Rethinking Transformation –
The Evolution from Digital Transformation to Twin Transformation

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The following sections are partly comprised of content from the Research Articles included in this thesis. To improve the readability of the text, I omit the standard labeling of these citations.

Abstract

In light of today's pressing economic, environmental, and social challenges, the concept of twin transformation offers a promising pathway. Its mutually reinforcing relationship highlights the potential of digital technologies to enable sustainability transformation while also emphasizing how sustainability transformation can guide digital transformation. Twin transformation builds upon the long-standing trajectory of digital transformation, which has laid the technological and organizational foundations for its emergence.

Yet despite this foundation, many organizations continue to face significant difficulties in implementing digital transformation successfully. Both research and practice continue to lack a comprehensive understanding of how to effectively manage and sustain digital transformation over time. At the same time, growing environmental and social challenges ranging from poverty to climate change are intensifying the need for sustainability transformation, pushing twin transformation further into the spotlight. The traditional focus of digital transformation, which was primarily geared toward achieving economic goals at an organizational level, appears increasingly insufficient for addressing today's complex, multidimensional challenges. Organizations are now expected not only to advance digital transformation but also to take responsibility for the social well-being of individuals and environmental sustainability of society, alongside maintaining economic performance. In response, the transformation agenda of organizations is shifting toward an integrated approach that combines economic, ecological, and social sustainability across individual, organizational, and societal levels. This evolution from digital transformation to twin transformation is increasingly evident in both research and practice, signaling a shift from siloed transformation efforts toward more integrated and synergistic approaches.

Addressing these research gaps, specifically, the limited understanding of how digital transformation can be effectively managed and sustained over time, how it can serve as a basis for broader twin transformation, and how the evolution toward an integrated twin transformation unfolds, this thesis pursues two primary research objectives: (1) deepening the understanding of digital transformation as a foundation for twin transformation, and (2) exploring the evolution from digital transformation to twin transformation and analyzing twin transformation in detail. Together, these two parts offer a comprehensive and cumulative perspective on how organizations can evolve from navigating digital transformation to managing the broader and more complex challenge of twin transformation. The thesis structures the transformation pathway across individual, organizational, and societal levels, and examines the economic, ecological, and social dimensions of sustainability.

Aligned with these objectives, the first three research articles focus on the organizational level and primarily address the economic dimension of sustainability, thereby contributing to the first research objective. Research Article 1 investigates technological progress as a key driver of digital transformation by examining how new technological features (i.e., affordances) evolve across technology iterations and ultimately trigger change. Building on these insights, Research Article 2 analyzes *what* changes occur

within organizations as a result of digital transformation and *how* these changes evolve over time. Research Article 3 finally explains how agile practices can drive and sustain organizational change throughout digital transformation, thereby exploring the concept of agile transformation.

On these grounds, the second part of the thesis shifts focus on the broader challenge of twin transformation, forming the basis of the second research objective. The thesis expands the analytical lens to the individual, organizational, and societal levels, and addresses all three dimensions of sustainability. Research Article 4 explores the interplay between digital and sustainability transformation, identifying twin transformation initiatives, synergies, and cross-cutting effects across organizational layers. To thereby ensure alignment between digital and sustainability goals, Research Article 5 examines how organizations can develop and embed a twin transformation strategy into their overarching business strategy. Finally, Research Article 6 addresses the social dimension of sustainability at both the individual and societal levels, contributing to a nascent design theory by formulating design principles for assistive digital technologies that foster social inclusion.

This thesis makes a meaningful contribution to Information Systems literature by introducing and exploring the evolution from digital transformation to twin transformation. Drawing on six research articles, the thesis offers both theoretical insights and practical guidance for researchers and practitioners. The findings not only inform future research directions but also provide valuable input for the design of integrated transformation efforts. In light of accelerating change and rising societal and environmental challenges, this thesis calls for a fundamental rethinking of transformation, emphasizing the need for integrated and synergistic approaches. The evolution from digital transformation to twin transformation signals the start of a broader shift toward multi-dimensional, interconnected transformations. By advancing this emerging field, the thesis fosters a more sustainable, resilient, and forward-looking understanding of transformation, one that enables individuals, organizations, and society to navigate complexity and shape meaningful, lasting change.

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Acronyms

AI	Artificial Intelligence
DO	Design Objective
DP	Design Principle
DSR	Design Science Research
DT	Digital Transformation
IoT	Internet of Things
IS	Information Systems
IT	Information Technology
UN	United Nations
SDG	Sustainable Development Goal
ST	Sustainability Transformation
TT	Twin Transformation

I. Introduction

I.1 Motivation

Pressing societal challenges, most notably the intensifying climate crisis and persistent social inequalities, such as impairments for people with disabilities or widespread poverty, are placing increasing pressure on individuals, organizations, and institutions alike (Christmann et al., 2024). Approximately 1.3 billion people, about 16 percent of the global population, live with significant disabilities and face ableism, stigma, and discrimination across all areas of life (World Health Organization, 2022). Another staggering 1.1 billion individuals live in acute poverty, nearly half of whom are children under the age of 18 (Alkire et al., 2024). These social inequalities are further intensified by the escalating climate crisis. According to Olhoff et al. (2024), the world is currently on a course toward a global temperature increase of 2.6°C to 3.1°C by the end of the century, a trajectory that will disproportionately affect marginalized populations already confronting substantial social, economic, and political disadvantage (United Nations Development Programme, 2023). For instance, individuals with disabilities are disproportionately affected by the negative consequences of climate change. These include heightened risks to their health, food and water access, energy and sanitation services, as well as their livelihoods, particularly in developing countries (Human Rights Council, 2020).

As these interwoven social and environmental challenges continue to intensify, digital technologies are increasingly seen not only as drivers of operational efficiency but also as powerful catalysts for societal change (Kotlarsky et al., 2023). Their potential extends far beyond automation and economic value creation, offering meaningful pathways to address complex global issues such as inequality, poverty, and climate change (Christmann et al., 2024; Kotlarsky et al., 2023). Yet, meaningful progress cannot be achieved through isolated efforts that prioritize economic, ecological, or social outcomes in isolation (Zimmer & Järveläinen, 2022). Instead, it is essential to adopt an integrated and holistic approach that simultaneously addresses economic, ecological, and social outcomes, which align with the UN's three pillars of sustainability (Kotlarsky et al., 2023; Zimmer & Järveläinen, 2022). Economic sustainability promotes long-term welfare and economic growth, social sustainability ensures the protection of human rights and overall well-being, and ecological sustainability supports environmental preservation (Purvis et al., 2019). This integrated perspective gave rise to the concept of Twin Transformation (TT), the simultaneous and coordinated pursuit of digital transformation (DT) and sustainability transformation (ST) (Breiter et al., 2024; Christmann et al., 2024; Graf-Drasch et al., 2023).

The concept of TT builds upon two foundational sustainability paradigms in IS research, Green IT (focused on minimizing the environmental impact of IT) and Green IS (focused on designing and using IS to support sustainability goals), and is rooted in the long-standing trajectory of DT (Kotlarsky et al., 2023). As such, a thorough understanding of DT forms a critical foundation for exploring and implementing TT. DT provides the expertise to harness technological progress, offers insight into complex change processes, and cultivates agile capabilities needed to navigate future transformations,

including those driven by sustainability imperatives. Without this foundation, organizations may lack the capacity to effectively align digital innovation with broader ecological and social objectives.

Over the past two decades, the continuous and unstoppable advancement of digital technologies has been fundamentally transforming organizations, markets, and entire industries (Vial, 2019; Yoo et al., 2010). This profound change is driven by the unique characteristics of digital technologies, namely, their re-programmability (i.e., the separation of operational logic from physical embodiment), data homogenization (i.e., the conversion of analog signals into binary data), and their self-referential nature (i.e., digital technologies build upon the use of other digital technologies) (Yoo et al., 2010). Drawing on these distinctive features, the outcomes of digital technologies can be set apart from traditional IT artifacts through their capacity for convergence (i.e., ability to flexibly combine previously separate components of digital technologies to create innovations) and generativity (i.e., capacity of digital technologies to produce spontaneous and unforeseen changes) (Ciriello et al., 2018; Yoo et al., 2010). Together, the advancements of digital technologies have triggered three waves of transformation: digitization, digitalization, and DT (Yoo et al., 2010).

The first wave, *digitization*, refers to converting analog information into digital formats, enabling more efficient data storage, processing, and transmission (Legner et al., 2017; Yoo et al., 2010). This phase focused on operational improvements by integrating basic digital technologies (e.g., standard enterprise resource planning systems) into existing workflows (Soluk & Kammerlander, 2021; Yoo et al., 2010). The second wave, *digitalization*, also known as IT-enabled transformation (Wessel et al., 2021), expanded the scope of digital technologies to enable new forms of external value creation (Legner et al., 2017; Pawlowski et al., 2025; Soluk & Kammerlander, 2021). This phase emphasized innovative, digitally enhanced products and services driven by both technological progress and rising customer expectations (Soluk & Kammerlander, 2021). The third wave, *DT*, marks a far-reaching and organization-wide transformation that transcends an organization's boundaries (Bharadwaj et al., 2013; Vial, 2019). This thesis adopts Vial's (2019, p. 120) definition of DT as *"a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies."* In contrast to digitalization, which typically refers to isolated innovations that enhance an existing value proposition (Liang Li et al., 2018; Wessel et al., 2021), DT demands a profound sociotechnical transformation (Legner et al., 2017), requiring a fundamental rethinking of the organization as a whole (Chanias et al., 2019). Technological progress increasingly influences not only an organization's strategy and structure (Bharadwaj et al., 2013; Chanias et al., 2019), but also shapes its corporate culture (Karimi & Walter, 2015), and redefines its value proposition (Wessel et al., 2021). As a result, organizations are beginning to integrate previously fragmented digitalization initiatives across departments and functions, with the goal of establishing a cohesive and entirely new organizational identity (Sebastian et al., 2017; Wessel et al., 2021).

I. INTRODUCTION

Organizations increasingly recognize DT as essential for long-term competitiveness in the digital age (Hanelt et al., 2021; Vial, 2019). Key technological advancements such artificial intelligence (AI), cloud computing, and internet of things (IoT) have profoundly reshaped how organizations operate (Hanelt et al., 2021; Legner et al., 2017), giving rise to an unpredictable and open-ended value landscape (Henfridsson et al., 2018). The unprecedented speed and scale of these technological advancements place organizations under continuous pressure to adapt to rapidly evolving market dynamics.

Despite extensive attention in both IS research (e.g., Hanelt et al., 2021; Vial, 2019) and practice (e.g., Fitzgerald et al., 2013; Westerman et al., 2014), many organizations struggle to fully realize the potential of DT due to its complex, multi-level nature (Carroll et al., 2021; Oberländer et al., 2025; Vial, 2019). With reported failure rates beyond 80 percent (Wade & Shan, 2020), significant barriers continue to impede successful DT (Carroll, Conboy, Hassan, et al., 2023; Rowe, 2018). A major challenge stems from the fragmented and diverse DT literature, which lacks consensus on foundational issues, particularly regarding how DT can be effectively managed and sustained over time (Carroll et al., 2021). Overcoming these challenges demands a more nuanced and integrated understanding of the process of DT (Carroll et al., 2021). Fundamentally, this raises questions on how technological progress triggers successive waves of technology iteration, what kinds of organizational changes these waves set in motion, and how these changes unfold over time within organizations (Chanias et al., 2019; Hanelt et al., 2021; Vial, 2019). At the same time, to navigate the high levels of uncertainty and rapid change, organizations must develop dynamic capabilities to effectively manage ongoing transformation (Warner & Wäger, 2019). In this regard, agile practices have gained traction as a promising means for fostering adaptability and responsiveness to shifting market conditions (Liu et al., 2022). Yet, despite the growing adoption of agile practices, our understanding remains limited to how these practices generate concrete value within organizations. Such knowledge would help organizations to guide DT and effectively scale agile practices. Developing this understanding is vital, not only to deepen theoretical insights into the process of DT, but also to establish a conceptual foundation for the evolution from DT to TT.

Throughout its history, the success of DT has predominantly been evaluated through the lens of economic sustainability (Barthel, 2021; Zimmer & Järveläinen, 2022) at the organizational level (Abraham & Junglas, 2011; Vial, 2019). DT contributes to economic sustainability by driving significant changes and creating value both within and beyond organizational boundaries (Hanelt et al., 2021; Mandrella et al., 2020; Oberländer et al., 2025). Internally (i.e., transformation of the organization) (Barthel, 2021), DT enhances process efficiency and process effectiveness by automating and optimizing tasks, reducing employee workload, and boosting overall productivity (Schryen, 2013; Zimmer & Järveläinen, 2022). Externally (i.e., transformation of the market offering) (Barthel, 2021), DT facilitates the development of new digital products and services, as well as the emergence of entirely new business models (Kane et al., 2015; Svahn et al., 2017). These innovations are aimed at generating additional revenue, expanding market share, enhancing the profitability of digital ventures, and

improving customer experiences through personalization and differentiated value propositions (Soluk & Kammerlander, 2021; Svahn et al., 2017).

However, with ST becoming a pivotal in IS research, the traditionally economic-centered approach of DT at the organizational level reveals significant limitations in addressing today's pressing societal and environmental challenges (Adams et al., 2016; Pasamar et al., 2023; Zimmer & Järveläinen, 2022). In line with Zimmer and Järveläinen (2022), we define ST as a fundamental transformation of organizational cultures, structures, and practices aimed at enhancing the triple bottom line while ensuring human well-being within the earth's carrying capacity. While DT has mainly been driven by technological progress (Chanias et al., 2019; Vial, 2019; Wessel et al., 2021), growing societal and environmental challenges are reshaping expectations and demand a more comprehensive and responsible approach to transformation (Dyllick & Muff, 2016; Seidel et al., 2013). Organizations are now expected not only to innovate digitally but also to contribute actively to environmental stewardship and social well-being alongside achieving economic growth (Zimmer & Järveläinen, 2022). Consequently, the transformation agenda is expanding beyond a purely digital and economically driven focus on the organizational level to incorporate sustainability goals across multiple levels (Bengtsson & Ågerfalk, 2011; Zimmer & Järveläinen, 2022).

Organizations are now challenged to rethink their strategies, operations, and innovations to contribute meaningfully to broader societal and environmental objectives, while continuing to leverage digital technologies for competitive advantage and economic growth (Purvis et al., 2019). This evolution gives rise to the concept of TT. While DT and ST have traditionally been viewed as separate and isolated transformations (Maffei et al., 2019; Zimmer & Järveläinen, 2022), TT aims to overcome these isolated transformation perspectives and pursue DT and ST in an integrated approach (Breiter et al., 2024; Christmann et al., 2024; Graf-Drasch et al., 2023). TT seeks to simultaneously advance economic, ecological, and social sustainability across individual, organizational, and societal levels by leveraging the mutually reinforcing relationship between DT and ST. DT and ST represent equally important and interdependent transformation pathways: DT opens up a vast opportunity space through technological innovation that enables ST (i.e., DT *enables* ST), while ST provides the normative orientation needed to navigate and shape this space, providing essential guidance to DT (i.e., ST *guides* DT) (Christmann et al., 2024). This interplay, shown in Figure 1, highlights a dynamic of mutual dependence, where each transformation contributes uniquely to the realization of TT. On one hand, DT acts as a powerful enabler of ST by offering digital technologies and advanced capabilities, such as data analytics and AI, these generate deep insights into environmental and social impacts, supporting evidence-based sustainability decisions (Khan, Kaur, et al., 2021). Moreover, with DT's long history, multiple best practices were refined on managing complex transformation processes and on implementing digital technologies to accelerate business developments at high speed and scale (Soluk & Kammerlander, 2021). As such, DT not only supports the achievement of economic goals and ensures organizational competitiveness but also serves as a foundational enabler for other forms of transformation, including TT (George et al.,

2020; Vega & Chiasson, 2019). On the other hand, ST enriches and redirects DT by embedding broader societal and ecological values into its logic and objectives. It challenges the conventional focus on efficiency and profitability, instead promoting purpose-driven innovation and long-term value creation aligned with the common good (Dyllick & Muff, 2016; Seidel et al., 2013). ST thus redefines the purpose of DT and ensures that technological progress serves a sustainable and inclusive future. For organizations, this interdependence requires a dual perspective: understanding not only how DT can drive sustainability, but also how sustainability imperatives can reshape the path and purpose of DT.

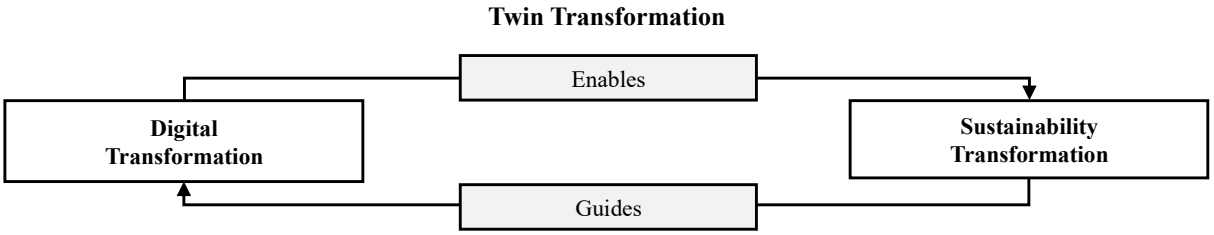

Figure 1. The Twin Transformation Interplay

Despite its growing relevance in both IS research and practice, the conceptualization, strategic development, and organizational anchoring of TT remains a complex challenge. In response, this thesis investigates the interplay between DT and ST, identifying concrete TT initiatives as well as DT and ST themes structured along organizational layers build on Alter's (2013) work system framework. Special emphasis is placed on the strategy layer, where a theoretically grounded and stepwise approach is proposed for formulating a TT strategy (Schallmo et al., 2024). This approach enables the alignment of economic, ecological, and social objectives within the overarching business strategy. While much of existing TT research focused on the ecological dimension of sustainability at the organizational and at the societal level, this thesis places particular emphasis on the underexplored social dimension of sustainability (Kotlarsky et al., 2023). It addresses the critical question of how assistive digital solutions must be designed intentionally to foster social inclusion and contribute meaningfully to the broader goal of improving quality of life for everyone.

In sum, the evolution from DT to TT is driven by the growing need to address not only economic sustainability at the organizational level but also ecological and social sustainability across individual, organizational, and societal levels. This evolution is increasingly driven by growing societal and environmental challenges, all of which require a more integrated and synergistic approach to change. In this context, the evolution from DT to TT shows that viewing transformation as a simple sequence of steps (like digitization, digitalization, and DT) or treating different types of transformations separately (such as DT and ST) is no longer sufficient. To effectively respond to today's complex and interdependent challenges, organizations must increasingly adopt an integrated and synergistic approach to transformation, such as that offered by TT. Building on this premise, this thesis draws from a comprehensive understanding of DT to explore the emerging phenomenon of TT, offering insights into how organizations can effectively integrate digital and sustainability imperatives.

I.2 Research Objectives

While organizations still primarily focus on rethinking their value propositions to adapt to the digital economy (Danneels & Viaene, 2022; Matt et al., 2015; Vial, 2019; Wessel et al., 2021), the global context in which these transformations occur is changing dramatically. It is more evident than ever that peace, prosperity, and the planet itself are under threat. In response, there is growing awareness across all types of organizations, even those traditionally oriented toward linear growth models, that a transition toward more sustainability is both urgent and inevitable (Zimmer & Järveläinen, 2022). As a result, we are witnessing an evolution from a digital and economically driven DT, largely centered at the organizational level, toward a more integrated approach that embraces economic, ecological, and social sustainability across individual, organizational, and societal levels (Bengtsson & Ågerfalk, 2011; Zimmer & Järveläinen, 2022). Against this backdrop, this cumulative doctoral thesis seeks to contribute to the overarching research question of *how organizations can navigate the evolution from digital transformation to twin transformation.* It sets out two primary research objectives: (1) deepening the understanding of DT as a foundation for TT and (2) exploring the evolution from DT to TT and analyzing TT in detail. Together, these two parts provide a comprehensive understanding of how organizations evolve from navigating DT to managing the broader and more complex challenge of TT. The thesis structures the transformation pathway across individual, organizational, and societal levels, and examines the economic, ecological, and social dimensions of sustainability.

