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Managing Digital Transformation for Innovation: A Multi-Level and Multi-Dimensional Integrated Model for Managers

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Abstract

A company's digital transformation (DT) is a fundamental change process enabled by digital technologies. DT aims to bring radical improvements and innovations to create value for its stakeholders. This paper introduces a Multi-Level and Multi-Dimensional Integrated (MMI) model to help managers understand and navigate the complexity of a company's DT. The framework contains three analytical levels (individual, organizational, and business ecosystem), four analytical dimensions (actor, determinant, process, and expected results), and two types of relations (same-level and cross-level). The framework emphasizes the interplays of the different dimensions within and across the various analytical levels that influence the process and performance of the company's DT. The MMI model addresses research gaps in single-level DT analyses by providing a holistic framework for managers to align internal and external resources, foster collaboration, and mitigate challenges such as resistance to change and regulatory pressures. While advancing theoretical understanding, the MMI model offers guidance for managing a company's DT, though further operationalization is required for practical application.

Keywords: digital transformation, innovation, multi-level analysis, multi-dimensional framework, integrated model

JEL-codes: O30, O32, M15, L29

1. Introduction

1.1 Background

The world is experiencing an industrial revolution characterized by the emergence of artificial intelligence, cloud computing, big data, and the deepening of digitalization. A company's digital transformation (DT) is a fundamental change process enabled by digital technologies that aims to bring radical improvements and innovations to create value for its stakeholders (Adner et al., 2019).

DT offers significant business opportunities to drive innovation, which brings economic returns to companies, social benefits to society, and mitigates environmental impact (ElMassah & Mohieldin, 2020). Digital technologies, such as Artificial Intelligence, Augmented Reality/Virtual Reality, Internet of Things, and blockchain, can enable innovations that promote, for example, green energy, smart waste management, equal access to clean water, decent work and economic growth, and healthy lifestyles. These advancements create enormous business opportunities for companies. At the same time, DT can also cause dilemmas and conflicts (Dąbrowska et al., 2022), such as individual resistance to change (Scholkmann, 2021), concerns over data privacy and security (Porter et al., 2019), and biases related to age, gender, ethnicity, or religion that arise from the mechanism by which algorithms learn (Reier Forradellas & Garay Gallastegui, 2021). To develop strategies for coping with the opportunities and challenges of DT, a company must have a good understanding of how DT unfolds in real life.

A company's DT is a systemic and complex innovation process that occurs within a specific context shaped by various organizational, sectoral, and societal factors (Garud et al. 2013; Tidd et al., 2024). It is not only about the acceptance and adoption of digital technologies. A large part of the challenges associated with DT relates to creativity and entrepreneurship, management and organizations, as well as governance and systems (Nambisan et al., 2019). Over-relying on technological innovation and centralized innovation agencies, without a holistic view of the broader innovation process and context, has been identified as a primary reason for the failure of many IT projects (Nambisan, Lyytinen, Majchrsak and Song 2017; Henderson and Clark 1990; Leonardi 2011). Organizations often fail because they don't align their resources – technological, human, and organizational – with their broader innovation goals and the competitive environment. This underscores the importance of the holistic consideration of innovation processes and contexts in DT (Sirmon, Hitt and Ireland, 2007).

A company's DT, as a systemic and complex innovation process, occurs concurrently at various levels: the individual/employee level, the company/organization level, and the business ecosystem level. It requires changes in employees' and managers' mindsets, skills, and capabilities (Gilli et al., 2023; Sousa & Rocha, 2019). It also demands changes in work design (Schwarzmüller et al., 2018), organizational structure (Mirković et al., 2019), and organizational culture (Imran et al., 2021). Moreover, these changes take place within and are influenced by the institutional environment (Scott, 2008) of the business ecosystem, which includes laws and regulations (Reier Forradellas & Garay Gallastegui, 2021) that influence company operations and governance, social norms and values that inform organizational culture and management practices (Hartl & Hess, 2017), and shared mental models and cognitive frameworks that shape individuals' perceptions, interpretations, and sense-making processes (Solberg et al., 2020).

To drive DT for innovation in companies and leverage the great potential of digital technologies while avoiding management pitfalls, it is important to understand DT as a systemic and complex innovation process that occurs within a specific context, where individual, organizational, and business ecosystem factors interact through various mechanisms.

1.2 Research gap

DT has long been studied through single-level analyses – either at the individual level, focusing on creativity (e.g., Kytömäki, 2020; Lazzeretti et al., 2022) and entrepreneurship (e.g., Li et al., 2018; Nambisan et al., 2019); at the organizational level, examining technology adoption and change management (e.g., Imran et al., 2021; Tabrizi et al., 2019; Vey et al., 2017); or at the system level, exploring DT within the business ecosystem (e.g., Mann et al., 2022; Tan et al., 2020) or complex economic and social systems (e.g., Skare et al., 2023). Single-level analysis may limit the development of holistic solutions for complex problems like DT. First, such analysis often focuses on a specific aspect of the problem without considering the broader context and interdependencies. A narrow focus on, for example, organizational processes alone may overlook the influence of external factors such as regulatory frameworks, market dynamics, and stakeholder expectations (Schweer & Sahl, 2017), leading to fragmented or ineffective solutions. Second, single-level analysis may miss opportunities to leverage complementary strengths and resources from internal and external stakeholders (Jacobides, Cennamo and Gawer 2018). Finally, it may also introduce the risk of unintended consequences (Reier Forradellas & Garay Gallastegui, 2021), such as privacy and security.

Besides the dominant single-level analysis of DT, there are a few comprehensive studies that discuss DT at different levels, such as the individual-group-organizational levels (Trenerry et al., 2021) within an organization, the individual-organization-system levels beyond organizational boundaries (Haskamp et al., 2021; Vigren et al., 2022), and the individual-organization-system-geopolitical levels (Dąbrowska et al., 2022) across systems. These studies greatly contribute to our understanding of DT as a systemic and complex phenomenon occurring concurrently at various levels. However, they present the different levels separately and suggest research agendas respectively for each level without further elaboration on cross-level interactions. Moreover, these papers mainly approach DT as a general phenomenon, offering theoretical frameworks for researchers rather than analytical models for company managers.

