? Why this score?

5.  Would you say the competitiveness of the market of your organization has evolved due to digital technologies? If so, please explain. When compared the present competitiveness of your organization to a pre-adoption era, would you say the competitiveness has diminished, remained constant, or increased?

**B3 Digital Strategy: Combination of IT and Business**

6.  If you compare the business strategy and the IT strategy of your organization, do you see any connections between them? Please explain.

7.  On a scale of 1 to 5, how quickly is the organization implementing digital transformation? Could you please explain? How fast do you think digital transformation activities are controlled and how does the internal management handle them?

8.  How does your organization allocate resources to the digital strategy that combines IT and business?

## B4 Multidisciplinary Cooperation

9. Could you talk about the organization's structure? How do the departments and teams collaborate? Is any multidisciplinary collaboration practiced in this organizational structure? If so, could you provide an example?

10. How well is this agile cross-functional structure currently implemented within the organization, on a scale of 1 to 5? Is there any part of the organization where you notice this is more prevalent? Why?

## B5 Organizational Culture

11. How does the organization involve in digital transformation with regards to the following two listed things? On a scale from 1-5, please rate how actively each are involved in the transformation.
    i. employees
    ii. management

12. How does the organization encourage its employees to use digital technologies by making them more accessible? Do you notice any resistance from employees regarding digital transformation?

13. How digitally savvy are the organization's employees, on a scale of 1 to 5? Why this score?

14. Looking at the organization's culture, how do you believe digital transformation decisions have been made in accordance with this culture? Could you elaborate within a 1 to 5 scale?

15. Has the existing organizational culture influenced decisions about whether or not to use certain digital technologies? To what extent do you believe the existing organizational culture was considered when making digital transformation choices? Could you clarify by providing a score from 1 to 5?

## B6 Digital Transformation Impact

16. Is the organization capable of evaluating the impact of digital transformation actions on the followings? Can you mention the metrices/KPIs that are used? Also, kindly mention the specific areas within (e.g., a department) and outside (e.g., a supplier) of the organization in each case.
    i. internal organization

ii. external organization

17. Could you provide examples of how digital transformation activities have -

i. benefited the internal and the external organization?
ii. harmed the internal and the external organization?

18. Could you rate the impact of digital transformation activities on a scale of 1 to 5 for the followings? Here, 1 is extremely negative and 5 is extremely positive. Could you clarify it in each case?
    i. internal organization
    ii. external organization

**B7 Digital Transformation Success**

19. Could you explain how the organization's revenue growth has changed over the last few years? Could you spot a pattern or percentage? How have the digital transformation influenced this trend?

20. Could you give an example of revenue growth triggered in part or entirely by the digital transformation?

21. Could you please elaborate on the types of investments made in relation to digital transformation? In what ways did the investments repay? Could you rate this on a scale of 1 to 5, with 1 being nothing and 5 being beyond expectations? Could you please explain the score?

22. Do you consider the organization as a whole to be a growing business at the moment? If so, how much of that expansion do you attribute to digital transformation? Could you give me a percentage?

**C. Business Model Innovation**

23. Has the product and service portfolio of the organization been modified and/or changed due to the introduction or increase of digital technologies? Is so, could you exemplify?

24. What do you think of your organization's relationship with the followings? Have they changed due to introducing any new technology (i.e., enhanced, unchanged, or degraded)?
    i. customers
    ii. suppliers

25. Could you give an example of how your company brings value to the followings through the use of digital technologies?
    i. customers
    ii. suppliers

26. How does the company innovate? Do you have adopted a platform for implementing new digital services? Is it project-based or step-by-step in nature? Could you give examples?

27. Do you believe your organization is adaptable enough to detect and respond to market changes? If so, could you provide an example of when this occurred?
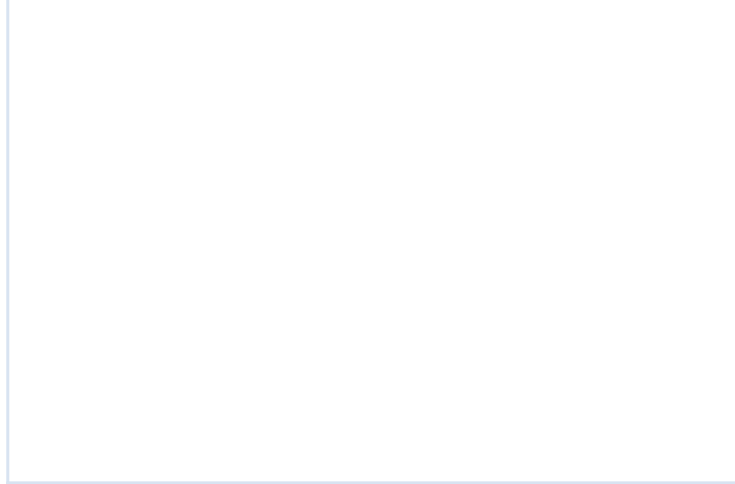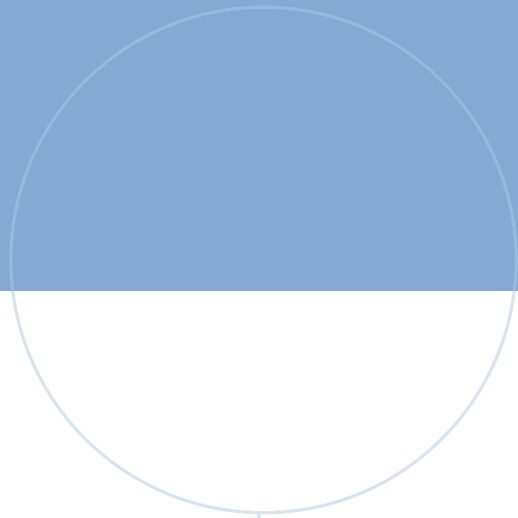
**D. Feedback**