In the first part, the thesis deepens the understanding of DT by focusing on the organizational level and examining the economic dimension of sustainability. The second part expands the perspective by analyzing the evolution toward TT, providing insights at the individual, organizational, and societal levels across all three dimensions of sustainability. Figure 2 illustrates the positioning of the Research Articles in terms of their levels of impact (i.e., individual, organizational, societal) and the dimensions of sustainability (i.e., economic, ecological, social) they address. The matrix highlights the overall development of the field, while the marked boxes indicate the specific contributions of this thesis. By actively shaping and significantly advancing the field, this thesis provides novel insights into the evolution from DT to TT, making it highly relevant for both researchers and practitioners.

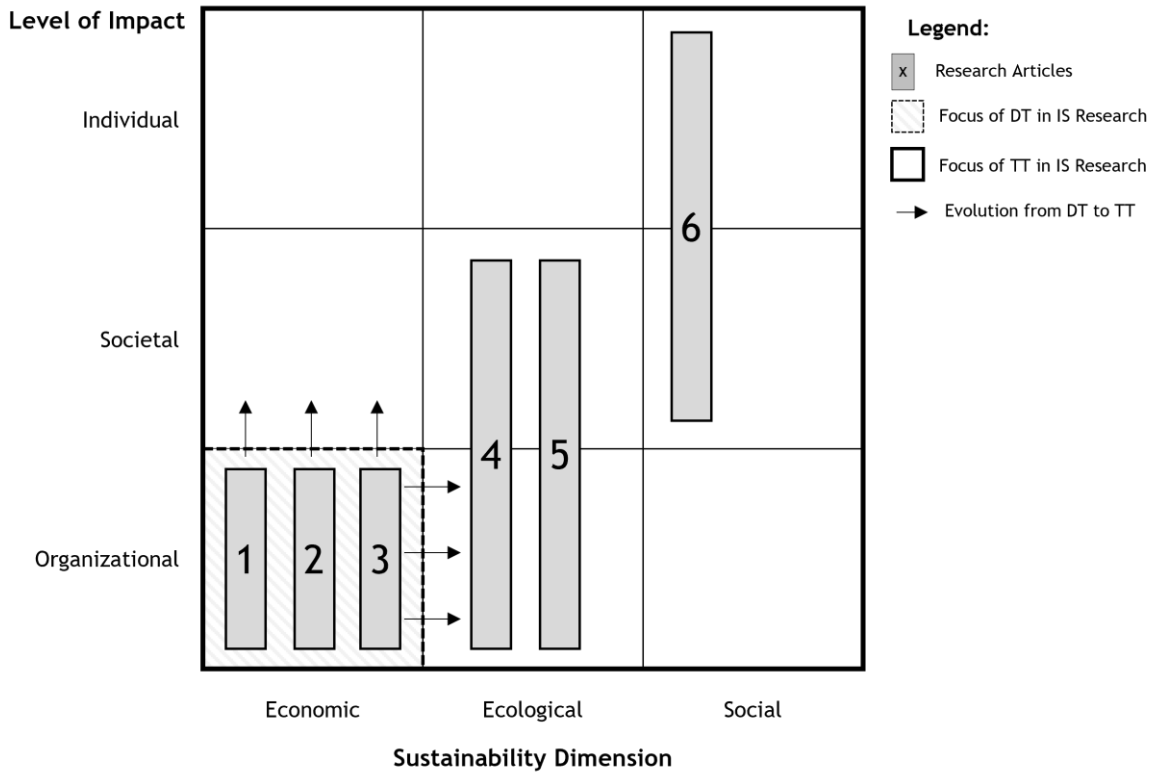

Figure 2. Assignment of the Research Articles to the Key Research Areas of this Thesis

This thesis deepens the understanding of DT at the organizational level, with a particular emphasis on the economic dimension of sustainability, making three significant contributions to the academic discourse on this subject (Section II). First, Research Article 1 investigates technological progress as a key driver of DT, examining how new technological features (i.e., affordances) evolve across technology iterations and ultimately trigger organizational change (Section II.1). Second, building on the identified drivers of change, Research Article 2 analyzes *what* changes occur within organizations as a result of DT and *how* these changes evolve over time, shedding light on the dynamics and challenges of organizational change processes (Section II.2). Third, Research Article 3 explains how agile practices can drive and sustain organizational change throughout DT, thereby exploring the concept of agile transformation (Section II.3).

Building on the insights gained from the study of DT, the second part of this thesis broadens the focus to address the more comprehensive challenge of TT (Section III). The thesis expands the analytical lens to the individual, organizational, and societal levels, and addresses all three dimensions of sustainability. Research Articles 4 and 5 examine both organizational and societal levels of impact, with a primary emphasis on the ecological dimension of sustainability. Research Article 4 explores the interplay between DT and ST, identifying TT initiatives, synergies, and cross-cutting effects across different organizational layers (Section III.1). To thereby ensure alignment between digital and sustainability goals, Research Article 5 examines how organizations can develop and embed a TT strategy into their overarching business strategy (Section III.2). Finally, Research Article 6 addresses the social dimension of sustainability at both the individual and societal levels, contributing to a nascent design theory

(Level 2, Gregor & Hevner, 2013) by formulating design principles for assistive digital technologies aimed at fostering social inclusion (Section III.3).

This thesis addresses the central research question of *how organizations can navigate the evolution from digital transformation to twin transformation.* It does so by first deepening the understanding of DT as a foundation and then exploring the evolution to TT through a detailed analysis of its characteristics and dynamics. The research adopts qualitative methodologies, drawing on grounded theory (Gioia et al., 2013; Wolfswinkel et al., 2013) to investigate emerging and fast-evolving phenomena such as DT and TT, and applying the design science research paradigm (Hevner et al., 2004; Tuunanen et al., 2019) to generate actionable design knowledge. To examine DT and TT from multiple angles, the thesis incorporates a range of theoretical perspectives, such as affordance theory, work systems theory, organizational change theory, paradoxical tensions theory, enabling a multi-level analysis across individual, organizational, and societal contexts.

I.3 Structure of the Thesis and Embedding of the Research Articles

This thesis comprises six Research Articles that collectively contribute to addressing the research objectives outlined in Section I.2. Table 1 provides an overview of the overall thesis structure and the embedded Research Articles.

The structure of the thesis is as follows: Section I introduces the research gaps addressed in this thesis and outlines the overarching research objectives. Section II deepens the conceptual understanding of DT. The three Research Articles included lay the groundwork for the evolution toward TT by examining how technological progress and emerging affordances trigger organizational change, *what* changes occur within organizations as a result of DT, *how* these changes evolve over time, and how agile practices can drive and sustain organizational change throughout DT. Section III explores the evolution from DT to TT and analyzes TT in detail. It includes three Research Articles that investigate the interplay between DT and ST across organizational layers, how a TT strategy can be developed and be integrated into the overarching business strategy, and how assistive digital technologies should be designed to foster social inclusion. Section IV presents a summary of the key findings and limitations of the thesis before it outlines relevant avenues for future research. Section V lists all references. The appendix in Section VI provides an index of the Research Articles, a summary of their individual author contributions, and the full versions of the Research Articles.

I.	**Introduction**
II.	**Deepening the Understanding of Digital Transformation**
	Research Article 1 What's Next? – Toward a Theory of Technology-Affordance-Evolution Lockl, A., Lockl, J., Oberländer, AM., Weidlich, R.
	Research Article 2 Understanding Organizational Change in the Context of Digital Transformation – A Multi-Level Perspective Henner, G., Lockl, A., Oberländer, AM., Röglinger, M., Schäfer, R.
	Research Article 3 Scaled Agile Framework Meets Traditional Management – A Case of a Financial Services Provider Bitzer, M., Brax, F., Lockl, A.
III.	**Exploring the Evolution from Digital to Twin Transformation**
	Research Article 4 Driving Twin Transformation – The Interplay of Digital Transformation and Sustainability Transformation to Realize Twin Transformation Lockl, A., Heim, L., Oberländer, AM.
	Research Article 5 Navigating Twin Transformation – A Systematic Approach for Twin Transformation Strategy Development Heim, L., Buck, C., Lockl, A., Oberländer, AM.
	Research Article 6 Towards Digitally Enabled Social Inclusion – Navigating Tensions in the Design of Assistive Digital Technologies Kneissel, K., Lockl, A., Oberländer, AM., Rosemann, M.
IV.	**Conclusion**
V.	**References**
VI.	**Appendix**

Table 1. Structure of the Thesis Embedding the Research Articles

II. Deepening the Understanding of Digital Transformation

As outlined in Section I, the concept of TT builds on the long-standing trajectory of DT. Decades of IS research have examined how the emergence and interplay of new technologies shape transformation processes, providing essential insights into how organizations can navigate dynamic and uncertain environments. Building on these insights, it becomes essential to further investigate technological progress as a fundamental driver of DT. Such an investigation asks for understanding how evolving technological features, referred to as affordances, emerge across successive technology iterations and ultimately trigger organizational change. These dynamics are explored in Section II.1 (Research Article 1). Expanding on this foundation, Section II.2 (Research Article 2) examines *what* changes occur within organizations as a result of DT and *how* these changes evolve over time. These insights offer a robust conceptual foundation for the evolution from DT to TT and can be transferred to the analysis of the emerging phenomenon TT. Having completed the examination of the first research objective (i.e., to deepen the understanding of DT as a foundation for TT), this thesis explores agile transformation. It illustrates how agile practices drive and sustain change throughout DT (Section III.3, Research Article 3). It thereby provides another vital basis for TT.

II.1 Technological Progress as a Driver of Organizational Change

As technology advances at an unprecedented pace, it is vital to align evolving action possibilities with user goals to create value for both users and organizations (Lixu Li et al., 2025; Steffen et al., 2019; Vassilakopoulou et al., 2023). Affordance theory explains many aspects of technology use by focusing on how users perceive and actualize the action possibilities that technologies offer (Seidel et al., 2013). Affordance theory has traditionally been studied within single, isolated technology iterations (e.g., Leonardi, 2011; Thapa & Sein, 2018) Thapa and Sein's (2018) "trajectory of affordance", for example, focuses on how affordances evolve and build upon each other within the same technology iteration. However, Research Article 1 argues that such a narrow, time-bound perspective is no longer sufficient. As technology progresses across multiple iterations, new affordances may arise not only from the actualization of previous affordances within a single technology iteration but also from broader technological advances. Therefore, the study proposes an expanded, longitudinal view of affordance evolution that considers spatiotemporal change and stepwise technological development over time. Ignoring technological progress risks developing an incomplete understanding of affordances and overlooking insights about earlier technology iterations or their interrelations. This limits the transferability of knowledge across iterations and weakens the explanatory and predictive power of affordance research. In view of these risks, Research Article 1 asks the following research question: *How does affordance evolution unfold in the course of technological progress?*

Research Article 1 introduces the Theory of Technology-Affordance-Evolution as a response to the limitations of existing affordance theory, particularly its narrow focus on single technology iterations. At its core are three distinct patterns of technology-affordance evolution. Each represents a unique

pathway by which affordances evolve throughout the course of technological progress. These patterns build on the foundational work of Thapa and Sein (2018) and are further informed by the complementary perspectives of Arthur (2009) and Leonardi (2011). Arthur (2009) emphasizes the compositional logic of technological evolution, in which new technologies are assembled from the components of previous ones. Leonardi (2011) extends this view by highlighting the dynamic interplay between users and technology, where user goals, practices, and constraints actively shape technological progress.

In line with this perspective, Research Article 1 argues that just as new technologies are constructed from components of previous ones, affordances of a technology are similarly composed of and evolve from the basic affordances of its sub-technologies. However, this evolution depends on the presence of goal-oriented actors, who actualize existing affordances and, in doing so, adapt their goals. When current technology iterations cannot fulfill these evolving goals due to inherent constraints, this gap drives the development of technology iterations, which in turn unlock new affordances.

This recursive cycle of constraint, adaptation, and technological progress forms the basis for the proposed patterns of affordance evolution. Figure 3 illustrates this dynamic interplay between technological progress and affordance evolution.

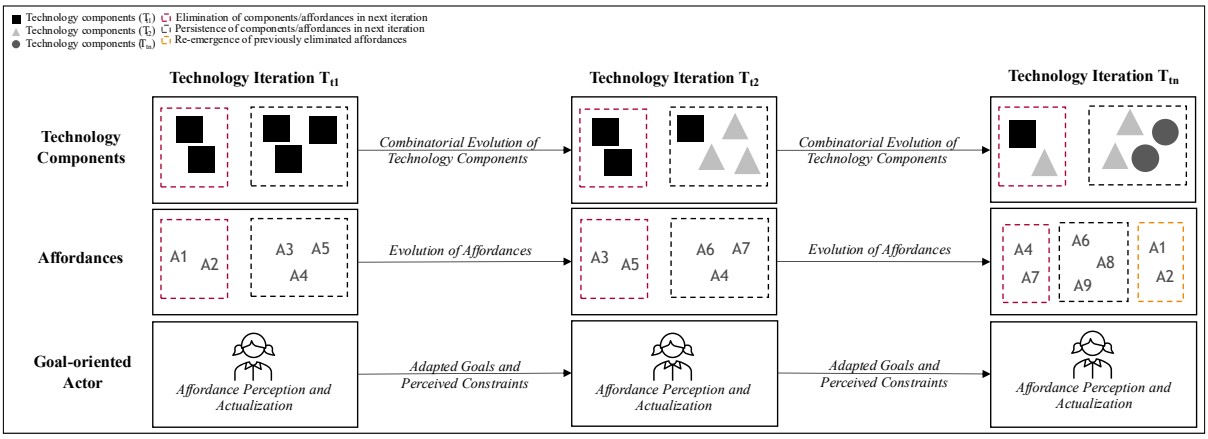

Figure 3. Overview of Technological Progress and Affordance Evolution

Pattern I – Technology-Driven Affordance Evolution explains how affordances evolve from one technology iteration to the next. The features of a given technology (T_{t1}), together with facilitating conditions, lead to the perception and actualization of an affordance (A1). The actualization of an affordance, or a cluster of affordances, prompts users to adapt their goals (Leonardi, 2011), which can, in turn, lead to the perception and actualization of further affordances (A2). Thereby the evolution of a new affordance (A2) is not necessarily confined to a single technology iteration. Instead, it evolves from the interaction between a previously actualized affordance (A1) and a newly available technology iteration (T_{t2}). Technological progress unfolds when actualized affordances lead to user goals that exceed what the current iteration can support (Arthur, 2009; Leonardi, 2011). A subsequent technology iteration builds on the sub-technologies of its predecessor (Arthur, 2009), whose embedded affordances provide the foundation for further affordance evolution in the latest technology iteration. Thus, new affordances

are created out of the previously actualized affordances from the previous technology iteration in combination with technological progress (i.e., Figure 4).

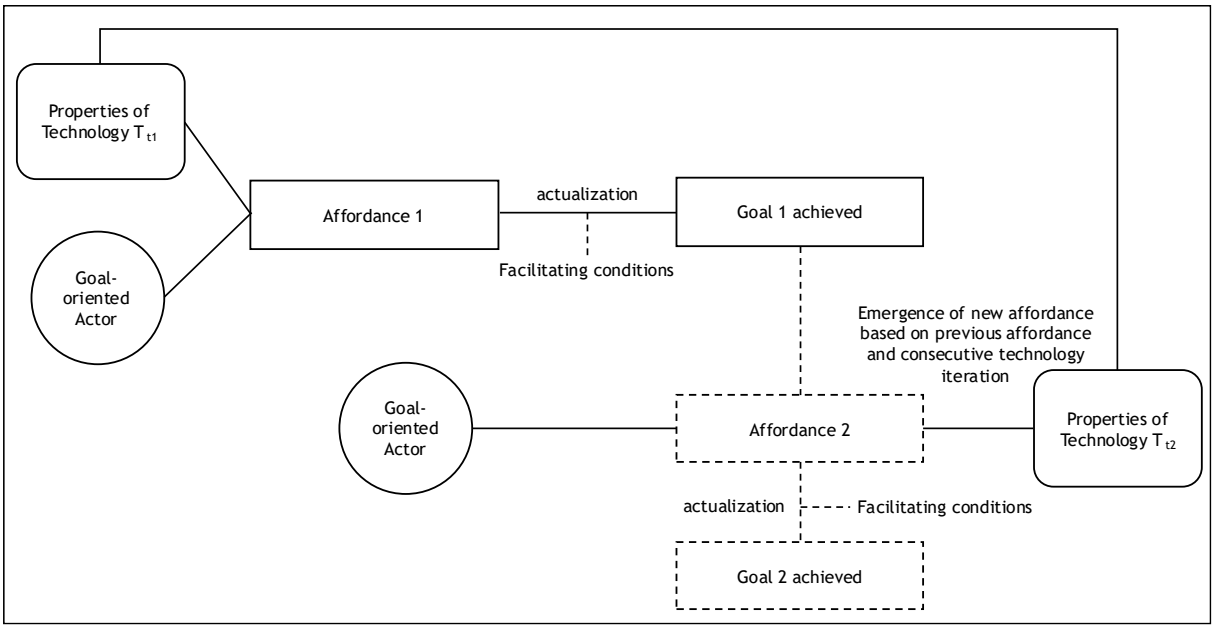

Figure 4. Technology-driven Affordance Evolution

Pattern II – Non-Consecutive Technology-Driven Affordance Evolution describes how an affordance can evolve across non-sequential technology iteration. In Pattern I, affordance development follows a consecutive sequence. In contrast, Pattern II shows that an affordance in a more advanced iteration (T_{t3} or beyond) may build upon a previously actualized affordance from an earlier iteration (T_{t1}), bypassing intermediate iterations (T_{t2}) that did not offer the necessary technical features that would allow an extension of the affordance from T_{t1}. Pattern II highlights how technological progress is not always linear in effect. Some technology iterations may retain existing affordances without enhancing or transforming them, while others, further along the trajectory, introduce new technical features that allow for meaningful affordance evolution. Pattern II captures how new affordances can evolve discontinuously, drawing on the foundations of earlier technology iterations and skipping over iterations that, although relevant, did not allow for affordance evolution (i.e., Figure 5).

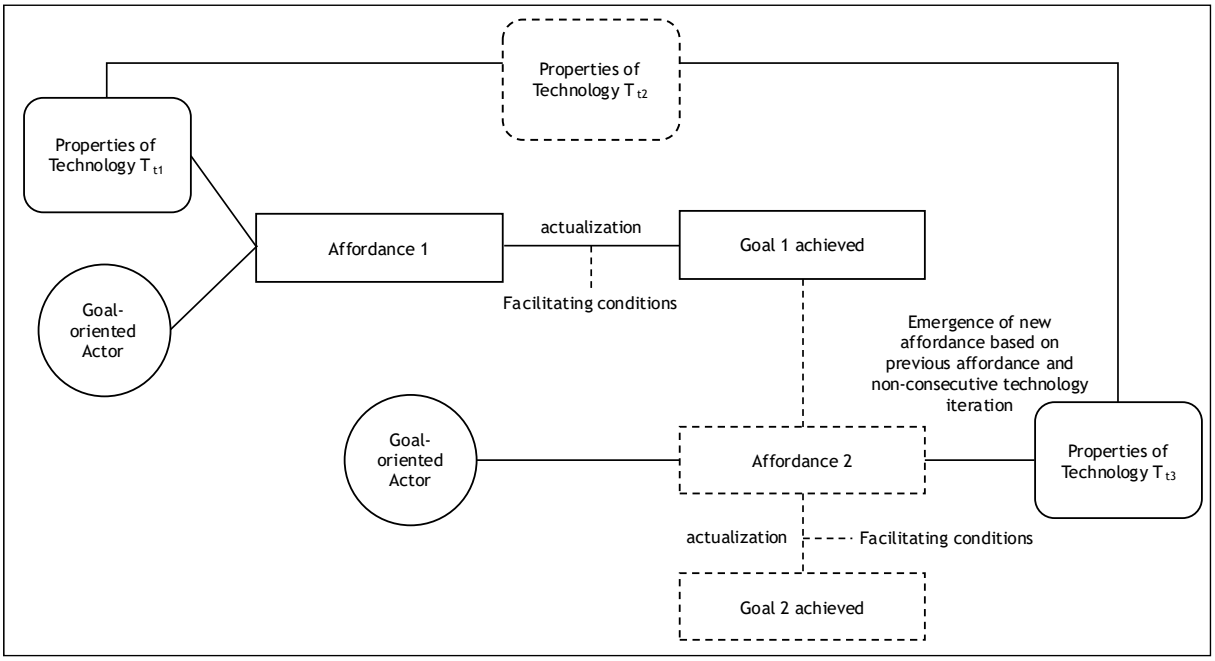

Figure 5. Non-consecutive Technology-driven Affordance Evolution

Pattern III – Affordance Elimination and Re-Emergence addresses a less-explored but equally important dynamic: the disappearance and later re-emergence of affordances as a consequence of technological progress. Technological progress often introduces new constraints even as it resolves old ones (Volkoff & Strong, 2018). In this process, some affordances get lost, because they are no longer supported by the features of the new technology iteration. However, as technology continues to evolve, these affordances can re-emerge in a more advanced iteration. Pattern III thus reveals that affordance evolution is not merely about linear progress but also involves a dialectical process of loss and restoration driven by shifts in user expectations and technical features (i.e., Figure 6).