1.3 Aim and contributions

This paper aims to contribute to the transformation and innovation literature by presenting a new Multi-Level and Multi-Dimensional Integrated Model (MMI model) that views a company's DT as a systemic and complex innovation process occurring concurrently at different levels. The framework contains three analytical levels, four analytical dimensions, and two types of relations. The three levels are the individual, organizational, and business ecosystem levels. The four dimensions include the actor, the determinant, the process, and the expected results. The two types of relations refer to same-level relations and cross-level relations. The framework emphasizes the interplays of the different dimensions within and across different levels, which shape the process and performance of DT within a company. Finally, the framework emphasizes that DT is a dynamic innovation process, with learning being the most central aspect, as it serves as the foundation for innovation (Lundvall 2016).

1.4 Structure of the paper

The rest of the paper is organized into four sections. The second section explains the three theoretical assumptions that form the basis of the MMI model. The third section introduces the three theoretical foundations supporting the MMI model. The fourth section provides a detailed introduction to the MMI model, covering its three analytical levels, four analytical dimensions, and the two types of relationships embedded within the model. Finally, the fifth section discusses the contributions and limitations of the MMI model and suggests directions for future research.

2. The three theoretical assumptions underpinning the MMI model

The MMI model (see Figure 1) is based on the notion that a company's DT is a systemic and complex phenomenon, with interconnected actors as the driving agency, learning as the most important process, and innovation as the expected outcome, all shaped by individual, organizational, and institutional complexities.

Firstly, a company's DT requires broad knowledge creation, sharing, and exchange among diverse actors, including employees, customers, technology suppliers, regulators, and other stakeholders, through various forms of participation and interaction (Bondar et al., 2017; Camarinha-Matos et al., 2019). This interconnectedness facilitates and drives innovation and adaptation throughout the DT journey of the company.

Secondly, a company's DT entails a complex and dynamic learning process that is non-linear in nature (Baiyere et al., 2020; Sousa & Rocha, 2019). Learning enables individuals and organizations to adapt to the continuous structural changes resulting from new technologies, reconfigure their capabilities, and seize new opportunities for innovation. Moreover, learning fosters resilience and adaptability in the face of disruptive forces, such as the fast advancements in digital technologies. As companies embrace new technologies and processes, they must navigate a continuous cycle of experimentation, feedback, and adjustment. This iterative learning process is essential for uncovering insights, refining strategies, and optimizing outcomes in the ever-evolving digital landscape (Schuchmann & Seufert, 2015; Wu et al., 2021).

Lastly, a company's DT is driven by individuals within an organization and unfolds within a sophisticated institutional environment shaped by rules, norms, regulations, and routines (Hinings et al., 2018). Companies must navigate this institutional context, which may include legal frameworks, industry standards, and cultural norms, as they implement digital initiatives. Understanding and adapting to the institutional environment is important for ensuring compliance, managing risks, and fostering innovation within the business ecosystem (Thomas & Ritala, 2022).

3. The three theoretical foundations of the MMI model

The theoretical foundations of the MMI model combine 1) behavior science and creativity studies, 2) organizational and management studies, and 3) industrial and evolutionary economics. Understanding a company's DT as a systemic and complex innovation process,

which involves various individuals and organizations in the business ecosystem, requires incorporating multiple, cross-level analyses using ideas and concepts from different fields and disciplines (Nambisan et al., 2019). The three disciplines provide theoretical tools to understand the dynamic process a company's DT at the individual, organizational, and business ecosystem levels, as well as the interactive relations across these three levels.

Behavioral science provides insights into individual decision-making processes, cognitive biases, and behavioral patterns that influence the adoption and utilization of digital technologies (Oreg et al., 2018; Solberg et al., 2020). Understanding how individuals perceive, interpret, and respond to DT initiatives is important for designing incentives and strategies to encourage innovation and address resistance to change. *Creativity studies* focus on the cognitive processes and social dynamics involved in generating novel ideas, solutions, and innovations. DT requires creative thinking and problem-solving skills to identify new opportunities, challenge existing paradigms, and develop innovative solutions that balance economic, social, and environmental objectives (Jiang et al., 2022; Lazzeretti et al., 2022; Öngel et al., 2023). By integrating insights from creativity studies, organizations can foster a culture of innovation, experimentation, and collaboration that drives a company's DT.

Organizational studies provide frameworks and theories for understanding how organizations manage complexity, resources, and performance, respond to competitive and institutional pressures, gain legitimacy, and achieve their goals. DT requires organizational agility, resource deployment, and change management capabilities to navigate the complexities of technological disruption and innovation challenges (Burchardt & Maisch, 2019; Hanelt et al., 2021; Schwarzmüller et al., 2018). Organizational studies offer insights into organizational structures, processes, and cultures that either facilitate or inhibit the learning and renewal required for DT initiatives. *Management studies* focus on the role of leadership, governance, and strategy in driving organizational performance and innovation. DT requires strategic vision, leadership commitment, and cross-functional collaboration to align digital initiatives with sustainability goals and stakeholder expectations (AlNuaimi et al., 2022; Bartsch et al., 2021; Porfírio et al., 2021; Schwarzmüller et al., 2018). Management theories offer frameworks for strategic planning, decision-making, and performance measurement that help organizations effectively integrate sustainability considerations into their DT strategies.

Industrial and evolutionary economics examine the structure, behavior, and performance of industries, including the role of competition, collaboration, and regulation in shaping market dynamics. DT reshapes industry boundaries, disrupts traditional business models, and creates new opportunities for value creation and capture (Barnewold & Lottermoser, 2020; Li, 2020; Llopis-Albert et al., 2021). Industrial economics provides insights into the drivers of technological change, market dynamics, and industry evolution that inform DT, as well as the roles of learning, knowledge accumulation, and the institutional environment underlying a company's DT (De Bem Machado et al., 2022). By integrating insights from industrial economics, organizations can better anticipate and respond to technological disruptions, harnessing the potential of digital technologies to drive a company's innovation.

4. A detailed introduction to the MMI model

The MMI model consists of three analytical levels (individual, organizational, and business ecosystem), four analytical dimensions (actors, determinants, processes, and expected results), and two types of relations (same-level and cross-level relations) (see Figure 1).