28. Do you have any feedback on the interview? Anything you want to add?

# Appendix B: PRISMA Checklist Updated with the Thesis Protocol

| Section and Topic | Item # | Checklist item | Location where item is reported |
|---|---|---|---|
| **TITLE** | | | |
| Title | 1 | Identify the report as a systematic review. | Preface |
| **ABSTRACT** | | | |
| Abstract | 2 | See the PRISMA 2020 for Abstracts checklist. | Abstract |
| **INTRODUCTION** | | | |
| Rationale | 3 | Describe the rationale for the review in the context of existing knowledge. | Methodology |
| Objectives | 4 | Provide an explicit statement of the objective(s) or question(s) the review addresses. | Introduction |
| **METHODS** | | | |
| Eligibility criteria | 5 | Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses. | Methodology |
| Information sources | 6 | Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted. | Methodology |
| Search strategy | 7 | Present the full search strategies for all databases, registers and websites, including any filters and limits used. | Methodology |
| Selection process | 8 | Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process. | Methodology |
| Data collection process | 9 | Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process. | Methodology |
| Data items | 10a | List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect. | Methodology |
| | 10b | List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information. | Methodology |
| Study risk of bias assessment | 11 | Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process. | Methodology |
| Effect measures | 12 | Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results. | Results |
| Synthesis methods | 13a | Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)). | Nothing to declare |
| | 13b | Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions. | Nothing to declare |
| | 13c | Describe any methods used to tabulate or visually display results of individual studies and syntheses. | Methodology |
| | 13d | Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used. | Methodology |
| | 13e | Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression). | Nothing to declare |
| | 13f | Describe any sensitivity analyses conducted to assess robustness of the synthesized results. | Results |
| Reporting bias assessment | 14 | Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases). | Methodology |
| Certainty assessment | 15 | Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome. | Methodology |
| **RESULTS** | | | |
| Study selection | 16a | Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram. | Methodology |
| | 16b | Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded. | Methodology |
| Study characteristics | 17 | Cite each included study and present its characteristics. | Results |
| Risk of bias in studies | 18 | Present assessments of risk of bias for each included study. | Methodology |

| Section and Topic | Item # | Checklist item | Location where item is reported |
|---|---|---|---|
| Results of individual studies | 19 | For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots. | Results |
| Results of syntheses | 20a | For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies. | Methodology |
| | 20b | Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect. | Nothing to declare |
| | 20c | Present results of all investigations of possible causes of heterogeneity among study results. | Methodology |
| | 20d | Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results. | Results, Discussion |
| Reporting biases | 21 | Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed. | Methodology |
| Certainty of evidence | 22 | Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed. | Methodology |
| **DISCUSSION** | | | |
| Discussion | 23a | Provide a general interpretation of the results in the context of other evidence. | Conclusion |
| | 23b | Discuss any limitations of the evidence included in the review. | Methodology |
| | 23c | Discuss any limitations of the review processes used. | Methodology |
| | 23d | Discuss implications of the results for practice, policy, and future research. | Recommendations |
| **OTHER INFORMATION** | | | |
| Registration and protocol | 24a | Provide registration information for the review, including register name and registration number, or state that the review was not registered. | Not registered |
| | 24b | Indicate where the review protocol can be accessed, or state that a protocol was not prepared. | Nothing to declare |
| | 24c | Describe and explain any amendments to information provided at registration or in the protocol. | Nothing to declare |
| Support | 25 | Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review. | Nothing to declare |
| Competing interests | 26 | Declare any competing interests of review authors. | Nothing to declare |
| Availability of data, code and other materials | 27 | Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review. | Nothing to declare (removed according Sikt policy) |