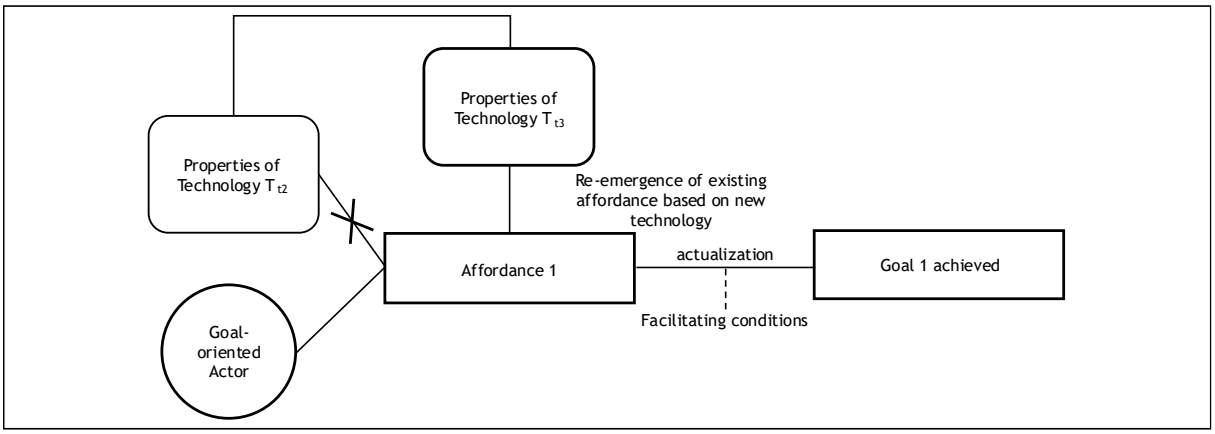

Figure 6. Affordance Elimination and Re-emergence

The main contribution of Research Article 1 is the development of the Theory of Technology-Affordance-Evolution, which extends the well-established trajectory of affordances (Thapa & Sein, 2018) by incorporating a longitudinal perspective. While prior IS research has primarily focused on affordance evolution within a single technology iteration, this approach tends to overlook critical

spatiotemporal interrelations that occur across multiple iterations. In response, Research Article 1 proposes a theory that captures the process of affordance evolution over time. By leveraging spatiotemporal insights into how affordances emerge, disappear, and re-emerge, the theory enables the identification of affordance gaps and future technological needs. As such, it makes a significant contribution to the explanatory knowledge of affordance evolution within IS research. The paper's theoretical implications are twofold. First, it enriches affordance research with a longitudinal perspective, encouraging scholars to trace affordances across technology iterations rather than examining them in isolation. This perspective invites researchers to build on existing knowledge, linking current technology iterations to their historical foundations, thereby deepening theoretical understanding and avoiding redundant inquiries. Second, the paper highlights a neglected dimension of technological progress: the elimination and potential re-emergence of affordances. While IS literature often emphasizes the enabling power of technology, Research Article 1 argues that technological progress can also constrain user action by phasing out certain affordances, intentionally or as a byproduct of change. As technologies continue to evolve, some of these affordances may re-emerge in response to new technical features. Research Article 1 therefore calls upon IS scholars to explore not only how new affordances evolve, but also how and why older affordances are lost or re-emerge. The article advocates for a more nuanced, historically aware approach to affordance research.

In the broader context of this thesis, Research Article 1 lays the foundation for a more profound understanding of DT. It explores the role of technological progress as a key driver of DT and investigates how new technological features (i.e., affordances) evolve across technology iterations ultimately triggering organizational change.

II.2 Revealing Different Pathways of Organizational Change

DT has been widely discussed in IS research and practice for over two decades, but the prevalence of high failure rates remains an enduring challenge (Wade & Shan, 2020). Failure is due to barriers such as DT's complexity and a lack of clarity about what DT entails and how it affects organizations at different organizational levels. To overcome these barriers and improve DT success, a clear understanding of *what* changes during DT and *how* organizational change unfolds is necessary. However, debates differ on the types of change in DT. Some view DT as a source of continuous change, others as episodic, while some argue it can be either or a mixture of both due to its uncertain boundaries. Different perspectives arise because organizational change in DT is studied at different levels: at the organizational level (e.g., Hanelt et al., 2021; Vial, 2019; Wessel et al., 2021), within specific organizational areas (e.g., Gregory et al., 2018), or in the context of day-to-day operations (e.g., Hinsen et al., 2019; Iden & Bygstad, 2024; Mirbabaie & Marx, 2024). Since change occurs across and within these levels, and levels influence each other, understanding DT from a single-level perspective is insufficient (Findikoglu & Watson-Manheim, 2016; Iden & Bygstad, 2024; Oberländer et al., 2024). To improve the success rates of DT, greater clarity is needed about the nature of organizational change

within this context. A deeper understanding is needed of *what* changes occur at each level and *how* these changes unfold from an intra- and inter-level perspective. Therefore, Research Article 2 poses the following research question: *How does organizational change unfold within and across organizational levels in the context of digital transformation?*

Research Article 2 draws on a structured literature review (vom Brocke et al., 2015; Wolfswinkel et al., 2013), whose analysis follows Gioia et al. (2013). The article presents a multi-level analysis framework distinguishing the micro-level (individuals/teams), meso-level (departments/areas), and macro-level (organization). It identifies three change constructs that describe *what* changes occur at each level: DT initiatives (concrete changes embedded in employees' work routines and/or projects at the micro-level), DT patterns (collective changes embedded within specific organizational areas at the meso-level), and DT themes (organization-wide changes spanning multiple areas at the macro-level). Table 2 presents an overview of the different levels of analysis and associated change constructs, including their scope, definitions, and illustrative examples. Figure 7 shows the multi-level analysis framework including seven DT themes, 23 DT patterns, and one DT initiative for one exemplary DT pattern per theme. The DT themes do not follow a specific order from left to right.

Level	Scope	Change Construct	Definition	Example
Macro	Organization	DT Theme	Organization-wide changes embedded in and across multiple areas of an organization	Unfolding of employee engagement
Meso	Department/ Area	DT Pattern	Collective changes embedded in a specific area of an organization	Transforming from a focus on promoting employees' domain expertise to developing learning opportunities that promote digital literacy
Micro	Individual/ Team	DT Initiative	Concrete changes embedded in employees' work routines and/or projects	Provide customized self-learning opportunities that are easily integrable in the daily routine

Table 2. Overview of Levels of Analysis and Change Constructs

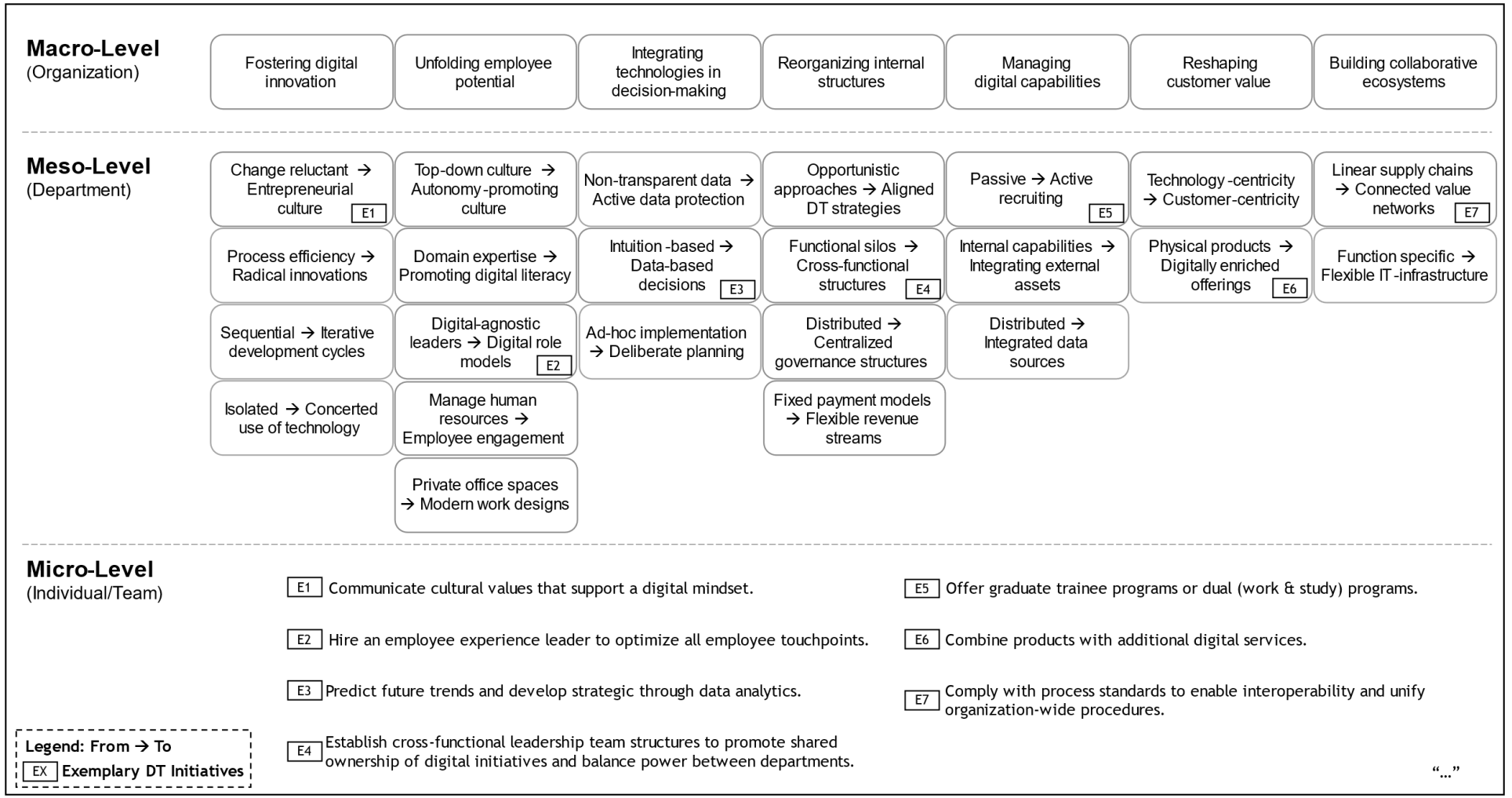

Figure 7. What Changes in the Context of Digital Transformation

After analyzing existing literature on *what* changes during DT at different organizational levels (DT initiatives, DT patterns, DT themes), Research Article 2 turns to *how* change unfolds across these levels. Drawing on multi-level theorizing, it finds that organizational change in DT originates at the micro-level since only human actors can initiate activities and decisions. Change at higher levels emerges through aggregation: micro-level initiatives form meso-level patterns, and meso-level patterns build macro-level themes. Thus, the nature of change at lower levels shapes how DT is perceived at higher levels. The study further analyzes DT initiatives based on their frequency and radicality. Some initiatives, like designing modern office concepts, occur infrequently but trigger radical change (i.e., episodic change). Others, such as providing regular learning opportunities, happen frequently but bring smaller incremental changes (i.e., continuous change).

At the meso-level, DT patterns emerge from the aggregation of similar DT initiatives, resulting in three types: (1) DT patterns composed solely of episodic initiatives, (2) DT patterns composed solely of continuous initiatives, and (3) hybrid DT patterns combining both. Figure 8 illustrates the aggregation of hybrid DT patterns. Purely episodic patterns are rare in practice, as they require all DT initiatives to start, last, and impact change simultaneously. Instead, most DT patterns evolve toward hybrid or continuous forms. At the macro-level, DT themes are composed of multiple DT patterns (episodic, continuous, or hybrid), and the nature of these patterns shapes *how* change unfolds at this level. The analysis shows that all seven macro-level DT themes identified in Research Article 2 exhibit a hybrid nature of change, characterized by a continuous flow of small changes, complemented by episodic periods of larger shifts. While purely episodic or purely continuous DT themes are theoretically possible, the literature reviewed indicates that macro-level DT themes are consistently hybrid.

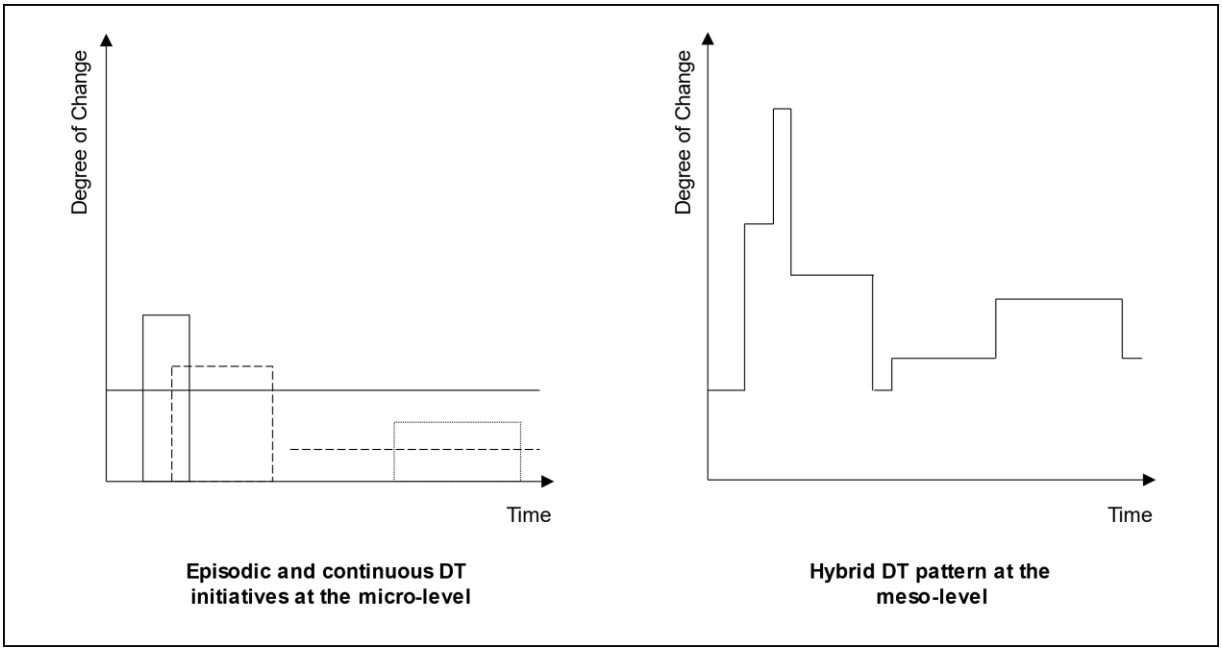

Figure 8. Aggregation of Hybrid Digital Transformation Patterns

In sum, Research Article 2 illustrates *how* change progresses from micro- to meso- to macro-levels. It shows that depending on the composition of DT initiatives, DT patterns, and DT themes, change unfolds differently across levels. Figure 9 illustrates *how* change aggregates across levels for the DT theme "fostering digital innovation", showing the related DT patterns and DT initiatives. At the micro-level, episodic and continuous DT initiatives coexist. As change aggregates through the meso- and macro-levels, the overall nature of change increasingly shifts toward a more continuous nature.

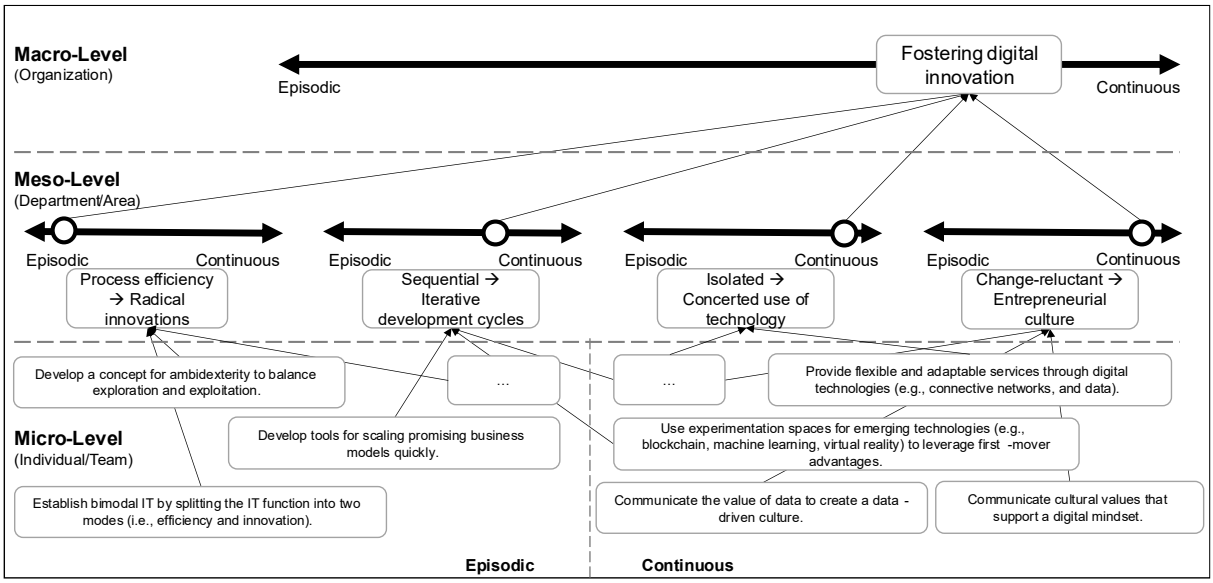

Figure 9. Exemplary Aggregation of Change Constructs for One DT Theme

By answering the question of *what* changes at each level and across levels and *how* organizational change unfolds from an intra- and inter-level perspective, Research Article 2 makes three key contributions. First, it develops a multi-level analysis framework that distinguishes between micro-, meso-, and macro-level of analysis. It serves as a means of explaining the complex phenomenon of organizational change in the context of DT. Second, it provides a detailed overview of changes at each level through the identification of DT initiatives (micro-level), DT patterns (meso-level), and DT themes (macro-level), advancing descriptive knowledge of DT. Third, it shows how organizational change progresses across levels. The article highlights that while change at the micro-level can be episodic or continuous, at higher levels, change tends to evolve into a more hybrid and continuous form due to aggregation and balancing effects. Overall, the study offers a more lucid and structured view on organizational change in DT, transcending the limitations of single-level perspectives.

Expanding on the foundation laid by Research Article 1, Research Article 2 delves into the specific changes brought about by technological progress and explores how these changes evolve over time.