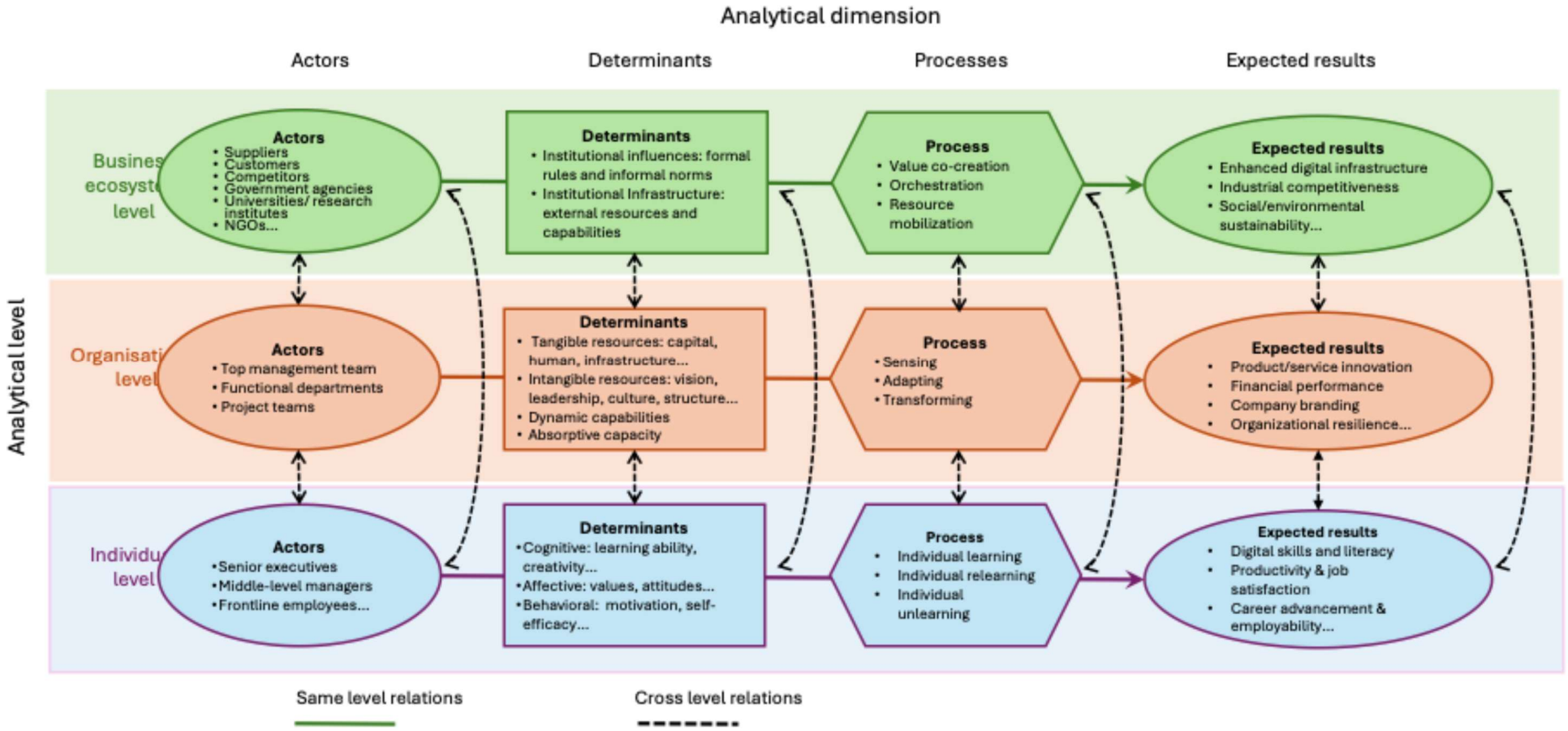

Figure 1. A Multi-Level and Multi-Dimensional Integrated (MMI) model for managers to manage digital transformation

4.1 The three analytical levels

A company's DT is a systemic and complex process that occurs concurrently at three distinct levels: individual, organizational, and business ecosystem. Addressing these three levels is essential because DT unfolds across them, and each plays an important role in the success of the overall transformation.

At the *individual level* are the people driving and engaging in a company's DT. Individuals must undergo personal change by learning new skills, adapting to digital tools, and embracing new mindsets (Shakina et al., 2021). The process of learning, relearning, and unlearning ensures that employees are equipped to handle the demands of new technologies and contribute to innovative outcomes. Without individual adaptation, any organizational changes are likely to fail.

At the *organizational level* are the collectives participating in organizational transformation, which involves restructuring internal processes, workflows, and culture to align with a company's digital goals (Saarikko et al., 2020). This includes adopting new digital platforms, redesigning business models, and fostering a culture that supports continuous innovation. The process of sensing, adapting and transforming at the organizational level ensures that the company can actively respond to the technology push and market pull created by digital technology advancements, positioning itself to leverage emerging digital opportunities and create innovation to meet evolving market demands.

At the *business ecosystem level* is the focal company's engagement with its broader business ecosystem. A business ecosystem is a set of distinct yet interdependent organizations based on various types of complementarities (Jacobides et al., 2018). While a company's DT efforts are primarily implemented within the focal company, their success is heavily influenced by the surrounding business ecosystem. This requires the focal company to collaborate with various stakeholders, aligning technologies, standards, and workflows across entities to ensure seamless collaboration and integration (Adner, 2017).

4.2 The four analytical dimensions

Analytical dimensions are essential components of the MMI model, as they provide the structure and depth needed to systematically analyze complex DT phenomena. The four analytical dimensions in the model are *actors, determinants, processes,* and *expected results*. By examining these analytical dimensions, managers can capture the full spectrum of factors that influence – and are influenced by – the company's DT phenomena. This holistic perspective enables a deeper understanding of the dynamics, interactions, and implications involved in DT.

4.2.1 Actor

An actor refers to a material entity that plays a relevant functional role, with specific responsibilities, activities, and agency in a particular context. It can be an individual human actor (e.g., an employee), a non-individual actor (e.g., a work team or a customer as a group concept), or a non-human actor (e.g., a company). This definition is based on the broad definition of an actor in Actor-Network Theory (Latour, 1996, 2007), but excludes non-

material or semiotic actors, such as technologies, discourses, or ideas. In the MMI model, actors are identified at individual, organizational, and business ecosystem levels. Distinguishing actors across these three analytical levels unveils the different natures, scopes of influence, action paradigms, and coordination mechanisms within and beyond a company. Understanding these internal and external forces, which concurrently shape organizational dynamics and performance, is essential for effective management and decision-making in a company's DT.

Actors at the individual level

At the individual level, the actors are the employees, ranging from frontline employees to senior executives, each as a single person within the company. They are characterized by their unique values, beliefs, attitudes, and behaviors toward digital technologies. As individual human resources, they possess diverse knowledge, skills, and competencies that may or may not contribute to the company's DT. Individual actors have a direct influence on their immediate work environment, team dynamics, and personal performance in the company's DT. Their actions and behaviors can affect team cohesion, collaboration, and productivity, as well as the overall organizational culture and climate for DT. The performance of and collaboration among individuals shape the effectiveness of their teams, departments, and ultimately, the entire company's DT.

Actors at the organizational level

At the organizational level, the actors include top management teams (TMT), functional departments, project teams, and other groups within an organization. Unlike individual actors, organizational actors are collective entities representing specific units in the organization, and therefore have a broader scope of influence on the company's DT. Organizational actors are responsible for setting strategic direction, allocating resources, and coordinating activities across different functions or departments for the company's DT. Their decisions and actions shape organizational structures, processes, and the performance of the company's DT. These actors facilitate communication, alignment, and collaboration among various external stakeholders, ensuring coherence and synergy in organizational efforts for DT.

Actors at the business ecosystem level

At the business ecosystem level, the actors are external entities directly or indirectly involved in the focal company's DT. These actors include suppliers, customers, competitors, government agencies, universities and research institutes, technology intermediaries, NGOs, media, and other organizations or societal groups. They may have diverse interests, goals, and priorities that influence the DT of the focal company. Such influence can vary widely depending on their roles, resources, and relationships with the focal company. For example, customers can demand digital solutions that directly impact the company's DT, while government agencies and regulatory bodies exert influence through policies, regulations, and compliance requirements that shape the business environment for the company's DT. The focal company can leverage the resources and competencies of these actors, benefiting from collaboration, competition, negotiation, and cooperation for their DT, while also facing potential negative impacts such as conflicts of interest, increased competition, or misaligned goals related to their DT.

4.2.2 Determinant

A determinant is an underlying factor, condition, or variable that influences the initiation, implementation, and outcomes of a particular phenomenon or process. In the MMI model, determinants are identified at individual, organizational, and business ecosystem levels. Each level presents unique determinants that affect the focal company's DT in distinct ways, reflecting variations in scope, impact, and dynamics. Distinguishing determinants across these three analytical levels enables managers to identify and address specific factors that could facilitate or hinder the company's DT efforts. This, in turn, helps develop adaptive DT strategies that leverage relevant internal and external resources, thereby enhancing decision-making, organizational responsiveness, and overall innovation.

Determinants at the individual level: cognitive, affective, and behavioral

At the individual level, a determinant refers to any factor that influences or drives a person's actions, decisions, and responses in the context of DT. These determinants can be categorized into three groups: *cognitive*, *affective*, and *behavioral*. This typological framework is inspired by the theory of planned behavior (Ajzen, 1991), which suggests that an individual's behavior is guided by attitudes, subjective norms, and perceived behavioral control, as well as by Bloom's taxonomy of learning domains (Bloom et al., 1956), which includes the cognitive, affective, and psychomotor domains.

The *cognitive* determinants are the mental abilities and resources that individuals possess, enabling them to process information, solve problems, generate ideas, and adapt to new situations. Examples include an learning ability, cognitive flexibility, problem-solving and reasoning skills, creativity, and critical thinking. These skills are essential for driving innovation and navigating DT (Runco & Chand, 1995; Sweller, 2009). DT requires individuals to continuously acquire knowledge about new technologies, tools, and processes. Learning ability is essential for keeping up with fast-paced innovations (Sousa & Rocha, 2019). The rapid and disruptive nature of DT demands flexibility in thinking. Cognitive flexibility enables individuals to adapt to new technologies, business models, and workflows while navigating uncertainty and change (Volberda et al., 2021; Zhu & Jin, 2023). DT often introduces complex challenges, such as integrating new technologies and optimizing processes for digital efficiency. Strong problem-solving and reasoning abilities help individuals analyze situations, identify innovative solutions, and make effective decisions (Van Laar et al., 2017; Westerman et al., 2014). A company's DT is not just about adopting new technologies but also about using them to drive innovation. Creativity and divergent thinking are essential for imagining new business models, customer experiences, and operational processes enabled by digital technologies (Van Laar et al., 2017). However, a company's DT is not always solely positive; it can also involve risks and, at times, lead to negative or even disastrous outcomes. Critical thinking helps individuals to question assumptions, assess risks, and make informed choices (Van Laar et al., 2017).

The *affective* determinants at the individual level include an individual's values and attitudes, which shape how they perceive and respond to a company's DT. Values are fundamental beliefs or principles that individuals hold about what is desirable, important, and worth striving for in life (Schwartz & Bilsky, 1987). These values shape how individuals view and engage with the changes brought about by DT and affect their overall willingness to embrace or resist DT efforts. For example, individuals who prioritize ethical responsibility may be more inclined to promote value-sensitive design (Bednar & Spiekermann, 2024) in DT, ensuring that digital innovations are implemented in ways that respect data privacy and mitigate potential negative

impacts on society. Attitudes, on the other hand, are evaluative statements – either favorable or unfavorable – about artifacts, people, or events. For example, skepticism toward digital technologies often arises from concerns about job security, ethical implications, or the potential failure of digital initiatives. Such skepticism, common among both employees and managers, can lead to resistance in embracing DT initiatives (Scholkmann, 2021).