II.3 Navigating Organizational Change in Dynamic Environments

Agile practices have become mainstream as organizations face increasingly volatile and complex markets (Brühl, 2022; Naslund & Kale, 2020). Following their success at the team level, organizations attempt to scale agile practices across larger, interdependent projects, leading to large-scale agile transformations (Carroll, Conboy, & Wang, 2023; Edison et al., 2022; Fuchs & Hess, 2018). However, maintaining agile principles while expanding across larger structures poses ongoing challenges (Dikert et al., 2016). Frameworks like SAFe (Scaled Agile Inc, 2023), LeSS (Larman & Vodde, 2015), or Spotify model (Kniberg & Ivarsson, 2012) have been introduced, but simply adopting these frameworks does not guarantee agility (Carroll, Conboy, & Wang, 2023). Research has primarily focused on early-phase challenges and success factors in scaling agile (Brühl, 2022; Kalenda et al., 2018; Santos & Carvalho, 2022), highlighting the importance of management support, framework customization, and business unit buy-in. Yet significant issues persist, such as resistance to change, conflicts with hierarchical structures, and difficulties integrating agile and non-agile teams (Dikert et al., 2016; Gabriel et al., 2021; Thesing et al., 2021). Some of these challenges stem from tensions between traditional management and agile approaches (Conboy & Carroll, 2019; Naidoo & Rikhosto, 2021). While frameworks seek to address these tensions (e.g., SAFe's lean agile portfolio management), more research is needed to understand how organizations navigate them. To address this gap, Research Article 3 addresses the following research question: *Which tensions arise when applying a scaled agile framework in a non-agile environment?*

Research Article 3 draws on an in-depth case study of a German financial services provider that adopted SAFe in 2018 to manage large-scale projects involving multiple interdependent teams across IT, marketing, and sales. The study focuses on an agile release train designed to enhance the customer journey by connecting sales, marketing, and back-office activities through a customer relationship management system. Structured according to SAFe, the agile release train includes 12 teams and 150 employees from IT, marketing, sales, and process management. Alongside non-agile projects, the agile release train forms part of the organization's broader IT project portfolio, managed by the IT division to ensure alignment with business objectives and corporate strategy. Figure 10 illustrates the agile release train's integration within the organizational structure.

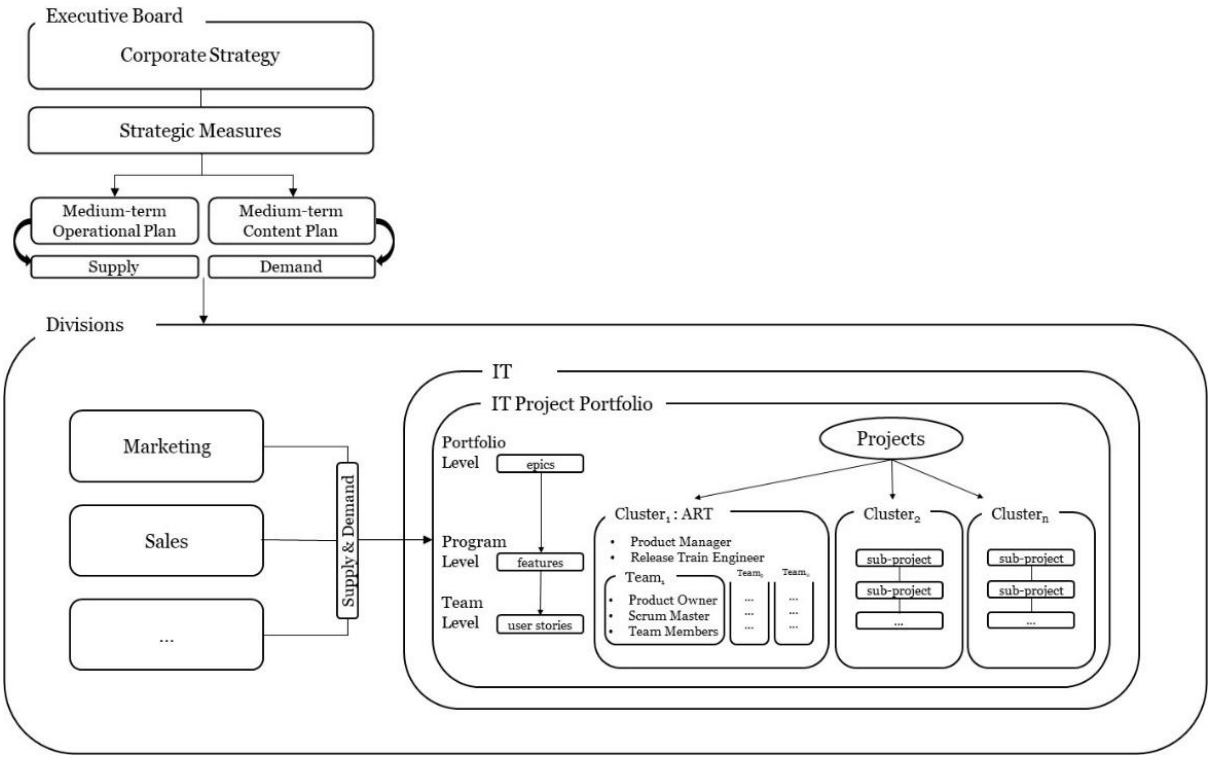

Figure 10. Integration of the Agile Release Train

Following Yin's (2018) case study method, data collection took place between November 2022 and April 2023, using multiple sources to ensure triangulation, including expert interviews, observations, and internal documents. A total of 16 semi-structured interviews were conducted with 18 participants from various organizational levels and backgrounds. Interviewees included agile roles (e.g., Release Train Engineer, Product Managers, Scrum Masters) as well as non-agile roles (e.g., Team, Department, and Division Managers) from different divisions like marketing, sales, IT, and process management. The analysis centered on the interplay between the agile release train and its non-agile environment, following Gioia et al. (2013). As a result, Research Article 3 identifies 13 tensions, grouped into three key areas: goal-setting, planning, and reporting. These tensions illustrate how deeply rooted traditional management logics conflict with agile principles.

In the area of **goal-setting**, tensions emerged from divergent objectives between agile team members and their respective departments. Product managers often struggled to align strategic goals across departments, resulting in conflicting priorities that hindered the agile team's ability to focus on delivering consistent value. A lack of clear prioritization further compounded this issue, as product managers attempted to satisfy all stakeholders rather than making focused, value-driven decisions. As a result, the agile release train is working on too many epics and features in parallel, which limits the focus and progress within the epics. Personal agendas and overlapping responsibilities also weakened commitment and transparency, especially when managers occupied multiple roles both inside and outside the agile release train. This approach diluted role clarity and undermined core agile principles such as ownership and alignment.

Planning-related tensions were equally problematic. One significant issue was the disconnect between the agile release train and the organization's medium-term operational planning. While agile teams worked based on short planning cycles, portfolio management demanded fixed, up-front planning aligned with annual budgets. This divergence made it difficult for agile teams to remain flexible in response to changing needs. Conflicting investment philosophies further deepened the divide: whereas agile methods support trust-based allocation of resources, traditional management requires precise budget estimates and predefined outcomes. The organization's adherence to annual planning horizons limited agile responsiveness and led to resource mismatches when priorities shifted. Additionally, conflicting expectations about planning accuracy surfaced, with traditional managers demanding estimates in "person days," undermining agile estimation tools like story points. The classic project mindset, emphasizing milestone delivery and deadline pressure, clashed with the agile rhythm of Program Increments, often resulting in quality compromises and stress on development teams. Lastly, stakeholder participation in planning activities such as feature prioritization and refinement was inconsistent. While agile success depends on iterative, collaborative involvement, many stakeholders lacked time, interest, or understanding of the process, which led to misaligned deliveries and resources.

In the **reporting dimension**, traditional and agile paradigms also collided. Success in the traditional view was often measured through budget adherence and resource usage, whereas agile practices emphasized delivering business value and customer benefit. This misalignment made it difficult for agile teams to communicate progress in a language that satisfied traditional stakeholders. Agile teams preferred holistic, outcome-focused reporting, but traditional managers demanded granular task-level data, forcing teams into inefficient and often contradictory reporting practices. Moreover, agile progress, which can be nonlinear due to conceptual and preparatory work, was misinterpreted when judged by linear resource consumption models stemming from traditional project tracking. This tension revealed a need for reporting mechanisms that better reflect the dynamics and value orientation of agile delivery.

Research Article 3 contributes to descriptive knowledge on large-scale agile transformations by moving beyond the initial adoption phase to explore the ongoing and evolving challenges that emerge over time. It argues that tensions between agile clusters and non-agile environments are not merely implementation issues but are rooted in deeper contradictions between underlying management philosophies. The study provides detailed insights into where agile and traditional practices collide and highlights areas where managers need to intervene, whether by addressing misunderstandings, adapting affected processes, or finding pragmatic workarounds that enable traditional and agile approaches to coexist in support of organizational value delivery. It emphasizes that large-scale agile transformation should not be viewed as a one-time shift but rather as a continuous journey, with tensions resurfacing as new teams, divisions, and hierarchical layers become involved. Given the stepwise nature of transformation and scaling, effectively managing these tensions demands ongoing, deliberate, and mindful attention.

In the overall context of this thesis, Research Article 3 builds on the preceding work by addressing how DT can be effectively managed through agile practices. After examining the triggers and effects of DT in Research Articles 1 and 2, this article focuses on tensions that may arise when applying a scaled agile framework in a non-agile environment.

Section II answers key questions in the field of DT, thereby fulfilling the first research objective of deepening the understanding of DT as a foundation for TT. Research Article 1 sets the scene by introducing the Theory of Technology-Affordance-Evolution and investigating how new affordances evolve through technological progress across multiple iterations. The Research Article explains how technological progress leads users to adapt their goals and perceive new constraints, thereby driving continuous change. Building on these insights, Research Article 2 explores *what* changes occur within organizations as a result of DT and *how* change unfolds within and across different organizational levels. It focuses particularly on *how* change cumulates from the micro-level, through the meso-level, to the macro-level, and what implications this cumulation has for understanding change dynamics in DT. Following the exploration of DT's triggers and effects in Research Articles 1 and 2, finally, Research Article 3 explains how agile practices can drive and sustain such organizational change throughout DT, thereby exploring the concept of agile transformation.

III. Exploring the Evolution from Digital to Twin Transformation

As outlined in Section I, pressing societal challenges, such as inequality, poverty, and the escalating climate crisis, make it increasingly clear that focusing on DT alone is no longer sufficient. The urgency and inevitability to involve ST are widely acknowledged (Zimmer & Järveläinen, 2022). In response, we are observing a shift away from a purely digital and economically driven perspective on DT, traditionally centered at the organizational level, toward a more integrated approach that encompasses economic, ecological, and social sustainability across individual, organizational, and societal levels (Bengtsson & Ågerfalk, 2011; Zimmer & Järveläinen, 2022). However, the aim is not to pursue DT and ST as isolated initiatives, but rather to leverage their synergistic potential at the intersection of both transformations – an approach conceptualized as TT (Christmann et al., 2024).

While Section II provides foundational insights into DT that can be transferred to other transformation contexts, Section III focuses in detail on the evolving concept of TT. Research Article 4 adopts a holistic perspective to explore the interplay between DT and ST across organizational layers, with a primary focus on the ecological dimension of sustainability. The findings highlight that like DT, TT constitutes an extensive, organization-wide transformation. To thereby ensure alignment between digital and sustainability goals, Research Article 5 investigates how organizations can develop and embed a TT strategy into their overarching business strategy. Previous strategies, such as for business and IT, typically evolved in parallel and required alignment (Avison et al., 2004; Baker et al., 2011; Henderson & Venkatraman, 1994). TT, in contrast, involves the synthesis of two distinct transformation logics into one coherent strategy that unifies digital and sustainability objectives. Finally, Research Article 6 extends the discourse by exploring how TT can unfold within the social dimension of sustainability. The article highlights design principles for assistive digital technologies that are not only applicable across a wide range of contexts but are also essential for the impact of such technologies, particularly in fostering social inclusion.

III.1 Unpacking Twin Transformation Across Organizational Layers

In light of the growing societal and economic pressures and the promising potential of TT, it is critical for both scholars and practitioners to deepen their understanding of how to align DT and ST in a cohesive manner (Christmann et al., 2024). Although the relevance of TT has sparked a notable increase in academic work centered on either DT or ST, the intersection of these two forms of transformation remains largely unexplored. Meeting the dual demands of digitalization and sustainability requires a more integrated, less fragmented body of knowledge that captures the dynamic interplay between DT and ST (Guandalini, 2022). Understanding their specific interactions and mutual dependencies necessitates a holistic perspective, one that illuminates how DT and ST co-evolve across multiple layers of an organization (Graf-Drasch et al., 2023; Guandalini, 2022). Research Article 4 aims to contribute to IS, DT, and ST research by conceptualizing TT and elucidating its potential. It therefore asks the

following research question: *"How do digital transformation and sustainability transformation interact within twin transformation?"*

To address the research question, Research Article 4 adopts a multi-method approach (Mingers, 2001). Following Gioia et al. (2013), it combines a literature-based conceptualization of the interplay between DT and ST with insights drawn from 32 semi-structured interviews with practitioners. This approach led to the development of a TT model (i.e., Figure 11) that offers a structured analysis of the interplay between DT and ST through TT interactions (i.e., first-order concepts), central DT and ST themes (i.e., second-order themes), as well as organizational layers (i.e., aggregate dimensions).

At the core of its investigation, Research Article 4 reveals 44 TT interactions and 22 DT and ST themes structured along eight organizational layers. The organizational layers of the model build on Alter's (2013) work system framework. His framework serves as a theoretical lens, describing elements inside and outside an organization where TT unfolds (e.g., processes and activities). Additionally, DT themes (e.g., smart production systems) and ST themes (e.g., circularity) are central topics of DT and ST that influence each other and must be reconciled to achieve TT. TT interactions, in turn, describe in detail how DT can enable ST (e.g., smart production systems enable circularity by connecting production areas to enable efficient information sharing and precise manufacturing) and how ST can guide the design of DT (e.g., circularity guides smart production systems by applying the principles of repair, refurbish, remanufacture, and recycle to smart production processes) to converge both transformations. Table 3 summarizes our key findings and describes each TT interaction, including exemplary references for each interaction. The table can be read in either direction as illustrated with the following example of processes and activities. From left to right: *"Smart production systems enable circularity by connecting production areas to facilitate efficient information sharing and precise manufacturing."* From right to left: *"Circularity guides smart production systems by applying the principles of repair, refurbish, remanufacture, and recycle to smart production processes."*

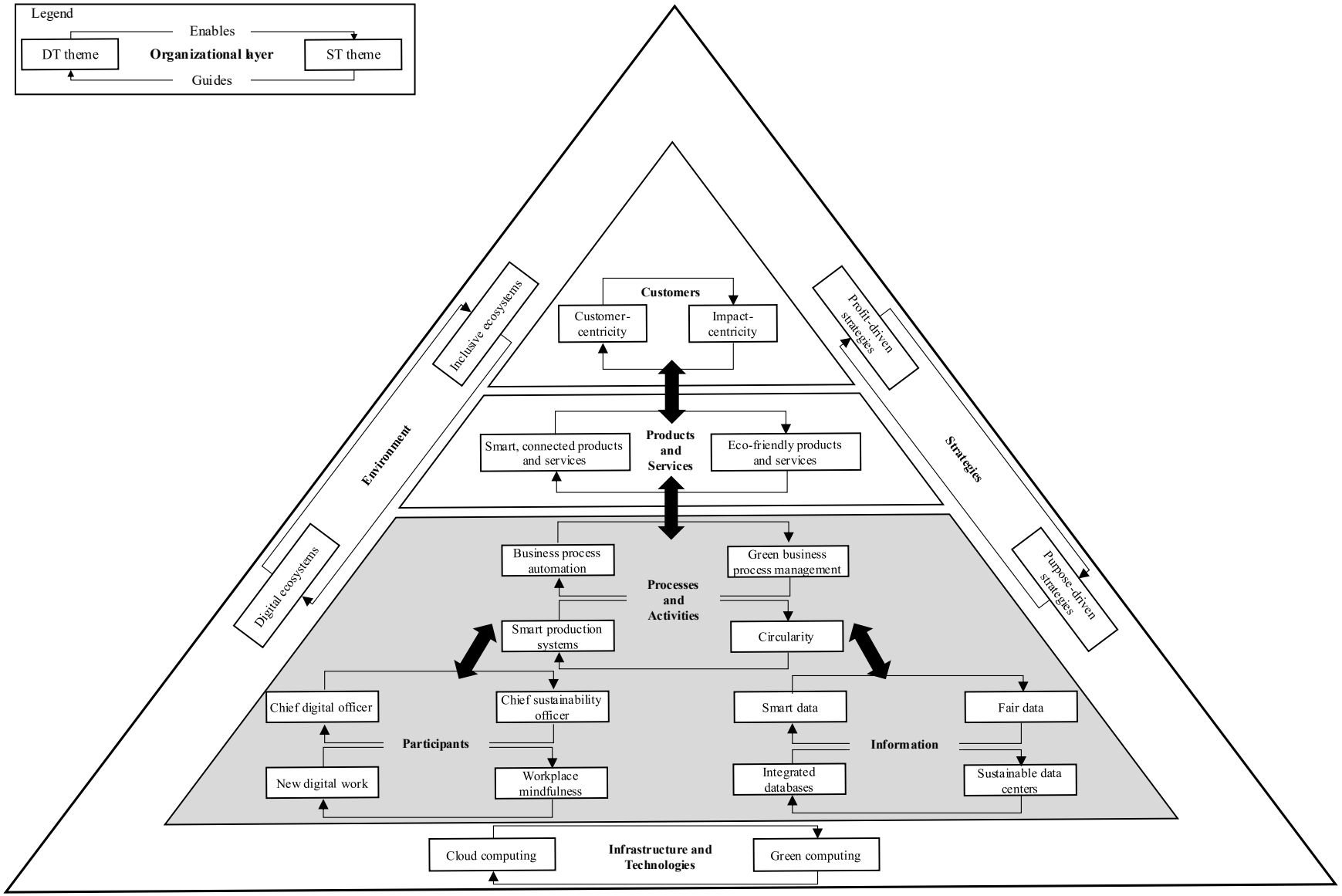

Figure 11. Twin Transformation Model

	DT	DT enables ST by …	Exemplary references	Twin Transformation	ST guides DT by …	Exemplary references	ST
Processes & Activities	Business process automation	… increasing administrative processes efficiency to minimize resource consumption.	Kneissel et al., 2023; E10		…ensuring that energy-efficient practices and technologies are incorporated in business process automation.	Zhu et al., 2023; E31	Green business process management
		… enabling accurate measurement and reporting to monitor and control process performance.	Ching et al., 2022; E31		… appreciating social and environmental responsibilities in business processes to overcome only profit-oriented process designs.	Yu et al., 2021; E25	
	Smart production systems	… connecting production areas to enable efficient information sharing and precise manufacturing.	Yu et al., 2021; E11		… applying the principles of repair, refurbish, remanufacture, and recycle to smart production processes.	Ozkan-Ozen et al., 2020; E29	Circularity
		… creating digital twins to simulate, test, and sustainably optimize systems and processes prior to commissioning.	Ghobakhloo et al., 2021; E29		... establishing systems thinking in Industry 4.0 to identify and address root causes of sustainability problems.	Ching et al., 2022; E5	
Participants	Chief digital officer	… monitoring the market for technology trends that improve sustainability.	K. Wang et al., 2024; E8		… overseeing digital initiatives to achieve sustainability goals.	ElMassah & Mohieldin, 2020; E6	Chief sustainability officer
		… providing technological expertise and education on using digital technologies for sustainability.	Mendez-Picazo et al., 2024; E29		... increasing visibility and alignment of sustainability themes to make them a core of the digital agenda.	Feroz et al., 2023; E12	
	New digital work	… creating a digital work environment that allows employees to access and collaborate from anywhere, at any time.	Beier et al., 2020; E17		… giving employees permission and space for self-awareness in an "always-on" culture.	Weritz et al., 2022; E21	Workplace mindfulness
		… automating workflows to take over monotonous work, lead to safer working conditions, and create new job opportunities.	Ghobakhloo, 2020; E11		… empowering and training employees for new job opportunities through digital transformation.	Ghobakhloo, Iranmanesh, et al., 2021; E12	
Information	Smart data	… analyzing large and diverse data to foster strategic and conscious decision-making.	Dionisio et al., 2023; E5		… implementing fair data principles (i.e., findable, accessible, interoperable, and reusable) to optimize data (re)use.	Dörr & Lautermann, 2024; E21	Fair data
		… enhancing information transparency to ensure compliance with legal and ethical requirements.	Guandalini, 2022; E19		… ensuring ethical data usage through greater transparency of what data is collected and possible data biases.	Clausen et al., 2022; E20	
	Integrated databases	… streamlining heterogeneous and redundant data sources to reduce server workload and energy consumption.	Guo et al., 2020; E7		… using renewable energy sources to reduce data management's overall ecological and economic footprint.	Nguyen et al., 2023; E29	Sustainable data centers
		… providing a central place of storage to gather information on sustainability.	Nayal et al., 2022; E4		… optimizing data center location and design to maximize efficiency and server longevity.	Del Giudice et al., 2021; E25	
Customers	Customer-centricity	… analyzing customer data to understand sustainability needs and expectations.	E10		… ensuring the preservation of natural resources in serving customer demands to save future generations' well-being.	Liu et al., 2022; E31	Impact-centricity
		… educating customers about environmentally responsible behavior to influence their purchasing decisions.	Nguyen et al., 2023; E18		… expanding the customer focus to environmental and social aspects (e.g., child labor, carbon emissions).	Pappas et al., 2023; E8	
Products & Services	Smart, connected products and services	… promoting predictive and prescriptive maintenance to expand product life cycles.	Liu et al., 2022; E16		… using sensor data to encourage consumers to rethink their behavior and act more environmentally and socially responsible.	Renland Haugjord & Kempton, 2022; E11	Eco-friendly products and services
		… leveraging the layered modular architecture to achieve rapid adaptations, shorter production time, and waste reduction.	Yu et al., 2021; E18		… respecting the principles of the sustainable web manifesto to build high-performing, low-carbon digital value propositions.	Chotia et al., 2024; E16	
Environ-ment	Digital ecosystems	… dissolving organizational boundaries to connect a growing number and variety of actors for societal impact.	E17		… accounting for inclusiveness to ensure equity for all stakeholders in digital ecosystems	Crivellari et al., 2024 E21	Inclusive ecosystems
		… enabling unlimited data sharing and recombination to effectively manage the utilization of resources and foster innovation.	Del Giudice et al., 2021; E1		… addressing sustainability goals through networking effects on cross-sectoral collaboration platforms.	E17	
Infrastruc-ture & Technology	Cloud computing	… migrating applications to the cloud to shut down local infrastructure.	Schmermbeck et al., 2020; E26		… optimizing algorithms, data processing methods and software solutions to maximize performance while reducing energy consumption.	Nguyen et al., 2023; E14	Green computing
		… using cloud-powered technologies to accelerate decarbonization initiatives.	Feroz et al., 2023, E5		… optimizing the use of physical devices (such as machinery and facilities) to reduce waste and lower overall energy consumption.	Dou & Gao, 2023; E5	
Strategies	Profit-driven strategies	… incorporating cost- and efficiency-driven KPIs to ensure economic stability and finance sustainability investments.	J. Wang et al., 2023; E24		… incorporating environmental and social metrics to ensure dual value creation through intertwining economic and sustainable goals.	Ukko et al., 2019; E6	Purpose-driven strategies
		… ensuring resilience to financial threats and thus securing employment for the long-term.	Narula et al., 2024; E4		… considering the interests of the employees as a part of the organizational interests to ensure their well-being and commitment.	Weritz et al., 2022; E4	