The *behavioral* determinants at the individual level are factors that directly influence actions and decision-making. Among the most critical of these determinants are motivation and self-efficacy (Trenerry et al., 2021). Motivation is an internal state that drives individuals to engage in goal-directed behaviors, playing an important role in behavior change during DT. Highly motivated individuals are more likely to take ownership of digital initiatives, learn new skills, and explore new tools. Self-efficacy refers to an individual's belief in their ability to succeed in specific situations. In the context of DT, individuals who believe they are capable of learning and using new technologies are more likely to participate actively in the DT process. Employees with higher self-efficacy are more likely to adopt digital tools and experiment with new processes, whereas those with low self-efficacy may resist or avoid DT due to fear of failure or a lack of confidence.

These three types of individual determinants are not independent of one another; rather, they are interrelated and often interact, influence, and reinforce each other in shaping an individual's behavior during DT. For instance, an individual with strong cognitive flexibility (cognitive) is more likely to feel confident and respond positively (affective) when adapting to new digital technologies, thereby reducing fear or resistance. Similarly, an employee enthusiastic about career advancement (affective) may be more motivated to participate in training for new digital tools (behavioral), thereby actively adopting those tools. Furthermore, employees with strong problem-solving skills (cognitive) are more likely to develop high self-efficacy, which motivates them to experiment with new digital systems (behavioral). In contrast, those with limited digital literacy may be more inclined to avoid adopting these systems. Therefore, an integrated approach is needed when addressing the individual determinants of DT. The cognitive, affective, and behavioral determinants work together to shape how an individual engages with DT. Successful DT requires addressing all three determinants.

Determinants at the organizational level: resources and capabilities

At the organizational level, determinants refer to the factors that shape an organization's competitive advantage and thus influence its DT. These determinants are broadly categorized as *resources* and *capabilities*. This typology is based on the resource-based theory of the firm (Barney, 1991; Penrose, 1959; Teece et al., 1997) and inspired by Hall's (1993, 2009) distinction between what a firm "has" (resources) and "does" (capabilities). The resource-based theory rigorously describes the processes through which firms develop and grow (Rugman & Verbeke, 2002). Therefore, it well-suited for understanding the process of DT in an organization.

The *resource* determinants include both *tangible* and *intangible* resources. *Tangible resources* include financial and physical assets measured on the organization's balance sheet, such as technological infrastructure (e.g., servers and data centers), financial capital, digital tools and software, facilities and equipment, and a skilled workforce. Tangible resources enable an organization to initiate and execute DT initiatives, such as developing digital solutions, maintaining digital platforms, and financing the acquisition of digital technologies. *Intangible resources* are non-physical or non-financial assets that are rarely included in the organization's

balance sheet. Examples include vision and leadership, organizational structure, culture, norms and routines, and brand reputation. Intangible resources are often the key drivers of DT. Vision and leadership provide strategic direction and commitment for DT initiatives, fostering an environment where digital adoption is encouraged (McCarthy et al., 2022; Porfírio et al., 2021). Organizational culture and norms play an important role in how employees engage with new technologies, influencing their openness to change and innovation (van Tonder et al., 2020) and unlocking the potential of digitalization (Martínez-Caro et al., 2020).

The *capability* determinants include both *dynamic capability* and *absorptive capacity*. *Dynamic capabilities* are the firm-internal technological, organizational, and managerial processes that enable a company to remain competitive and respond to new opportunities in a changing environment (Teece, Pisano and Shuen 1997). They help organizations overcome path dependencies related to existing, ordinary processes and create new routines and workflows (Winter, 2003). Examples of such higher-order processes include product development, strategic decision-making, and alliancing (Eisenhardt and Martin 2000). Dynamic capabilities are an important component of DT in organizations (Ghosh et al., 2022; Matarazzo et al., 2021), as they allow organizations to continually adapt, innovate, and respond to rapid technological advancements. Another key capability is the organization's *absorptive capacity*, which refers to the organization's ability to acquire and process new information, for example, for the development of new products and services (Cohen and Levinthal 1990; Sahra and George 2002). Absorptive capacity is important for a company's DT, as it helps in the integration of new digital technologies and collaboration with new actors (Miroshnychenko et al., 2021; Siachou et al., 2021). Companies with high absorptive capacity are better equipped to remain competitive as digital technologies evolve.

These two types of organizational determinants, namely resources (tangible and intangible) and capabilities (dynamic capability and absorptive capacity), are interconnected factors in a company's DT. On the one hand, capabilities enable the acquisition, expansion, and reconfiguration of resources (Teece, 2007) to address the challenges in DT. On the other hand, an organization's resources function as the micro-foundations of its capabilities. This relationship is symbiotic (Lin & Wu, 2014), with resources forming the basis of competitive advantage, while dynamic capabilities ensure that these resources are continuously renewed, adapted, and enhanced to address emerging challenges and opportunities presented by the advancement of digital technologies.

Determinants at the ecosystem level: institutional influence and institutional infrastructure

At the business ecosystem level, determinants refer to external factors influencing DT in companies and how companies can gain advantages in their DT processes by engaging with their business ecosystems. Business ecosystem theory (Adner, 2017; Moore, 1993, 2006) generally addresses topics such as institutions, the co-evolution of companies and value propositions, interdependencies and complementarities among firms, shared standards, digital platforms, and network effects — all mechanisms that impact DT in companies. We categorize these determinants into two groups: *institutional influences* and *institutional infrastructure*. This typology is informed by institutional theory and business ecosystem literature, as well as the innovation literature, particularly those on DT, which highlight how organizations adapt their strategies in response to institutional pressures, leverage shared resources and collaborative networks for innovation, and utilize established technological platforms and standards to enhance their competitive positioning in a dynamic environment.

The determinants of *institutional influence* are the formal rules and informal norms that impact a company's boundary conditions for DT. This perspective on strategy (DiMaggio and Powell 1983; Scott 2008) emphasizes that organizations are influenced by their broader social, economic, and political environments, which shape their strategic options. In the MMI model, institutional influence aligns with the "Northian" typology of institutions-as-rules-of-the-game (North, 1990), which includes formal rules (e.g. laws, regulation, policies) and informal norms (e.g., conventions, societal expectations, mental models, values, and beliefs) that enable and constrain social interactions (Edquist, 2010; Liu, 2016; Lundvall, 1992). The institutional influences from rules involve regulatory enforcement by influential stakeholders such as the government (DiMaggio and Powell 1983; Berrone et al. 2013). For example, the General Data Protection Regulation (GDPR) – a comprehensive data protection law introduced by the European Union – compels organizations to prioritize data protection, security, and transparency. The institutional influences from informal norms arise from social obligations and expectations. For example, institutional investors and stakeholders increasingly demand that companies report their Environmental, Social, and Governance (ESG) performance. In response, companies use digital analytics platforms to collect, analyze, and report on their environmental impact, aligning with these expectations.

The determinants of *institutional infrastructure* include external resources and capabilities (Teece 2007; Dattée et al. 2018; Vigren et al. 2022) that companies access through collaboration with other actors in the business ecosystem to support DT. These resources include shared standards (Teece 2007; Dattée et al. 2018), governance structures (Tiwana et al. 2010; Kapoor and Lee 2023), and technologies such as platforms (Gawer and Cusumano 2008; Gawer and Cusumano 2014; Ceccagnoli et al. 2012), all of which facilitate collaboration, interdependence, and interoperability among ecosystem participants. Actors in an ecosystem co-evolve by adapting and innovating collectively in response to technological, market, and regulatory changes (Moore 1993; de Vasconcelos Gomes et al. 2018; Rong et al. 2015). Through mutual adjustments and collaborative learning, they develop interdependencies (Ritala et al. 2013; Adner and Kapoor 2010) that reflect the extent to which companies rely on each other's capabilities, products, and services. Examples include buyer-seller relationships, data sharing and integration across platforms, strategic alliances, joint ventures, shared R&D facilities for digital solutions, and common industry initiatives to develop new digital standards or digital technologies. Complementarities emerge when companies create products and services that provide value beyond what they could achieve independently, thus benefiting from operating collectively within the ecosystem (Jacobides et al. 2018). Institutional infrastructure also enables companies to amplify their business outcomes by accessing markets and intermediaries (Eckhardt et al. 2018; Hernández-Chea et al. 2021) otherwise out of reach and by leveraging network effects (Gawer and Cusumano 2014; Katz and Shapiro 1994).

Institutional influence and institutional infrastructure at business ecosystem level are deeply interconnected in the context of a company's DT. Institutional influences, namely the formal rules and the informal norms, create the contextual framework which drives and constrains the company's DT, while institutional infrastructure provides external resources and capabilities, such as shared digital technology standards or platforms, enabling the company to collaborate and innovate. Together, institutional influence and institutional infrastructure form a dynamic business ecosystem that underpins the DT of a company.

4.2.3 Process

A process is a sequence of actions or steps taken to achieve a specific goal or produce a particular outcome. It involves a systematic and often repeatable set of tasks or activities carried out in a defined order, usually with inputs being transformed into outputs. From a company's perspective, DT involves the strategic integration and adoption of digital technologies, tools, and processes across the individual, organizational, and business ecosystem levels. Understanding these processes at each level is essential for effectively navigating the transformation journey.

Processes at the individual level: learning, relearning, and unlearning

Individuals are the primary agents who implement and sustain DT within an organization. In innovation research, learning has long been considered as the most important process at the individual level (Hirst et al., 2009; Karwowski et al., 2020). However, in the context of DT, we argue that relearning and unlearning are equally important, if not more so. *Learning* refers to acquiring entirely new knowledge and skills. *Relearning* involves revisiting and updating previously learned knowledge and skills, bringing them up to date with rapid technological advancements or changing work practices. *Unlearning* is the process of removing outdated or obsolete knowledge, practices, or mindsets that no longer serve the current environment.

The cycle of learning, relearning, and unlearning aligns closely with transformative learning theory (Mezirow, 1997), which emphasizes the importance of critically questioning existing assumptions and adopting new ways of thinking and behaving. While traditional learning theories, such as self-directed learning (Knowles, 1975), social learning (Bandura, 1977), the SECI model (Nonaka, 1994), and experiential learning (Kolb & Kolb, 2009), do not explicitly differentiate relearning and unlearning from learning, they address processes related to updating prior knowledge and skills and removing outdated practices. In the context of DT, however, distinguishing between learning, relearning, and unlearning is essential. Individuals must not only acquire new knowledge and skills but also update previously learned information and discard outdated practices or mindsets that hinder progress.

The processes of learning, relearning, and unlearning are interconnected and form a continuous cycle that supports individual adaption, particularly in the dynamic environments of a company's DT. Learning forms the foundation for both relearning and unlearning. It is often the first step when individuals face new challenges or innovations, such as mastering a new digital tool or understanding sustainability principles. Relearning builds on prior learning but updates it to suit new contexts or applications. Unlearning is essential for creating the mental and behavioral space necessary for new learning and relearning. Without unlearning obsolete methods, individuals may resist new learning efforts – a common challenge DT. When individuals unlearn obsolete methods, they are usually required to either learn a completely new way of thinking and practicing or relearn how to approach similar tasks or problems in a new way. Understanding the interplay of learning, relearning, and unlearning at the individual level is crucial for the success of a company's DT. By fostering an environment where individuals can effectively learn new skills, relearn existing knowledge, and unlearn outdated practices, organizations can better equip their workforce to thrive in an evolving digital landscape.

Processes at the organizational level: sensing, adapting, and transforming

At the organizational level, a company's DT involves reimagining and restructuring business operations, processes, and models to leverage digital technologies for strategic advantage. This

transformation requires organizational learning (Nooteboom 2000) to adopt digital platforms, automation tools, data analytics, and artificial intelligence. These tools aim to streamline workflows, improve customer experiences, and foster innovation across functional areas like marketing, sales, operations, and customer service. The process begins by aligning digital initiatives with the organization's strategic vision and objectives. To better understand these processes, we categorize them into three key phases: *sensing*, *adapting*, and *transforming*.