Table 3. Detailed Twin Transformation Interplay

Starting from an organization's core, we distinguish between processes and activities, participants, and information as they are inside an organization (Alter, 2013). **Processes and activities** reflect the interplay between *business process automation* and *green business process management* as well as *smart production systems* and *circularity.* Business process automation enables green business process management by streamlining administrative workflows and facilitating accurate measurement as well as reporting (Narula et al., 2024). In turn, green business process management guides automation efforts by promoting energy-efficient practices and embedding social and environmental responsibility into operational design (vom Brocke, 2012). *Smart production systems* enable largely self-organized manufacturing, in which people, machines, plants, and products communicate and collaborate directly (Beier et al., 2020). They contribute to sustainability transformation by enhancing resource efficiency, reducing waste, and optimizing products across their entire life cycle, thereby supporting *circularity* (Ching et al., 2022). Circularity focuses on repairing, refurbishing, remanufacturing, and recycling existing materials and products. It shifts away from linear production models toward systems in which resources continuously circulate, supporting regeneration and reducing waste (Wood & Godsill, 2021). The organizational layer **participants** captures the interplay between the roles of the *chief digital officer* and *chief sustainability officer,* as well as the interplay between *new digital work* and *workplace mindfulness.* The chief digital officer supports the chief sustainability officer by monitoring digital market trends and providing technological expertise to advance sustainability through digital innovation. In return, the chief sustainability officer guides the chief digital officer by ensuring that digital initiatives align with sustainability goals and by raising the visibility of these goals within the digital agenda (ElMassah & Mohieldin, 2020). Meanwhile, the DT theme of new digital work fosters workplace mindfulness by enabling flexible, location-independent work and automating repetitive tasks (Beier et al., 2020). In turn, workplace mindfulness guides new digital work by encouraging self-awareness in an always-connected work culture and by empowering employees through training and purposeful engagement in emerging digital roles (Weritz et al., 2022). Within the organizational layer **information,** *smart data* plays a critical role in DT and enables *fair data* by analyzing large and diverse data to foster strategic and conscious decision-making and by enhancing information transparency to meet legal and ethical standards (Dionisio et al., 2023). Fair data, on the other hand, guides smart data by promoting fair data principles and ensuring ethical data practices. From a data infrastructure perspective, *integrated databases* enable *sustainable data centers* by reducing server workload, lowering energy consumption, and consolidating sustainability information (Guo et al., 2020). Conversely, sustainable data centers guide the development of integrated databases by leveraging renewable energy sources and optimizing infrastructure design and location to minimize environmental impact (Nguyen et al., 2023).

Second, while processes and activities, participants, and information are located inside the organization, the layers customers as well as products and services, span an organization's boundaries (Alter, 2013). The organizational layer **customers** highlights the interplay between *customer-centricity* and *impact centricity.* In the context of DT, customer-centricity is essential for addressing rapidly evolving customer

needs by leveraging data to personalize experiences and services. This focus enables impact-centricity by uncovering customer expectations around sustainability and influencing purchasing behavior toward more responsible choices (He et al., 2024). In return, impact-centricity guides customer-centricity by broadening the focus beyond individual preferences to include environmental and social considerations, ensuring that customer value is created without compromising natural resources (Dao et al., 2011). **Products and services** comprise an organization's physical, digital, or hybrid value propositions (Alter, 2013). Within this layer, the interplay between *smart, connected products and services* and *eco-friendly products and services* is essential. Smart, connected products and services enable eco-friendly products and services by leveraging the layered modular architecture of digital technology in two ways (Yoo et al., 2010). First, they enable rapid adaptation by reducing production time and waste. Second, they extend product life cycles by providing predictive and prescriptive maintenance (Ghobakhloo, 2020). Conversely, eco-friendly products and services guide the evolution of smart, connected products and services. They do so by integrating sensor data to promote sustainable consumer behavior and by adhering to principles such as those in the sustainable web manifesto, ensuring that digital value propositions are high-performing, low-carbon, and socially responsible (Chotia et al., 2024).

Third, following Alter's (2013) work systems framework, environment, infrastructure and technologies, as well as strategies, are mainly external to the organization, with a direct impact on all other layers. The organizational layer **environment** captures the dynamic relationship between *digital ecosystems* and *inclusive ecosystems*. Digital ecosystems enable inclusive ecosystems by breaking down organizational boundaries, allowing diverse stakeholders to connect, collaborate, and co-create value (Dao et al., 2011). Through seamless data sharing and recombination, they facilitate more efficient resource utilization and foster innovation across sectors. In turn, inclusive ecosystems guide digital ecosystems by embedding principles of equity, diversity, and accessibility, ensuring that all voices are represented and empowered (Crivellari et al., 2024). By leveraging cross-sectoral collaboration platforms, inclusive ecosystems help to align digital innovation with broader sustainability goals, driving systemic change and amplifying social and environmental impact. The organizational layer **infrastructure and technology** explores the interplay between *cloud computing* and *green computing*. Cloud computing enables green computing by shifting applications from energy-intensive local infrastructure to scalable, cloud-based environments, thereby reducing physical resource demands (Wen et al., 2021). It also supports decarbonization by powering digital solutions that monitor and manage environmental performance. In return, green computing guides cloud computing by optimizing algorithms, data processing methods, and software solutions to enhance efficiency while minimizing energy consumption (Nguyen et al., 2023). Additionally, it emphasizes the responsible use of physical devices, such as machinery and facilities, ensuring that digital infrastructure operates with reduced waste and a lower environmental footprint (Dou & Gao, 2023). The organizational layer **strategy** reflects the interplay between *profit-driven strategies* and *purpose-driven strategies*. Profit-driven strategies enable purpose-driven strategies by establishing economic stability through cost- and efficiency-focused KPIs, which not only secure

financial resilience but also create the capacity to invest in sustainability initiatives and maintain long-term employment (J. Wang et al., 2023). In turn, purpose-driven strategies guide profit-driven ones by integrating environmental and social metrics to achieve dual value creation, balancing economic performance with sustainable impact. They also broaden the strategic perspective by recognizing employee well-being and engagement as core organizational interests, ensuring a more committed and purpose-aligned workforce (Skerlos, 2015; Ukko et al., 2019).

Research Article 4 makes two significant contributions to both researchers and practitioners. First, it contributes to a deeper and more nuanced understanding of TT by explaining the interplay between DT and ST across the organization in detail. To do so, the study takes isolated perspectives from central DT and ST themes and repositions them in the context of TT. Thereby, on the one hand, it shows how DT enables ST by providing digital opportunities to address societal challenges (Khan, Dhir, et al., 2021; Soluk & Kammerlander, 2021). On the other hand, ST brings a new perspective to DT and guides its design toward broader purposes beyond economic objectives, such as higher efficiency or profitability (Dyllick & Muff, 2016; Seidel et al., 2013). Second, Research Article 4 contributes by developing a TT model that deepens the understanding of how DT and ST reinforce each other. The model highlights key DT and ST themes as well as TT interactions across organizational layers.

Within the broader context of this thesis, Research Article 4 takes a holistic perspective to explore the interplay between DT and ST across various organizational layers. It illustrates that like DT, ST is a sociotechnical transformation that permeates the entire organization.

III.2 Twin Transformation as a Strategic Imperative Within Organizations

While TT is well established at a conceptual level, its practical implementation remains challenging. One reason is that organizations struggle to develop a TT strategy and align it with their overarching business strategy (Breiter et al., 2024; Christmann et al., 2024). Developing and integrating a TT strategy into an organization's existing business strategy is essential for long-term resilience and competitiveness (Ollagnier, 2021). First, it offers a structured approach to fully leverage digital and sustainability transformations by aligning them into impactful TT action fields. Second, TT can only drive meaningful change when it is embedded at the highest strategic level, guided by leadership, and supported with the necessary resources and commitment. Third, a well-aligned TT strategy strengthens organizational agility and adaptability, allowing firms to navigate market shifts and technological change while staying strategically focused. Existing methods offer limited guidance for effectively managing and implementing TT, as they typically address digital and sustainability transformations in isolation (Broman & Robèrt, 2017; Kopnina, 2017; Vial, 2019). Consequently, there is a lack of methodological support for developing and integrating a TT strategy that provides a structured, step-by-step approach aligned with the overall business strategy (Guandalini, 2022). Therefore, Research Article 5 poses the following research question: *How can organizations develop a twin transformation strategy by systematically integrating digital and sustainability transformation?*

Following the design science research paradigm by Peffers et al. (2007), Research Article 5 develops, evaluates, and demonstrates the TT Strategy Framework, a structured representation of an organization's TT strategy once completed. Alongside the framework, Research Article 5 also provides a step-by-step methodology comprising five sequential activities for TT strategy development. The design was guided by design objectives and informed by insights from both literature and practice, including 22 interviews with digital and sustainability experts. The five sequential activities guide organizations through a structured and iterative process, where the first and the last activity define and refine the strategic scope, while the three intermediate activities build awareness of digital and sustainability transformation, explore their synergies and tensions, and identify TT action fields along with a concrete execution plan. Three workshops involving students, IS researchers, and practitioners were conducted to demonstrate and evaluate the TT Strategy Framework and its step-by-step methodology.

The TT Strategy Framework enables organizations to systematically design and integrate a TT strategy into their overarching business strategy, To guide the development of the framework, design objectives were formulated (Peffers et al., 2007). Table 4 provides an overview of the design objectives (DO).

DO.1	To empower organizations in developing a TT strategy, the method needs to bridge the gap between digital and sustainability transformation, making both equal components of the strategy.
DO.2	To empower organizations in TT strategy development, the method must promote strategic alignment by ensuring coherence between the TT strategy and the overarching business strategy.
DO.3	To empower organizations in developing a TT strategy, the method needs to foster mutual understanding for sustainability experts to learn about digital transformation and vice versa.
DO.4	To empower organizations in developing a TT strategy, the method needs to divide the process into manageable, understandable steps.
DO.5	To empower organizations in TT strategy development, the method must incorporate top-down and bottom-up approaches.
DO.6	To empower organizations to develop an individual TT strategy, the method must be generalizable and adapt to diverse industries, organizational structures, and cultures.

Table 4. Overview of Design Objectives

Figure 12 shows the final version of the TT Strategy Framework and its accompanying methodology. The completed TT Strategy Framework showcases the TT strategy itself as the tangible outcome of the strategy development process. By placing the identified TT action fields at its core and embedding them within the broader context of digital as well as sustainability transformation and the overarching business strategy, the framework offers a holistic view of an organization's TT strategy. The accompanying methodology consists of five structured activities that guide users through the strategy development process (Kuch et al., 2024). The design of these activities was shaped by the defined design objectives and informed by both literature and practical insights.

Activity 1 – Strategic Direction: Activity 1 lays the groundwork for all subsequent activities by defining the strategic direction and establishing clear guardrails for the TT strategy. This ensures

alignment with the overarching business strategy from the very beginning. A diverse team, comprising top management, digitalization, and sustainability experts, collaborates to analyze the organization's vision and long-term objectives, fostering a shared understanding of the strategic context. This common foundation helps to maintain consistency and coherence throughout the TT strategy development. By setting clear strategic objectives early on, the process gains focus and direction, enabling more targeted discussions and effective prioritization in the following activities. The outcome is a concise list of two to five long-term strategic objectives that guide the strategy moving forward.

Activity 2 – Strategic Planning: The second activity captures the status of digital as well as sustainability transformation within the organization. Conducted in separate teams, experts identify existing initiatives bottom-up and prioritize three to six key objectives for each domain. These insights are then presented across groups to build shared understanding across all participants. This bottom-up approach complements the top-down direction set in Activity 1, establishing a solid foundation for TT strategy development. The results must be clear, consistent, and feasible, and can be revised if necessary.

Activity 3 – Strategic Fit: Activity 3 promotes collaboration between digitalization and sustainability experts by having them assess each other's objectives for synergies and tensions. Building on the key objectives from Activity 2 and using color-coded sticky notes (to differentiate between synergies and tensions), each team evaluates how their expertise can influence and complement the other domain's goals. This reciprocal perspective-taking helps identify synergies, tensions, and opportunities for innovation. It promotes mutual understanding and supports the development of joint TT actions in Activity 4. The activity also fosters stronger cooperation and shared strategic vision across domains.

Activity 4 – Strategic Prioritization: Activity 4 identifies and prioritizes TT action fields based on the synergies and tensions uncovered in Activity 3. For the first time, all team members come together and collaboratively assess each action field using an impact/effort matrix to determine their value and implementation feasibility. The focus is on selecting quick wins and major initiatives while deprioritizing low-impact, high-effort actions. The expected outcome of Activity 4, depending on the scope of the TT strategy, is the identification of at least three quick wins and one major initiative. Clear responsibilities and next steps are assigned to each prioritized TT action field to ensure accountability and execution. This activity results in a practical, outcome-oriented roadmap for TT implementation.

Activity 5 – Strategic Integration: The final activity ensures that the prioritized TT action fields are seamlessly integrated into the organization's overarching business strategy. The team examines how these action fields influence key strategic elements, such as organizational culture, capabilities, finances, and product offerings. Based on this analysis, necessary adjustments are identified and documented to align the TT strategy with long-term business objectives. This step reinforces that the TT strategy is not a standalone initiative but a central lever for driving strategic value and long-term transformation.

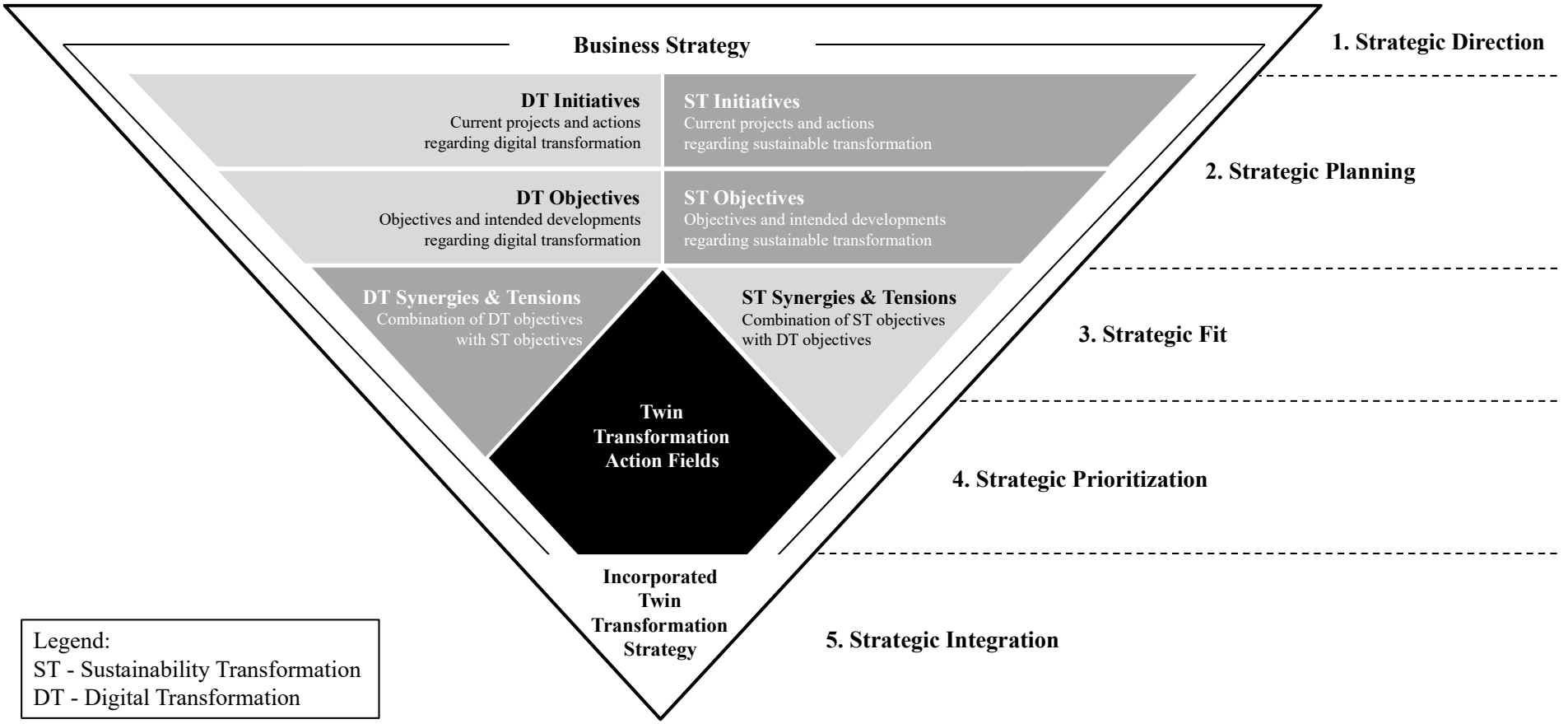

Figure 12. Twin Transformation Strategy Framework

The TT Strategy Framework and its accompanying methodology were evaluated and demonstrated through a combination of formative and summative artificial and naturalistic approaches (Venable et al., 2016). The evaluation aimed to assess both theoretical soundness and practical applicability, using criteria such as *ease of use, operationality, efficiency,* and *generality*. These criteria were examined across three workshop settings involving 20 participants in total. Two formative artificial evaluation workshops were conducted during the development phase, one with six students and another one with ten IS researchers. These evaluations offered early-stage feedback on clarity, structure, and relevance, contributing to iterative refinement of the TT Strategy Framework and its methodology.

The final summative naturalistic evaluation took place in a real-world setting within a manufacturing organization, where two digitalization and two sustainability experts applied the complete framework and its methodology. This workshop emphasized hands-on application, producing actionable insights and demonstrating the method's applicability and effectiveness in practice. Each evaluation workshop helped validate the artifact's completeness and consistency, revealed areas for improvement, and confirmed its adaptability across different user groups. Overall, the combined evaluations provided robust support for the artifact's practical value and readiness for organizational use.

Research Article 5 makes significant theoretical contributions by introducing the TT Strategy Framework and its step-by-step methodology, designed to help organizations systematically develop and integrate a TT strategy within their overarching business strategy. The TT Strategy Framework offers a visual, consolidated representation of an organization's TT strategy, promoting alignment, clarity, and strategic coherence. The accompanying methodology guides organizations through five structured activities, integrating transformation perspectives and aligning them with the overall business strategy. Classified as an Exaptation under Gregor and Hevner's (2013) design science research framework, this contribution builds on and extends existing theoretical insights by offering an innovative, systematic approach to developing and strategically implementing TT strategies. In doing so, Research Article 5 advances the theoretical discourse on TT and addresses a growing need for integrated transformation guidance.

In the overall context of this thesis, Research Article 5 provides a deep dive into the strategy layer introduced in Research Article 4, explaining how organizations can develop a TT strategy and integrate it into their existing business strategy. By doing so, it sets the scene for understanding how TT can be practically implemented.

III.3 Designing the Social Dimension of Twin Transformation

As digital technologies increasingly shape daily life, their role extends beyond functional or economic value to serve as catalysts for societal change (Baskerville et al., 2020). The emerging concept of *digital sustainability* highlights digital technologies as a lever to address social and environmental challenges (Kotlarsky et al., 2023). While environmental aspects have received significant attention (e.g., Ixmeier et al., 2024; Melville, 2010), their social potential, particularly for fostering social inclusion, remains

underexplored (Kotlarsky et al., 2023; Schoormann & Kutzner, 2020). A key barrier to social inclusion is posed by individual accessibility constraints affecting over 1.3 billion people worldwide (World Health Organization, 2022), ranging from physical to cognitive limitations (Rosemann et al., 2021). Addressing these challenges aligns closely with the Sustainable Development Goals (SDGs). Specifically, SDG 10.2, calls for the inclusion of all individuals, regardless of disability or background (United Nations, 2015). In this context, digitally enabled social inclusion refers to using digital tools to help individuals fully participate in all aspects of life (Kotlarsky et al., 2023; Wilson & Secker, 2015), often through assistive digital technologies.

However, despite promising applications, we are far from realizing the full potential of assistive digital technologies to foster social inclusion (Becker et al., 2023; Faik, Sengupta, & Yimeng Deng, 2024). High failure rates of assistive digital technologies apparently stem from a lack of design knowledge (Curto-Millet & Cañibano, 2023; Faik, Sengupta, & Deng, 2024; Schoormann & Kutzner, 2020). Poorly designed assistive digital technologies may fail to meet actual user needs or may even unintentionally reinforce exclusion. Design-oriented IS research has primarily focused on bridging the digital divide and promoting inclusion in digital environments (social *in* IS) (Vassilakopoulou & Hustad, 2023), while largely overlooking digitally enabled inclusion in the physical world (social *by* IS) (Schoormann & Kutzner, 2020). Recent studies have started to explore how assistive digital technologies can enhance real-world social inclusion, though most contributions still center on the design of specific technologies (e.g., Jonas et al., 2024). To maximize the impact of assistive digital technologies on social inclusion, it is essential to develop foundational design principles that apply across various assistive digital technologies and constraints. Against this backdrop, Research Article 6 asks the following research question *"What are foundational design principles for assistive technologies to foster social inclusion?"*

Following the well-established design science research approach by Peffers et al. (2007) and Sonnenberg and vom Brocke (2012), and drawing on the guidance of Gregor et al. (2020) and Möller et al. (2020) for the formulation of design principles, we developed meta-requirements and corresponding design principles to guide the design of assistive digital technologies. The iterative design process consisted of three distinct design cycles that alternated between development and evaluation to ensure continuous improvement (i.e., Figure 13). The process included two artificial, formative evaluations and one naturalistic, summative evaluation (Venable et al., 2016). The first cycle validated the problem and produced initial meta-requirements and design principles. The second focused on validating the design and refining the initial design, while the third emphasized user-centered proof of value, informing the final design iteration. To assess the value of the proposed design principles, a three-step process was developed, focusing on successfully implemented assistive digital technologies, their users, and the extent to which the principles were reflected in these technologies. Three distinct assistive digital technologies, *EasyRest, FuelAssist,* and *BladderSense,* were selected, each representing an acronym and encompassing both hardware and software components. The first technology, *EasyRest,* helps

individuals with accessibility needs locate nearby public restrooms, enhancing independent navigation. The second, *FuelAssist,* supports drivers with physical limitations in refueling by coordinating assistance through a mobile app. The third, *BladderSense*, is a wearable device that uses AI to monitor bladder levels and to alert users with incontinence, promoting autonomy through timely interventions. Insights from these cases led to the development of a final set of meta-requirements and design principles for assistive digital technologies. A total of 17 users of the selected assistive digital technologies were interviewed. The users, who included individuals with conditions such as paraplegia, multiple sclerosis, ulcerative colitis, and bladder weakness, brought a diverse range of perspectives on individual accessibility constraints in daily life. The interviews explored the relevance and impact of the design principles, providing valuable insights that informed the final design.

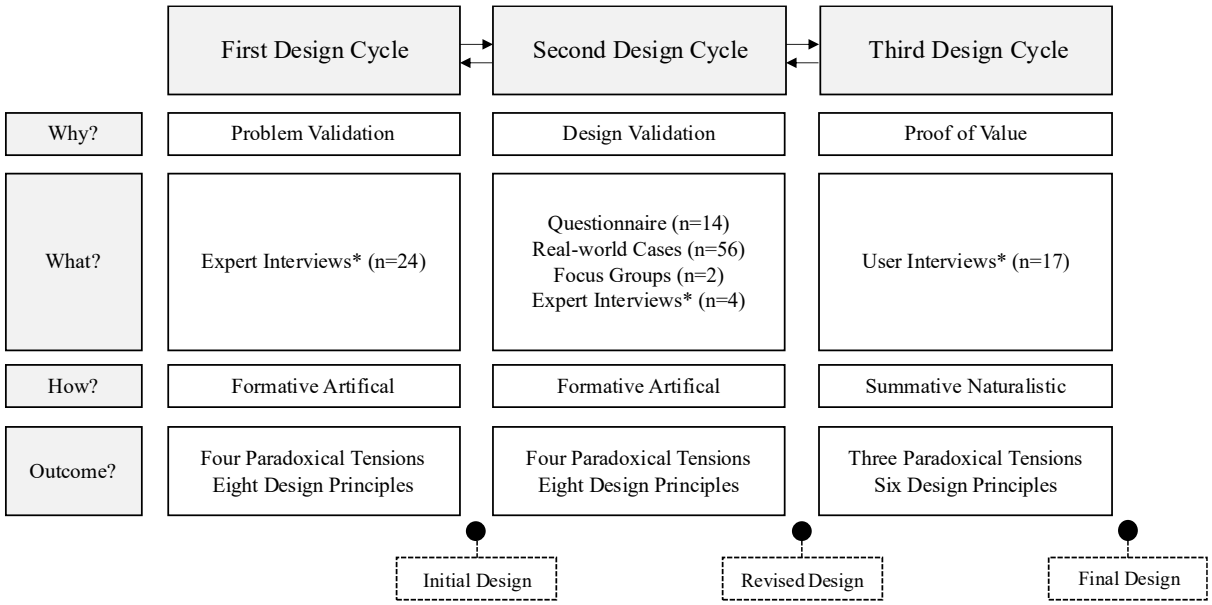

Figure 13. Iterative Research Approach

Through iterative refinement and in-depth author discussions, it became evident that the meta-requirements were not isolated needs but reflected underlying tensions between provider (i.e., implementer of an assistive digital technology) and user (i.e., individual with lived experience of individual accessibility constraints who regularly uses an assistive digital technology) (i.e., Table 5). Human-centered IS design inherently involves navigating the friction between technological capabilities and human values (Gasson, 2003; Wessel et al., 2025), shaped by two interdependent yet contrasting logics: the provider's *professional, rational* logic and the user's *personal, emotional* logic. While both strive for social inclusion, providers' overarching goal of *universality* emphasizes scalability, efficiency, and standardization, whereas users' overarching goal of *individuality* prioritizes personal needs, habits, emotions, and contextual circumstances. The central design challenge is to apply an appropriate degree of *human centricity.* This insight marked a pivotal moment in the analysis, shifting the focus from addressing discrete needs to understanding and reconciling their intersections. The contrasting logics generate paradoxical tensions, characterized by interrelatedness, complementarity, and simultaneity

(Gaim et al., 2018), with each influencing and being influenced by the other. Managing their coexistence demands continuous negotiation, mutual adaptation, and alignment throughout the design process.

Actor	Provider	User
Logic	Rational, professional	Emotional, private
Goal	Universality	Individuality
Purpose	Social Inclusion	
MR1	**Digitization**: converting analog information into digital information	**Humanity**: reflecting attributes inherent to human beings (e.g., empathy)
MR2	**Assistance**: providing external support and guidance	**Autonomy**: ensuring self-determination and independence
MR3	**Flexibility**: enabling short-term adaptability and variability	**Reliability**: ensuring long-term stability and dependability

Table 5. Overview of Meta-Requirements Forming Tensions

To address the identified tensions and foster social inclusion, Research Article 6 proposes six foundational design principles to inform the development of assistive digital technologies. Figure 14 illustrates these principles and their connection to the distinct meta-requirements of provider and user. While the meta-requirements differ between provider and user, the design principles intentionally transcend this divide, aiming to balance both perspectives in pursuit of the shared purpose of social inclusion, encompassing self-determination, belongingness, and social capital (Wass et al., 2023). Table 6 organizes the design principles within the framework established by Gregor et al. (2020).

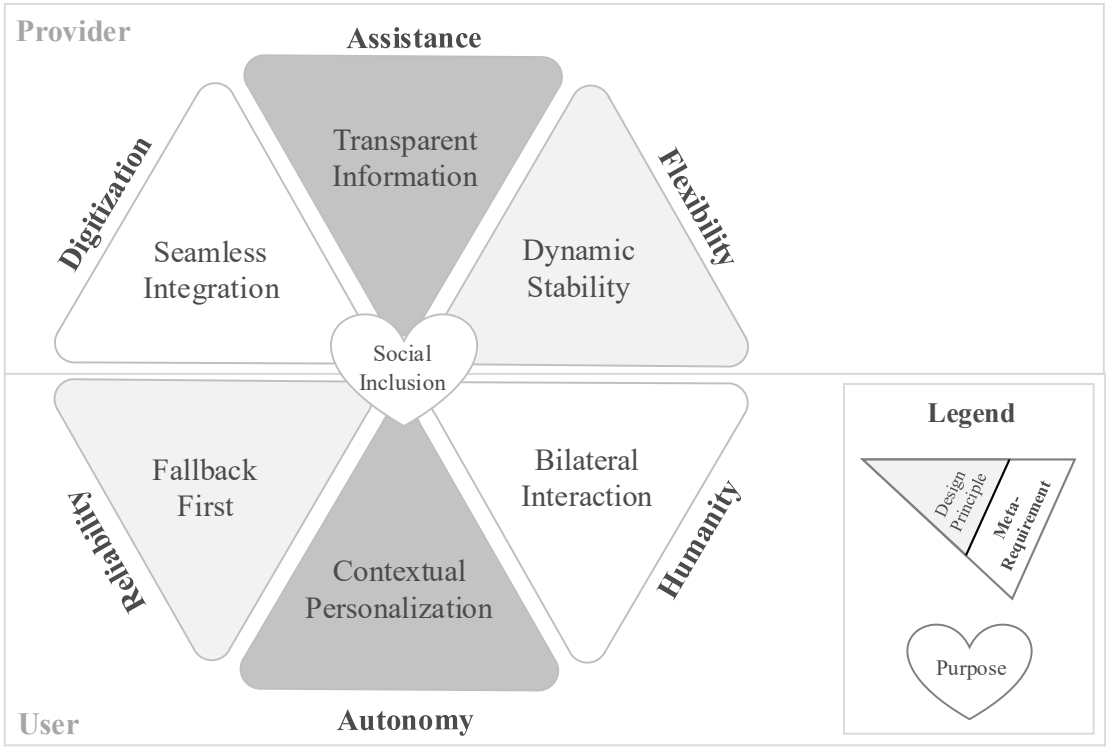

Figure 14. Six Design Principles for Assistive Digital Technologies

	Aim	Enactor …	… Mechanism	Boundary Condition	Rationale
Seamless Integration	Assistive digital technologies should foster social inclusion by leveraging the potential of digitization while preserving humanity through the unobtrusive integration of the assistive digital technology into users' lives. Therewith, users are empowered to manage their constraints in a self-determined way and to develop a sense of belonging.	Employ advances in sensing, AI, low-power hardware, natural interfaces, and connectivity, as well as digital interfaces …	… to integrate the digital assistive technology seamlessly with existing digital infrastructure, thereby embedding itself into the users' daily routines and enable unobtrusive, seamless, natural, and convenient usability of and communication with the digital assistive technology without incurring additional effort.	Efforts to achieve seamless integration must not impair or restrict core functions, to ensure their reliability and uninterrupted operation.	By enabling seamless integration, assistive digital technologies act as an extension of users' abilities without demanding extra cognitive or mental load, enabling a synergetic interaction between digitization and humanity. This unobtrusive integration into daily life fosters self-determination by reducing the usually high mental load and social burden associated with assistive digital technologies. Users are empowered to act on their own terms, with assistive digital technologies adapting to them rather than the reverse. In turn, this unobtrusiveness nurtures a sense of belongingness, allowing users to engage confidently in public life without feeling "different" or stigmatized and to be seen as full participants rather than defined by their constraints.
Bilateral Interaction	Assistive digital technologies should foster social inclusion by leveraging the potential of digitization while preserving humanity through meaningful interactions with humans behind the technology. Therewith, users are empowered to access resources within social relationships (i.e. social capital), fostering a sense of belonging.	Provide channels to communicate with supporters and fellows …	… that enable reciprocal communication and community-driven knowledge exchange.	Fellows and supporters must be empathetic and appropriately educated, to provide informed, compassionate, and respectful assistance.	By enabling bilateral interaction, assistive digital technologies foster a partnership between humans and technology, enhancing rather than replacing human agency. This two-way communication allows users to correct misinterpretations in real time, reducing frustration, minimizing safety risks, and reinforcing a sense of being genuinely "heard." Through community-driven knowledge exchanges, users share insights, experiences, and solutions with each other. Such responsive design not only builds trust and motivation but also strengthens social capital by empowering users to engage more confidently and authentically in social settings. As users experience greater control and mutual understanding through technology, their sense of belonging deepens, enabling fuller participation in public life.

	Aim	Enactor …	… Mechanism	Boundary Condition	Rationale
Transparent Information	Assistive digital technologies should foster social inclusion by offering necessary assistance while fostering autonomy enabled through accessible and comprehensive information. Therewith, users are empowered to build social capital, make informed and self-determined decisions, and ultimately enhance their sense of belonging.	Collect and transform data into multi-sensory information …	… to provide comprehensive, information (e.g., spatial, environmental) for users with diverse abilities.	The information provided must be complete and accurate, to ensure information reliability.	By providing transparent information, the digital assistive technology establishes a synergetic relationship between digital assistance through the provision of information and human autonomy, in that the decision on the evaluation of this information lies in the autonomy of the user. Providing information enables individuals to prepare for and engage in experiences based on their own abilities, promoting self-determination, allowing users to assess accessibility on their own terms. Further, transforming diverse data into multi-sensory formats ensures belongingness, because it makes information equally accessible to users with varying sensory or cognitive needs. This shared access builds social capital by creating common ground, fostering communication, coordination, and mutual respect, strengthening community bonds even without direct interaction.
Contextual Personalization	Assistive digital technologies should foster social inclusion by offering necessary assistance while fostering autonomy enabled through context-based suggestions and manual adaptions. Therewith, users are empowered to realize self-determined use and freedom of choice.	Capture, process and analyze user data and offer fine granular modularity …	… to enable options for personalization by translating data-driven insights into improvements and enabling individual and manual adjustments of functionalities in the assistive digital technology.	Data must be processed in compliance with data security standards, to ensure secure and responsible handling.	By enabling contextual personalization, the assistive digital technology provides intelligent defaults and hence assistance that guide users while preserving freedom of choice, opportunities for exploration, and autonomy. While autonomy implies freedom of choice, an excess of options can lead to decision fatigue. Hence, by adaptation to context, such as recent activities or user behaviour, assistive digital technology can provide timely, relevant, and low-friction assistance that reduces cognitive load without compromising user autonomy and self-determination.

	Aim	Enactor …	… Mechanism	Boundary Condition	Rationale
Dynamic Stability	Assistive digital technologies should foster social inclusion by embracing flexibility and adapting to changing environments, while maintaining reliability enabled through predefined, safe boundaries across diverse contexts. Therewith, users are empowered to exercise greater self-determination through a balanced experience of adaptability and dependability.	Enable predictive error prevention and allow for a high error tolerance …	… that ensures flexible system behavior with reliable performance.	Inherent limitations of the technology in use (e.g., hard- and software) and environmental conditions must be considered, to ensure realistic expectations.	By embedding dynamic stability, the assistive digital technology proactively avoids failures while allowing the system to operate effectively even when imperfections occur. This approach ensures that the system remains dependable without requiring rigid constraints, enabling it to adapt to diverse or unforeseen conditions. Predictive error prevention and high error tolerance enhance self-determination by allowing users to act independently and confidently, even when facing uncertainty or making minor mistakes.
Fallback First	Assistive digital technologies should foster social inclusion by embracing flexibility and adapting to changing environments, while maintaining reliability enabled through a dependable baseline experience that ensures functionality. Therewith, users are empowered to act independently without fear of system failure, reinforcing their sense of self-determination.	Employ multiple fallback options…	… that allow for gradual downgrading in the event of failures while maintaining core functionality.	Fallback options must be proportional to the criticality of the functionality, distinguishing between critical applications (e.g., medical) vs non-critical utility apps, to ensure safety levels according to the potential impact of failure.	By embedding fallback first, assistive digital technologies can flexibly adapt to changing conditions, such as partial service outages, degraded inputs or missing components, while the reliability of core functionalities is ensured through predefined fallback mechanisms. Hence the assistive digital technology remains both dependable and responsive across diverse scenarios. This reliability is crucial as a foundation for users' self-determination and independence. Without fallback options, system failures can severely limit usability, undermining users' trust and autonomy.

Table 6. Design Principles for Assistive Digital Technologies

The findings of Research Article 6 offer contributions to IS research in three ways. First, the study advances digital sustainability research by drawing attention to its underexplored social dimensions (Kotlarsky et al., 2023). Second, it contributes to social inclusion research by conceptualizing digitally enabled social inclusion and presenting six design principles for assistive digital technologies. Addressing the lack of design knowledge in this area (Schoormann & Kutzner, 2020), the study provides insights at the level of a nascent design theory (Gregor & Hevner, 2013), classified as a theory for design and action (Gregor, 2006). Third, it enriches the growing discourse on tensions in human-centered IS design (Curto-Millet & Cañibano, 2023; Schoormann & Kutzner, 2020; Wessel et al., 2025). By adopting an actor perspective, the study identifies two underlying logics that give rise to paradoxical tensions. The proposed design principles address these tensions by simultaneously embracing both logics, thereby guiding the creation of truly human-centered assistive digital technologies. Our work responds to calls from the IS discipline to expand digital sustainability research (Kotlarsky et al., 2023) and, in particular, social sustainability research (Schoormann & Kutzner, 2020). Its core theoretical implication is that human-centered IS design must be understood as a multidimensional phenomenon that must navigate paradoxical tensions to advance social sustainability goals.

In the broader context of this thesis, Research Article 6 illustrates how TT can unfold within the social dimension of sustainability at both individual and societal levels. The study shows that assistive digital technologies, when thoughtfully designed, can significantly foster social inclusion. By aligning human values with technological capabilities, it highlights how digital innovation can meaningfully support social sustainability goals, bridging the gap between technological progress and the promotion of societal well-being.