Sensing refers to the processes through which a company seeks information about its changing environment amidst the rapid advancement of digital technology, aligning with what Teece (2007) describes as sensing. Examples of sensing include the identification of opportunities and threats presented by digital technologies. This involves continuously scanning the environment to identify technological changes, market shifts, or competitive threats, as well as conducting market research and competitor analysis to actively seek emerging opportunities. These efforts enable the company to reconfigure its strategies in response to digital advancements. Another important aspect of sensing is engaging stakeholder, which involves building and maintaining relationships with key external stakeholders (e.g., customers, suppliers, and regulators). This engagement helps the company gain insights into the business environment and align its practices with external expectations. It may include participation in industry forums, government consultations, or professional networks to shape organizational practices and policies in response to social, political, or economic pressures. A third example is monitoring shifts in regulations and norms within the industry or market (Scott 2008). This involves staying informed about changing institutional pressures, such as new legislation or industry standards.

Adapting refers to the processes through which a company interprets and internalizes information (Weick 1995; Maitlis and Christianson 2014) about sensed opportunities, threats, and institutional pressures, aiming to align with and respond to the rapidly evolving digital landscape. A key motivation behind adapting is achieving legitimacy and compliance. This process is supported by the organization’s absorptive capacity, which reflects its ability to acquire, assimilate, and apply new information (Cohen and Levinthal 1990; Sahra and George 2002). Examples of adapting include regulatory compliance and alignment, such as monitoring and adhering to EU’s General Data Protection Regulation (GDPR) or meeting industry standards like ISO 27001 – Information Security Management Systems (ISMS). In addition to regulatory compliance, adapting also involves norm adoption, where organizations internalize industry best practices, cultural values, and professional standards. For example, sustainability reporting, often mandated by industry associations, relies heavily on digital technology to monitor and evaluate sustainability performance. This process may also involve integrating industry-specific certifications, codes of conduct, or ethical practices into the company’s DT goals. By doing so, organizations ensure alignment with broader institutional environments shaped by professional networks and industry norms.

Transforming refers to the processes through which a company reconfigures its resources and capabilities to develop innovative products or services or to significantly reshape its structures, culture, and systems (Teece et al. 1998; Winter 2003; Eisenhardt and Martin 2000) to meet the demands of a rapidly evolving digital landscape. A key component of transforming is fostering learning and digital innovation, where new knowledge and skills are cultivated to drive digital innovation in products, services, or processes (Nooteboom 2000; Lundvall 2016; Zhao and Wang 2020). This can be achieved through R&D, internal training programs, and the promotion of a culture of experimentation with digital technologies. Another important element of transforming is reconfiguring resources, which involves reallocating human, technological,

and financial resources to seize emerging opportunities or meet market demands for innovative digital solutions. This process may include restructuring teams, investing in advanced digital technologies, reshaping organizational structures, engaging new external stakeholders to foster digital innovation, or adopting best practices in DT to enhance the company's capabilities and competitiveness.

Processes at the business ecosystem level: value co-creation, orchestration, and resource mobilization

Several processes in the business ecosystem significantly influence a company's DT. In business ecosystem literature, a business ecosystem is defined as a complex system composed of interdependent yet hierarchically independent heterogenous actors that collectively generate an ecosystem value proposition (Thomas and Ritala 2022; Autio 2022). Among business ecosystem processes, orchestration plays an important role in aligning the efforts of various actors to establish a coherent system-level value proposition (Autio and Thomas 2020). Delivering this value proposition requires effective resource mobilization across the ecosystem. Thus, we categorize ecosystem processes into three areas: *value co-creation*, *orchestration*, and *resource mobilization*.

Value co-creation is the foundational process through which ecosystems generate value that exceeds individual organizations' contributions (Autio 2022). In the context of DT, this process requires the co-evolution of DT efforts among ecosystem participants, including the focal company, in response to technological, market, and regulatory shifts (Moore 1993; de Vasconcelos Gomes et al. 2018; Rong et al. 2015). In other words, the focal company's DT is inherently a part of the broader business ecosystem's DT. As an collective effort (Thomas and Ritala 2022), value co-creation in a business ecosystem's DT is driven by mutual learning and adjustments (Iansiti and Levien 2004), enabling the focal company to both contribute to and benefit from these processes.

Orchestration is a critical process for ensuring coordinated interactions among actors and maintaining the structural integrity of the business ecosystem (Autio 2022; Nambisan and Sawhney 2011). Orchestration is typically led by a central actor, often a platform owner, who manages interdependencies and sets the strategic direction for value creation within the business ecosystem (Iansiti and Levien 2004). This orchestrator facilitates collaboration, mitigates potential conflicts, establishes trust, and aligns participants towards shared goals (Iansiti and Levien 2004). Ecosystem orchestration has profound implications for the focal company's DT, It influences access to resources, innovation potential, agility, and strategic alignment. While it offers numerous opportunities to accelerate and enhance the focal company's DT through collaboration, it also introduces challenges, such as dependency on the orchestrator and the need to align with the orchestrator's goals. To navigate these dynamics successfully, the focal company must strategically align its DT efforts with ecosystem objectives while maintaining flexibility and independence where possible.

Resource mobilization is essential for the growth and scalability of a business ecosystem. It involves pooling and leveraging complementary assets (Jacobides, Cennamo and Gawer 2018), including knowledge, technology, and financial capital, from various ecosystem participants (Teece 2007). This process enables the efficient allocation of resources for innovation and scaling operations, allowing participants to achieve outcomes that would be unattainable individually (Adner and Kapoor 2010). Network effects further amplify the value of ecosystems as more participants join and interact, enhancing the utility of the platform or

ecosystems. As more participants join and interact, the utility of the platform or ecosystem increases for all members (Gawer and Cusumano 2014). Together, resource mobilization and network effects drive the growth and competitiveness of ecosystems in dynamic markets (Cusumano and Gawer 2002). Resource mobilization profoundly impacts the focal company's DT by providing access to complementary resources, fostering innovation, and enhancing scalability and efficiency. While these opportunities can drive growth and competitive advantage, they also introduce dependencies that require careful management. By effectively engaging in resource mobilization, the focal company can accelerate its DT journey, leveraging the strengths of the ecosystem to achieve transformative outcomes.