This section addresses the second research objective, which is to explore the evolution from DT to TT and to analyze TT in detail. Given that today's urgent economic, ecological, and societal challenges extend the economic dimension of sustainability at the organizational level, this section depicts the evolution from DT to TT. It examines TT in detail across dimensions of sustainability and levels of impact. Research Article 4 develops the TT model to demonstrate how TT unfolds across various organizational layers. This analysis helps identify ongoing TT initiatives, synergies, and cross-cutting effects. To thereby ensure alignment between digital and sustainability goals, Research Article 5, also situated at the organizational and societal levels, introduces the TT Strategy Framework. In addition, the article presents a step-by-step methodology that systematically guides the development process from defining strategic priorities to embedding TT within the broader business strategy. Extending the field of TT research further, Research Article 6 explores how assistive digital technologies must be designed to foster social inclusion at both the societal and the individual levels.

IV. Conclusion

IV.1 Summary

Given today's urgent economic, ecological, and societal challenges, the concept of TT offers a promising pathway. Its mutually reinforcing relationship highlights the potential of digital technologies to enable ST while also explaining how ST can guide and shape DT (Breiter et al., 2024; Christmann et al., 2024; Graf-Drasch et al., 2023). TT is rooted in the long-standing trajectory of DT, which has laid the technological and organizational foundations for TT's emergence. However, despite this foundation, many organizations still struggle to successfully implement DT in practice (Wade & Shan, 2020). Research and practice lack a comprehensive understanding of how to effectively manage and sustain DT over time (Carroll et al., 2021). At the same time, growing societal challenges are pushing TT further into the spotlight. Both in research (e.g., Christmann et al., 2024) and practice (e.g., Hinsen et al., 2023), a clear evolution from DT to TT is emerging, an evolution that forces organizations to move beyond thinking solely in terms of DT, and instead to consider the dynamic interplay between DT and ST.

In response to these gaps, the thesis contributes to DT and TT research with two primary objectives: (1) deepening the understanding of DT as a foundation for TT and (2) exploring the evolution from DT to TT and analyzing TT in detail. Together, these two parts provide a comprehensive understanding of how organizations evolve from navigating DT to managing the broader and more complex challenge of TT.

First, this thesis establishes a solid foundation for the evolution from DT to TT by deepening the understanding of DT at the organizational level, with a particular emphasis on the economic dimension of sustainability. Research Article 1 explores technological progress as a key driver of DT, focusing on how new technological features, referred to as affordances, emerge across technology iterations and ultimately drive organizational change. Thereby, Research Article 1 identifies three patterns that illustrate how affordance evolution unfolds in the course of technological progress. Pattern I "technology-driven affordance evolution" and Pattern II "non-consecutive technology-driven affordance evolution" depict the evolution of affordances across technology iterations. Meanwhile, Pattern III "affordance elimination and re-emergence" describes how technological progress may not only yield new affordances but simultaneously eliminate previous ones. In sum, Research Article 1 extends Thapa and Sein's (2018) "trajectory of affordances" to a Theory of Technology-Affordance-Evolution by introducing a longitudinal perspective on affordance evolution, accounting for spatiotemporal dynamics and stepwise technological progress over time. Building on these insights, Research Article 2 investigates organizational change in the context of DT from a multi-level perspective. It first examines *what* changes through technological progress in the context of DT and then analyzes *how* these changes unfold within organizations. To this end, the paper introduces a multi-level analysis framework, outlines specific organizational changes associated with DT at the micro-, meso-, and macro-levels and theorizes *how* change processes evolve both within and across these levels. By

examining both the characteristics of change and the mechanisms through which change occurs, Research Article 2 complements existing single-level studies and contributes to reconciling divergent perspectives on the nature of change in the context of DT. Research Article 3 complements this understanding by demonstrating how agile practices support and sustain organizational change throughout DT. It specifically examines the tensions that may arise when traditional organizations attempt to implement scaled agile frameworks in non-agile environments without adequate preparation or prior knowledge. In total, the paper identifies 13 tensions across the areas of goal-setting, planning, and reporting. Collectively, the three Research Articles provide essential insights that establish a strong conceptual foundation for understanding how organizations navigate DT, thereby laying the groundwork for addressing the broader and more complex challenge of TT.

Second, this thesis explores the evolution from DT to TT, extending beyond the organizational level with a focus on economic sustainability. It offers valuable insights at the individual, organizational, and societal levels across all three dimensions of sustainability. With a primary focus on the ecological dimension of sustainability, Research Article 4 investigates the interplay between DT and ST across organizational layers, revealing that like DT, TT represents an extensive, organization-wide transformation. TT initiatives span multiple organizational layers, such as processes & activities, participants, information, and customers. Building on these insights, Research Article 4 develops a TT model that captures a holistic picture of TT within organizations. Specifically, the model includes 44 TT interactions as well as 22 DT and ST themes structured along the organizational layers. Delving into the strategy layer, Research Article 5 introduces a TT Strategy Framework that provides a structured step-by-step approach for developing a TT strategy and integrating it into an organization's overarching business strategy. The framework comprises five sequential activities: 1) strategic direction, 2) strategic planning, 3) strategic fit, 4) strategic prioritization, and 5) strategic integration. Together, these activities represent the tasks a user must perform to ensure a structured and coherent approach for TT strategy development. With a focus on the social dimension of sustainability, Research Article 6 identifies competing meta-requirements and design principles to guide the design of assistive digital technologies: 1) transparent information, 2) contextual personalization, 3) dynamic stability, 4) fallback first, 5) bilateral interaction, and 6) seamless integration. During the derivation of the meta-requirements, paradoxical tensions between the perspectives of providers and users were observed. The foundational design principles aim to address these underlying tensions, thereby fostering social inclusion and improving the well-being of those affected in the context of individual accessibility constraints.

Overall, this thesis makes significant contributions to the rapidly evolving field of DT and the emerging phenomenon of TT by providing descriptive, explanatory, and prescriptive knowledge (Gregor, 2006; Gregor & Hevner, 2013; Seidel & Watson, 2020). Descriptive knowledge is essential when nothing or little is known about the phenomenon under study (Fawcett & Downs, 1986), as it focuses on understanding *"what"* is. In contrast, explanatory knowledge aims to uncover the underlying causes and

mechanisms, addressing questions of *"how", "why"*, and *"when"* certain phenomena occur (Gregor, 2006). Both research articles related to first research objective (i.e., deepening the understanding of DT as a foundation for TT) and those targeting the second research objective (i.e., exploring the evolution from DT to TT and analyzing TT in detail) incorporate elements of descriptive and explanatory knowledge. From a descriptive perspective, Research Articles 2, 3, and 4 describe core dimensions and characteristics of DT (e.g., change constructs that describe *what* changes during DT) and key elements of TT (e.g., TT initiatives that define *what* constitutes TT), contributing to a theory of analysis and description (i.e., Type I) (Gregor, 2006). These research articles offer foundational insights into the complex and dynamic nature of DT and TT. In terms of explanatory knowledge, Research Article 1, 2, and 4 each contribute to or represent a theory of explaining (i.e., Type II) (Gregor, 2006). They detail *how* technological progress drives organizational change, *how* these changes unfold over time, and *how* they culminate in the interplay between DT and ST at different organizational layers. The descriptive and explanatory knowledge developed in these papers lay the foundation for advancing toward theories of prediction (i.e., Type III/ IV) and theories for design and action (i.e., Type V) (Gregor, 2006). In this regard, Research Articles 5 and 6 represent an initial step toward a theory for design and action (Type V), offering prescriptive knowledge on *"how to do"* things (Gregor, 2006; Seidel & Watson, 2020). Research Article 5 proposes a structured approach that helps organizations develop and integrate a TT strategy, while Research Article 6 develops design principles for assistive digital technologies aimed at fostering social inclusion. Taken together, this thesis spans a broad spectrum of theory types and provides multiple avenues for extending and deepening theoretical contributions in future work.

IV.2 Limitations

The research findings presented in this thesis are subject to a number of overarching limitations, which are outlined below. These go beyond the specific limitations discussed in the individual research articles (see Sections VI.3–VI.8) and highlight broader considerations that should be taken into account when interpreting the results and building upon this work.

First, while the findings presented in this thesis are considered sufficiently abstract to maintain their relevance over time, the proposed artifacts are expected to evolve in the coming years. Both DT and TT are ongoing and dynamic transformations, characterized by continually emerging dimensions, shifting priorities, and evolving technological and societal contexts. Accordingly, the artifacts of this thesis should be seen as a snapshot of the current stage of DT and TT, as well as the transitional developments between them. To ensure continued applicability, these artifacts will require ongoing refinement and adaptation in response to future advancements. For example, the change constructs introduced in Research Article 2 and the TT initiatives proposed in Research Article 4 may require periodical revision to account for emerging digital technologies and evolving sustainability demands.

Second, the artifacts developed in this thesis are predominantly context-agnostic (i.e., they are not specifically tailored to, nor shaped by, particular contextual factors). This applies, for instance, to the

change constructs introduced in Research Article 2, the TT model presented in Research Article 4, and the TT Strategy Framework outlined in Research Article 5. Consequently, the applicability and effectiveness of these artifacts may vary across different contexts (e.g., specific industries or organizational sizes). These observations prompt important questions about how the findings hold up in diverse settings and whether they require adaptation to suit specific contextual conditions.

Third, the findings presented in Research Articles 3 to 6 are predominantly based on qualitative data collected through semi-structured interviews. This methodological approach was chosen due to its effectiveness in investigating novel and complex phenomena such as TT (Myers & Newman, 2007; Schultze & Avital, 2011). While expert interviews provide rich, in-depth insights into emerging topics (Etikan, 2016), they are inherently subjective, ranging from how questions are interpreted and answered, to how data is coded and analyzed. To reduce potential biases, all interviews were recorded to allow for repeated review of statements and their context, and multiple coding iterations were conducted within the research team to enhance reliability. Despite efforts to include a broad range of perspectives across different roles, organizations, and industries, the dataset cannot capture the full spectrum of possible angles. Moreover, the reliance on qualitative data limits the generalizability, comparability, and objectivity of the findings throughout this thesis. Developing and applying quantitative methods could enable more structured assessment and benchmarking, thereby complementing the qualitative insights provided in this thesis.

IV.3 Future Research

The contributions and limitations outlined in this thesis collectively point to several promising directions for future research. These opportunities emerge not only from the individual insights of the six research articles, but also from the overarching perspective shaped by the two guiding research objectives. While each article independently introduces novel avenues of inquiry, it is the integrated view of this thesis that exposes deeper, cross-cutting patterns and theoretical tensions within the field. This synthesis not only reveals broader gaps and emerging questions but also uncovers insights that may have remained hidden without this cumulative investigation. In doing so, the thesis lays a strong conceptual foundation for advancing the research agenda beyond fragmented studies. The following section outlines these future research trajectories, concluding with a reflection on how each research article has contributed to identifying and shaping the specific promising research areas.

First, most research examined TT in retrospect treating DT and ST as separate initiatives that are subsequently integrated and aligned. Future research should explore how TT unfolds when conceived and implemented as an integrated, synergistic transformation from the outset. Investigating organizations that embed both digital and sustainability goals from inception could yield valuable insights into integrated transformation pathways, insights that extend beyond short-term value creation or symbolic alignment. To further advance the understanding of TT from a long-term perspective, longitudinal (case) studies are needed to trace how TT evolves over time. Since TT is inherently a

dynamic process, shaped by emerging digital technologies, shifting sustainability priorities, and changing stakeholder demands, static, retrospective research captures only a partial view of its complexity. Longitudinal research designs can provide a more comprehensive picture of how organizations initiate, adapt, and institutionalize TT across different stages of development. For instance, they could reveal how strategic priorities evolve in response to regulatory shifts, technological disruptions, or societal pressures. Such studies are essential for sophisticated theories on TT and for deriving actionable insights that support long-term value creation.

Second, research on TT has focused on the synergistic interplay between the two major transformations: DT and ST. Yet, as transformation dynamics within organizations and societies continue to accelerate, the evolution from DT and ST to TT may represent only an initial step toward a broader and more complex multi-transformation phenomenon. Future research should therefore investigate which novel types of transformation may gain importance in the coming years. Unlike the historical progression of DT, which unfolded sequentially through digitization, digitalization, and DT, following a largely linear, technology-driven path, TT is characterized by the non-sequential convergence of two previously distinct transformation domains. It thereby sets a precedent for non-linear transformation models, in which multiple change trajectories intersect, evolve together, and reshape one another in unpredictable ways. The growing intersection of societal, technological, environmental, and economic disruptions suggests that additional transformation types may emerge, requiring more holistic, adaptive, and integrated frameworks. This thesis, thus, raises several important questions: Do new transformations emerge in sequence, or are they increasingly interwoven and co-evolving, as observed in TT? How do multiple transformations interact? Are they complementary, reinforcing, or potentially conflicting? In a triadic or multi-transformation setting, do organizations go back to prioritizing certain transformations over others depending on strategic goals, industry demands, or external pressures? And finally, can transformation synergies scale beyond dyads, or does rising complexity constrain integration efforts? In sum, future research should explore both which new types of transformation are emerging and how they interact within increasingly complex transformation ecosystems.

Third, the concept of TT has gained significant traction at the theoretical level, with key elements such as synergies, initiatives, and strategic action fields already extensively explored. Its practical impact, however, remains insufficiently understood. Despite strong conceptual foundations and promising theoretical insights regarding its potential for value creation, the implementation of TT in real-world business settings continues to be challenging. Many organizations hesitate to pursue TT because its added value often appears too abstract or intangible. The concept is frequently perceived as too broad, making it difficult to operationalize or directly link it to specific business outcomes. To address this gap, future research should aim to make the value of TT more tangible by analyzing concrete, real-world cases. Such cases can help assess the potential benefits of TT across different business contexts and industries. By extracting generalized insights from individual cases, future research can contribute to

the development of transferable knowledge and practical guidance for organizations. In particular, well-documented use cases could demonstrate the value of TT on economic, ecological, and social dimensions. The challenge is further amplified by the fact that even digital innovation in isolation, such as digital products and services, is often difficult to evaluate, due to the underlying dynamics of DT. This difficulty stems from the distinct logic of DT, which includes the blurring of product and industry boundaries, the erosion of traditional firm-customer relationships, the rise of multilateral value networks, and an increasing number and diversity of stakeholders participating in digital innovation processes (Kreuzer et al., 2022). Measuring value within the more complex, integrated context of TT is even more demanding. Developing frameworks and metrics to evaluate the multi-dimensional impact of TT will be critical for bridging the gap between conceptual understanding and actionable practice.

Fourth, this thesis takes a deliberately positive stance on the evolution from DT to TT, emphasizing the significant potential that emerges from the convergence of multiple types of transformation. However, future research must complement this perspective with a critical examination of the inherent tensions and unintended consequences that such integration may entail. A growing body of literature cautions against an overly positive narrative (Chatterjee & Sarker, 2024; Tirole, 2021; Verbeke & Hutzschenreuter, 2021). It highlights how the simultaneous pursuit of transformation efforts can generate organizational tensions, understood as *"contradictory yet interrelated elements that exist simultaneously and persist over time"* (Smith & Lewis, 2011, p. 382). These tensions can arise from conflicting priorities between economic performance, environmental responsibility, and social equity. As a consequence, an organization may suffer from strategic ambiguity, initiative overload, or superficial implementation. Moreover, rebound effects may undermine intended TT objectives due to, for example, increased energy consumption from digital infrastructures or unintended social exclusion caused by limited technological access, low digital literacy, or bias embedded in data and algorithms (Binswanger, 2001). Recognizing and addressing these challenges is essential for setting realistic expectations about TT's limits and for ensuring that its implementation delivers long-term value for individuals, organizations, and society alike.

This thesis establishes a foundational basis for several promising future research directions. The first of these is supported by Research Articles 1 and 5. Research Article 1 provides a valuable starting point for examining TT from a longitudinal perspective. As Research Article 1 demonstrates from a technological stance, it is important to understand history to make meaningful decisions in the present as well as future. Building on this, Research Article 5 illustrates how DT and ST can be conceptualized and developed as an integrated TT strategy from the outset. The second research direction is informed by Research Article 2. Research Article 2 explores both *what* changes occur in the context of DT and *how* these changes unfold across organizations. These findings on the *what* and the *how* of DT are transferable to TT and other types of transformations in the future, particularly in exploring *what* types of transformations occur and *how* different types of transformation interact. Research Articles 4 and 6

contribute to the third avenue for future research by addressing the ongoing challenge of measuring the impact of TT. Research Article 4 identifies concrete TT initiatives that can serve as a foundation for developing measurable indicators, and Research Article 6 provides the theoretical underpinnings for assessing the value of assistive digital technologies in fostering social inclusion. Finally, the fourth avenue for future research is informed by Research Articles 3 and 6. Research Article 3 highlights the organizational tensions that arise when emerging forms of transformation, such as agile transformation, are introduced without sufficient alignment with existing structures and cultural dynamics. Research Article 6, in turn, explores paradoxical tensions between providers and users rooted in conflicting logics. The study demonstrates that effectively navigating these tensions is essential to ensure that assistive digital technologies are both widely usable and deeply respectful of human needs.

IV.4 Concluding Remarks

This thesis explores the evolution from DT to TT, providing valuable insights and practical guidance for both researchers and practitioners. In the light of increasing societal and environmental demands, the perspective developed in this thesis for viewing transformation types synergistically becomes pivotal for organizations and society alike. Given the accelerating pace and growing complexity of change, this perspective can and should be applied to other forms of transformation. The evolution from DT to TT marks only the beginning of a broader shift toward multi-dimensional, interconnected transformations that organizations will increasingly face in the future. As multiple transformations unfold simultaneously, they generate a complex landscape characterized by overlapping goals, competing priorities, and interdependencies. This thesis examines how organizations can build on the experiences of past isolated transformation efforts to rethink and reorient their approach toward a more integrated and holistic model of transformation. By actively shaping and significantly advancing the field, I aim to contribute to a more sustainable, resilient, and future-oriented understanding of transformation, one that empowers individuals, organizations, and society to thrive in an increasingly complex world.

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VI. Appendix

VI.1 Index of Research Articles

Research Article 1	**What's Next? – Toward a Theory of Technology-Affordance-Evolution** **Lockl, A,** Lockl, J, Oberländer, AM., Weidlich, R (2025). What's Next? – Toward a Theory of Technology-Affordance-Evolution. Under review after 1st round of revision: *Outlet hidden due to the double-blind review process of the journal*
Research Article 2	**Understanding Organizational Change in the Context of Digital Transformation – A Multi-Level Perspective** Gimpel, H, **Lockl, A,** Oberländer, AM., Röglinger, M, Schäfer, R (2025). Understanding Organizational Change in the Context of Digital Transformation – A Multi-Level Perspective. Under review after 1st round of revision: *Outlet hidden due to the double-blind review process of the journal*
Research Article 3	**Scaled Agile Framework Meets Traditional Management – A Case of a Financial Services Provider** Bitzer, M, Brax, F, **Teuchert, A** (2023). Scaled Agile Framework Meets Traditional Management – A Case of a Financial Services Provider, ICIS 2023 Proceedings. https://aisel.aisnet.org/icis2023/isdesign/isdesign/7/ (VHB-24: A, VHB-JQ3: A)
Research Article 4	**Better Together – The Interplay Between Digital Transformation and Sustainability Transformation to Realize Twin Transformation** **Lockl, A,** Heim, L, Oberländer, AM (2025). Better Together – The Interplay Between Digital Transformation and Sustainability Transformation to Realize Twin Transformation, International Journal of Innovation Management (IJIM). https://doi.org/10.1142/S1363919625400018 (VHB-24: B, VHB-JQ3: B) Earlier version published in ECIS 2023 Proceedings. https://aisel.aisnet.org/ecis2023_rp/255/ (VHB-24: A, VHB-JQ3: B)
Research Article 5	**Navigating Twin Transformation - A Systematic Approach for Twin Transformation Strategy Development** Heim, L, Buck, C, **Lockl, A,** Oberländer, AM (2025). Navigating Twin Transformation - A Systematic Approach for Twin Transformation Strategy Development. Under review: *Outlet hidden due to the double-blind review process of the journal*
Research Article 6	**Towards Digitally Enabled Social Inclusion - Navigating Tensions in the Design of Assistive Digital Technologies** Kneissel, K, **Lockl, A,** Oberländer, AM., Rosemann, M (2025). Towards Digitally Enabled Social Inclusion - Navigating Tensions in the Design of Assistive Digital Technologies. 2nd round of revision: *Outlet hidden due to the double-blind review process of the journal* Earlier version published in ICIS 2024 Proceedings (Best Paper in Track, Best Paper Nominee). https://aisel.aisnet.org/icis2024/soc_impactIS/soc_impactIS/14/ (VHB-24: A, VHB-JQ3: A)

Table 7. Index of Research Articles

VI.2 Individual Contributions to Research Articles

This cumulative thesis includes six research papers, which were all written with multiple co-authors. The following section outlines the paper settings and describes my individual contribution to each paper. The descriptions follow the contributor roles taxonomy (CRediT) by Allen et al. (2019).[1]

Research Article 1 entitled "*What's Next? – Toward a Theory of Technology-Affordance-Evolution*" (Lockl et al. 2025; Section VI.3), was written by a team of four authors. I contributed to the conceptualization, investigation, and methodology of the manuscript. Moreover, I played a key role in writing the original draft as well as in revising the manuscript. In sum, I was involved in each part of the manuscript. As a team, we agreed that we all contributed to this research paper in equal parts.

Research Article 2, "*Understanding Organizational Change in the Context of Digital Transformation – A Multi-Level Perspective*" (Gimpel et al. 2025; Section VI.4), was written by a team of five authors. I overtook the project administration and contributed significantly to the paper through the study's conceptualization, i.e., in formulating the overarching research goals and aims. Additionally, I was involved in data curation (i.e., in the structured literature review and coding) and responsible for writing the original draft. In sum, I was involved in each part of the paper. The team agreed that all members contributed equally to this Research Article.

Research Article 3 entitled "*Scaled Agile Framework Meets Traditional Management – A Case of a Financial Services Provider*" (Bitzer et al. 2023; Section VI.5), was written by a team of three authors. I contributed to the conceptualization of the research paper as well as its data curation. Moreover, I contributed through reviewing and editing the original manuscript as well as taking over a supervising role for the original draft. In addition, I contributed significantly to reviewing and editing the entire manuscript during the revision process. The team agreed that all members contributed to this Research Article in equal parts.

Research Article 4 entitled "*Better Together – The Interplay Between Digital Transformation and Sustainability Transformation to Realize Twin Transformation*" (Lockl et al. 2024; Section VI.6), was written by a team of three authors. As the lead author, I held a crucial role in all parts and administered this research project. I contributed significantly to the conceptualization, methodology, investigation, and data curation for this Research Article. I was also responsible for writing and editing the original draft. I acted as lead author, while the other three co-authors acted as subordinate authors.

Research Article 5 entitled "*Navigating Twin Transformation – A Systematic Approach for Twin Transformation Strategy Development*" (Heim et al. 2025; Section VI.7), was written by a team of four authors. I was involved in the conceptualization of the research paper, writing parts of the original

[1] Allen, L., O'Connell, A., & Kiermer, V. (2019). How can we ensure visibility and diversity in research contributions? How the Contributor Role Taxonomy (CRediT) is helping the shift from authorship to contributorship. Learned Publishing, 32(1), 71-74.

manuscript, as well as assisting in data curation. Moreover, I was involved in the review and editing process of the original draft. I acted as a subordinate author on this manuscript.

Research Article 6 entitled *"Towards Digitally Enabled Social Inclusion - Navigating Tensions in the Design of Assistive Digital Technologies"* (Kneissel et al. 2025; Section VI.8), was written by a team of four authors. I was involved in the conceptualization of the research paper and writing parts of the original draft as well as of the revised version. I contributed significantly to investigation and data curation during the revision process. Furthermore, I overtook a supervising role in the beginning of the research project. In sum, I was involved in each part of the paper. The team members all contributed to this Research Article in equal parts.

VI.3 Research Article 1: What's Next? – Toward a Theory of Technology-Affordance-Evolution

Authors:

Antonie Lockl, Jannik Lockl, Anna Maria Oberländer, and Robin Weidlich

Under review after 1st round of revision:

Outlet hidden due to double-blind review process of the journal

Extended Abstract:

As technology develops at unprecedented speed, aligning technological possibilities with user goals is crucial to generate value for individuals and organizations (Li et al., 2025; Steffen et al., 2019; Vassilakopoulou et al., 2023). Affordance theory provides a valuable lens as it explains many aspects of technology use and how users perceive and actualize action possibilities that technologies offer to them (Gibson, 1986). Prior research has addressed many aspects of affordance theory, such as affordance perception and actualization (Zheng & Yu, 2016), their integration in IT artifacts (Strong et al., 2014), and the interrelation among multiple affordances (Fayard & Weeks, 2014). Thapa and Sein (2018), for example, developed the "trajectory of affordances" to explain how the actualization of one affordance within a technology iteration can lead to the emergence of new affordances.

However, in the context of technological progress, the emergence of new affordances cannot be explained solely by the actualization of previous affordances within a single technology iteration. From a broader perspective, new affordances may also arise as technologies advance across multiple iterations. This calls for an integrated perspective that acknowledges the interplay between technological progress and affordance evolution. Affordance theory should therefore account for the fact that technologies change over time and that new affordances can gradually emerge as technologies evolve step by step. While the evolution of affordances within a single iteration has been studied extensively (e.g., Thapa & Sein, 2018; Leonardi, 2011), there is still limited understanding of how affordances evolve across technology iterations.

This study argues for moving beyond a singular, linear analysis of affordances at one point in time. It proposes that affordance research must broaden its scope to include technological progress across multiple iterations. Without such an integrated perspective, three risks arise: 1) incomplete understanding of affordances, 2) insufficient explanatory and predictive power, and 3) poor guidance for practice. Practitioners in particular may overlook opportunities to leverage a technology's full potential if its evolutionary history is ignored. Against this background, the guiding research question is: *How does affordance evolution unfold in the course of technological progress?*

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To answer the research question, the study examines the metaverse as a technological concept that has progressed across multiple iterations. Building on Thapa and Sein's (2018) trajectory of affordances, three patterns of technology–affordance-evolution are developed. Pattern I, "technology-driven affordance evolution," and Pattern II, "non-consecutive technology-driven affordance evolution," explain how affordances evolve across different iterations. Pattern III, "affordance elimination and re-emergence," demonstrates that technological progress may not only create new affordances but also eliminate existing ones, which can later reappear.

The main contribution lies in extending the trajectory of affordances toward a broader theory of technology–affordance-evolution. The findings highlight that affordance evolution is not confined to a single technology iteration but unfolds across technological progress, and that progress is not always additive but can involve both gains and losses. From a practical perspective, managers should evaluate technological concepts by considering their evolutionary histories to identify what is genuinely novel and strategically valuable. Furthermore, they should remain attentive to the elimination and possible re-emergence of affordances, recognizing that technological progress may alter long-term adoption decisions in complex ways.

Keywords:

Affordances; Affordance Evolution; Affordance Theory; Affordance Trajectory; Emerging Technologies; Metaverse; Theory Building

References:

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VI.4 Research Article 2: Understanding Organizational Change in the Context of Digital Transformation – A Multi-Level Perspective

Authors:

Henner Gimpel, Antonie Lockl, Anna Maria Oberländer, Maximilian Röglinger, and Ricarda Schäfer

Under review after 1st round of revision:

Outlet hidden due to double-blind review process of the journal

Extended Abstract:

Over the past decade, digital transformation has been a central topic in IS research and practice. Following Hanelt et al. (2021), digital transformation is defined as organizational change triggered and shaped by the widespread diffusion of digital technologies. Thereby, digital transformation represents a distinct type of organizational change that extends beyond technology adoption and often coincides with cultural, sustainability, or IT-enabled transformations. While each organization experiences digital transformation uniquely, recurring building blocks, such as the shift from value chains to value networks or the integration of digital technologies into business models, appear consistently across industries, sizes, and contexts (Vial, 2019). These recurring building blocks suggest that, despite contextual differences, digital transformation follows certain underlying principles, making it possible to study organizational change systematically across varying organizational settings.

Research has examined organizational change in the context of digital transformation from different levels of analysis. Some studies take an organization-wide view (e.g., Vial, 2019) and investigate strategic building blocks, such as large-scale agile transformations (e.g., Fuchs and Hess, 2018). Others focus on specific departments, including IT governance or IT architecture (e.g., Gregory et al., 2018). Still others analyze day-to-day initiatives undertaken by individuals (e.g., Hinsen et al., 2019). Importantly, organizational change in the context of digital transformation occurs both within (intra-level) and across these levels of analysis (inter-level), with levels influencing one another.

Limiting analysis to a single level risks producing a partial or distorted picture and contributes to ongoing debates about the nature of organizational change in digital transformation. Scholars disagree on whether digital transformation is best understood as continuous change, ongoing, evolving, and cumulative, or as episodic change, involving both radical and incremental shifts. Some studies avoid committing to either view, arguing that digital transformation may be continuous, episodic, or a combination of both.

A multi-level perspective offers a way to reconcile these diverging views by clarifying *what* changes occur at each level of analysis and examining *how* change aggregates or cascades across levels. This

perspective is theoretically important for integrating fragmented conceptualizations of digital transformation and practically relevant for managing and sustaining digital transformation efforts.

Against this backdrop, the study asks: *How does organizational change unfold within and across organizational levels of analysis in the context of digital transformation?* To answer the research question, the study develops a multi-level analysis framework distinguishing three levels: the individual-level (employees), the group-level (departments), and the organizational-level (the firm as a whole). Based on a structured literature review (vom Brocke et al., 2015; Wolfswinkel et al., 2013) and analysis following Gioia et al. (2013), the paper identifies three change constructs linked to each level that describe *what* changes are taking place at each level (intra-level perspective). At the individual-level, DT initiatives represent concrete changes embedded in work routines or projects. At the group-level, DT patterns reflect collective changes within a department. At the organizational-level, DT themes denote broader changes spanning multiple departments. Subsequently, the study also examines *how* change unfolds across levels (inter-level perspective). At the individual-level, DT initiatives follow either an episodic or continuous nature of change. With higher levels of analysis, organizational change shifts towards a more hybrid (i.e., mixture of episodic and continuous DT initiatives) and continuous nature due to aggregation and balancing effects.

The paper contributes to digital transformation research and practice in three ways. First, it develops a multi-level analysis framework to structure organizational change in digital transformation. Second, it maps *what* changes at each level of analysis. Third, it demonstrates *how* change unfolds and aggregates across levels, helping to reconcile diverging views of digital transformation. Practically, the framework provides transparency on the types of organizational changes required at different levels and offers guidance for managing the evolving dynamics of digital transformation over time.

Keywords:

Digital Transformation; Multi-level Theorizing; Organizational Change; Types of Change

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VI.5 Research Article 3: Scaled Agile Framework Meets Traditional Management – A Case of a Financial Services Provider

Authors:

Michael Bitzer, Franziska Brax, and Antonie Lockl

Published in:

ICIS 2023 Proceedings, https://aisel.aisnet.org/icis2023/isdesign/isdesign/7/

Abstract:

Inspired by the success of agile practices in small teams, organizations seek to achieve agility at scale, leading to large-scale agile transformations. Several frameworks have been developed to guide organizations through this process. While multiple challenges for adopting scaled agile frameworks have already been identified, research on the interplay between traditional management approaches and scaled agile frameworks is scarce. We conduct an in-depth exploratory case study with a German financial services provider to identify tensions that arise when applying a scaled agile framework in a non-agile environment. As a result, we derive 13 tensions along with three areas: goal-setting, planning, and reporting. Thereby, we advance the understanding of tensions within large-scale agile transformations and provide a foundation for future research on scaled agile practices in traditional organizations. Further, we provide insights for managers to ensure the successful application of scaled agile frameworks.

Keywords:

Agile Transformation; Scaled Agile Framework; Project Management; Case Study

VI.6 Research Article 4: Better Together – The Interplay Between Digital Transformation and Sustainability Transformation to Realize Twin Transformation

Authors:

Antonie Lockl, Laura Heim, and Anna Maria Oberländer

Published in:

International Journal of Innovation Management (IJIM)

Earlier version published in ECIS 2023 Proceedings, https://aisel.aisnet.org/ecis2023_rp/255/

Abstract:

The urgency of digital transformation is undeniable. At the same time, societal challenges have brought sustainability transformation to the top of research and management agendas. Driven by the growing demands of digitalization and sustainability, organizations must think about both transformations together to leverage synergies, save resources, and act effectively. However, the convergence of both transformations remains poorly understood, and an integrated perspective that focuses on the two transformations' detailed interplay is required. We refer to this interplay as twin transformation and present a twin transformation model based on a structured literature review and 32 exploratory interviews as the key finding of our study. Building on the work system theory, the twin transformation model illustrates the mutually reinforcing relationships between both transformations across eight organizational layers. Our research contributes to the explanatory knowledge of twin transformation and serves as a foundation for further theorizing about this novel phenomenon. As for practice, the twin transformation model provides valuable insights for organizations on how to leverage the strengths of both transformations and become twin transformers.

Keywords:

Digital Transformation; Sustainability Transformation; Twin Transformation; Work System Theory; Interview Study

VI.7 Research Article 5: Navigating Twin Transformation - A Systematic Approach for Twin Transformation Strategy Development

Authors:

Laura Heim, Christoph Buck, Antonie Lockl, and Anna Maria Oberländer

Under review:

Outlet hidden due to double-blind review process of the journal

Extended Abstract:

The accelerating urgency of digital transformation and the rising importance of sustainability require organizations to rethink their strategies in an integrated manner. Twin transformation, the simultaneous pursuit of digital and sustainable transformation, has become a critical priority for long-term competitiveness. However, organizations often lack a structured approach for embedding twin transformation into their overall business strategy (Breiter et al., 2024; Christmann et al., 2024). Existing approaches remain limited, as they treat digital and sustainability transformations separately (Bharadwaj et al., 2013; Broman & Robèrt, 2017; Kopnina, 2017; Vial, 2019). As a result, there is little methodological guidance for designing a twin transformation strategy that ensures alignment with overarching business objectives. To address this gap, the present study investigates the following research question: *How can organizations develop and integrate a twin transformation strategy into their overarching business strategy?*

A Design Science Research approach (Peffers et al., 2007) was adopted to construct the Twin Transformation Strategy Framework, a structured representation of an organization's twin transformation strategy. In addition, a step-by-step methodology was designed to systematically guide organizations from defining strategic direction to embedding twin transformation within the business strategy. During the early phases, 22 expert interviews surfaced key challenges such as misalignment, leadership issues, and regulatory constraints, which informed the derivation of six design objectives. Subsequent development combined theoretical foundations with practical insights, leading to iterative evaluations: formative artificial evaluations with students and research assistants, followed by a summative naturalistic evaluation with practitioners from a manufacturing firm.

The resulting Twin Transformation Strategy Framework positions identified twin transformation action fields at its core, situating them within the broader contexts of digital transformation, sustainability transformation, and the overarching business strategy. This structure provides a holistic perspective on how organizations can align and operationalize twin transformation. The associated methodology structures the development process into five sequential activities: 1) Strategic Direction, 2) Strategic Planning, 3) Strategic Fit, 4) Strategic Prioritization, and 5) Strategic Integration.

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The study offers both theoretical and practical contributions. Theoretically, it advances the management of multiple transformation logics by extending strategic alignment toward a triadic view, integrating digital, sustainability, and overarching business dimensions. Practically, two key implications emerge. First, the framework serves as a visual representation of an organization's twin transformation strategy, enhancing transparency, promoting strategic clarity, and enabling focus on high-impact initiatives. Second, the methodology operationalizes the framework by breaking the development process into actionable steps, each supported by objectives, process descriptions, illustrative examples, and guiding questions. This structured approach supports collaborative strategy development and equips organizations to maintain direction and competitiveness over the long term.

Keywords:

Twin Transformation; Digital Transformation; Sustainability Transformation; Strategy; Design Science Research

References:

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Vial, G. (2019). Understanding digital transformation: A review and a research agenda. The Journal of Strategic Information Systems, 28(2), 118–144. https://doi.org/10.1016/j.jsis.2019.01.003

VI.8 Research Article 6: Towards Digitally Enabled Social Inclusion - Navigating Tensions in the Design of Assistive Digital Technologies

Authors:

Katharina Kneissel, Antonie Lockl, Anna Maria Oberländer, and Michael Rosemann

2nd round of revision:

Outlet hidden due to double-blind review process of the journal

Extended Abstract:

Digital technologies increasingly shape everyday life, not only through functional and economic potential but also as catalysts for societal change (Baskerville et al., 2020). The concept of digital sustainability highlights the role of digital technologies in addressing social and environmental challenges (Kotlarsky et al., 2023). While research has examined environmental benefits of digital technologies (Ixmeier et al., 2024; Melville, 2010) and begun to explore their social potential (Schoormann & Kutzner, 2020; Tim et al., 2021), the latter remains underexplored (Kotlarsky et al., 2023). To fully uncover the idea of digital sustainability and leverage digital technologies for social inclusion, more research is essential, particularly towards gaining extended design knowledge.

The quality of life of approximately 1.3 billion people, around 16% of the global population (World Health Organization, 2025), is regularly challenged by individual accessibility constraints, limiting participation in public life through physical or cognitive constraints (Becker et al., 2023; Rosemann et al., 2021). Addressing these barriers is central to SDG 10.2, which calls for the inclusion of all people irrespective of age, sex, disability, or status (United Nations, 2015).

Following the idea of digital sustainability, digitally enabled social inclusion refers to the use of digital technologies to allow full participation in social, economic, and cultural life (Kotlarsky et al., 2023; Wilson & Secker, 2015). Assistive digital technologies can enhance social inclusion, as illustrated by Microsoft's Seeing AI app for the visually impaired (Microsoft, 2024) or Apple's LED Flash Alert for the hard-of-hearing (Apple, 2024). Yet, their potential is far from realized (Becker et al., 2023; Faik et al., 2024). Poor design may fail to meet user needs or reinforce exclusion, while adoption is hindered by stigma, limited functionality, and concerns about trust and reliability (Dos Santos et al., 2022).

To date, design-oriented Information Systems research on social inclusion has mainly focused on fostering inclusion in the digital world (e.g., Schoormann & Kutzner, 2020). Initial research has begun to examine the role of assistive digital technologies in enhancing social inclusion in the physical world (e.g. Díaz Andrade & Doolin, 2016). The few design-oriented contributions in this context tend to focus on the design of specific assistive digital technologies (e.g. Jonas et al., 2024).

VI. APPENDIX

Complementing the valuable design knowledge for specific assistive digital technologies, more foundational design principles are needed to foster the impact of assistive digital technologies on social inclusion. With this in mind, the study asks the following research question: *What are foundational design principles for assistive digital technologies to foster social inclusion?*

An iterative design process was conducted consisting of three distinct design cycles (Peffers et al., 2007; Sonnenberg & vom Brocke, 2012; Tuunanen et al., 2024): 1) problem validation, 2) design validation, and 3) proof of value. Empirical evidence was gathered through 45 semi-structured interviews with experts, providers, and users, complemented by the analysis of 56 real-world cases, a survey involving 14 participants, and two focus groups with 18 IS researchers. During the data analysis process, paradoxical tensions embedded within the meta-requirements were identified and employed as a theoretical lens. This led to the extraction of three paradoxical tensions (i.e., digitization vs. humanity, assistance vs. autonomy, and flexibility vs. reliability) and the development of six design principles (i.e., seamless integration, transparent information, dynamic stability, bilateral interaction, contextual personalization, and fallback first) to guide the design of assistive digital technologies, with the aim of mitigating the underlying paradoxical tensions.

The study contributes to IS research in three ways. First, it advances digital sustainability research by focusing on currently under-researched social facets of digital sustainability. Second, it contributes to digitally enabled social inclusion research by offering prescriptive design knowledge in the form of six design principles for assistive digital technologies. Third, it extends the debate on tensions in human-centered IS design by illuminating paradoxical tensions between the meta-requirements of users and providers and by illustrating how design may mitigate them. In addition to these theoretical contributions, the study offers practical guidance for providers of assistive digital technologies.

Keywords:

Digital Sustainability; Social Sustainability; Social Inclusion; Paradoxical Tensions; Assistive Digital Technology; Design Principles

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