4.2.4 Expected results

A company's DT can yield diverse results, categorized as *outputs, outcomes*, and *impacts*, affecting individual employees, the organization, and the broader business ecosystem. *Outputs* are the tangible, immediate products, services, or deliverables produced as a result of activities or interventions related to DT. *Outcomes* refer to the changes, effects, or benefits that occur as a result of outputs. *Impacts* refer to the broader, long-term effects or consequences that follow from the achieved outcomes. This taxonomy is based on the theories of change and theory-based evaluation (Rogers & Weiss, 2007).

Expected results at individual level: outputs, outcomes and impact

At the individual level, the *expected outputs* of DT can include the acquisition of new knowledge and digital skills, the integration of digital tools and technologies into daily tasks, and enhanced workflows achieved through automation and streamlined processes. The *expected outcomes* can be increased individual productivity and job satisfaction as repetitive tasks are minimized, enhanced creativity and autonomy for innovation, enhanced focus on creative, social, or emotional activities that are less easily replicated by digital technologies, and greater employee engagement and commitment, driven by the availability of effective digital tools and resources. The *expected impacts* include long-term career advancement and employability due to advanced digital competencies, a more fulfilling and empowering work experience, and a shift in focus toward innovation for sustainability and higher-value tasks.

Expected results at organizational level: outputs, outcomes and impacts

At the organizational level, the *expected outputs* of the company's DT may include the development of innovative digital products, services, and processes; the implementation of data analytics, AI, and automation to enhance operational efficiency; and the creation of omnichannel customer experiences through digital platforms. The *expected outcomes* of the company's DT can be improved operational efficiency through optimized processes and resource utilization, enhanced financial performance due to cost reductions and improved decision-making supported by digital technologies, greater customer satisfaction driven by personalized, seamless, and proactive services, and strengthened collaboration and adaptability across organizational functions via digital platforms. The *expected impacts* of the company's DT include fostering a culture of experimentation based on successful DT experiences, collaboration, and continuous improvement within the organization; achieving stronger market differentiation and brand identity by offering unique digital products and services, creating lasting stakeholder value; and enhancing organizational resilience to market changes and competitive pressures in the digital era.

Expected results at business ecosystem level: outputs, outcomes and impacts

At the business ecosystem level, the *expected outputs* of the company's DT may include establishment of partnerships and alliances, the introduction or enhancement of shared digital platforms and infrastructure, and the creation of new business models and collaborative innovations. The *expected outcomes* of the company's DT can be enhanced industrial competitiveness through shared resources and co-created value, improved regional resilience due to ecosystem-wide collaboration and innovation, and the disruption of traditional industry boundaries, reshaping value chains and market dynamics. The *expected impacts* of the company's DT can be long-term economic growth, job creation, and entrepreneurship within the ecosystem; enhanced social and environmental sustainability driven by ecosystem-wide digital inclusion; and more dynamic and resilient business ecosystem that fosters innovation and adaptability.

4.3 The two types of relations in the MMI model

The MMI model is based on the notion that a company's DT is a systemic and complex phenomenon, driven by interconnected actors, with learning as the most important process, and innovation as the expected outcome that is shaped by individual, organizational and institutional complexities. DT occurs concurrently at the individual, organizational, and business ecosystem levels. The interplay and mechanisms between actors, determinants, processes, and outcomes are not confined to a single level but span across multiple levels. It is important for managers to comprehend both the relationships among these four analytical dimensions within the same level and how they interact across different levels. By grasping these connections, managers can more effectively allocate internal resources, harness external resources, formulate and implement DT strategies within the organization, and navigate challenges throughout the transformation journey in the business ecosystem.

4.3.1 Same level relations in the MMI model

The relations among actors, determinants, processes, and expected results at the same level are straightforward. Given the support, constraints, and influences of determinants, actors engage in a series of actions throughout a process to achieve specific goals and generate desired outcomes and impacts. Here are examples of the same-level relations.

Example1: The development of employees' digital skills at individual level.

At the individual level, motivation and self-efficacy (determinant) influence how actively an employee (actor) engages with a training program to learn a new digital tool (process). When the employee feels confident and motivated, they are more likely to complete the training effectively, which results in enhanced digital skills (expected result).

Example 2: Top management team leading digital strategy at the organizational level.

At the organizational level, visionary leadership and investment capital (determinant) influence the top management team (actor) to sense emerging trends, such as AI or blockchain, anticipate market shifts, and formulate and implements a digital strategy (process). Ultimately, they transform the organization by investing in advanced digital platforms, achieving innovation through a new AI-driven service, and boosting market share and financial performance (expected result).

Example 3: Digitalization in the renewable energy sector at the business ecosystem level.

At the business ecosystem level, government regulations on CO_2 emissions, growing societal demand for clean energy, and widespread belief in the importance of sustainability (determinants) drive technology suppliers to collaborate with energy companies and research institutes (actors). Together, they engage in developing and deploying smart grid technologies, predictive maintenance systems, and green energy solutions (process). These efforts lead to increased regional resilience by reducing reliance on non-renewable energy sources, boosting industrial competitiveness in the clean energy market, and the promotion of environmental sustainability (expected result).

4.3.2 Cross level relations in the MMI model

The relations between actors, determinants, processes, and expected results across individual, organizational, and business ecosystem levels can be summarized in three paradigms.

Paradigm 1: The elements at lower level are the micro-foundation of the higher level.

A lower-level actor is part of a higher-level actor. For example, a frontline facility manager (individual-level actor) is a member of a digital twin project team of a real estate company (organizational-level actor). This project team (organizational-level actor) is, in turn, a customer of a regional technology company specializing in AI and big data (business ecosystem-level actor).

A lower-level determinant forms the foundation of a higher-level determinant. For example, an individual employee's learning ability (individual-level determinant) forms the micro-foundation of the organization's absorptive capacity (organizational-level determinant). The organization's absorptive capacity (organizational-level determinant), in turn, underpins the business ecosystem's capacity (business ecosystem-level determinant) for absorbing, accepting, or rejecting new digital technologies.

A lower-level process supports higher-level processes. For example, an individual employee's processes of learning, relearning, and unlearning (individual-level process) are part of the organization's overall transformation process (organizational level process). The organization's transformation process (organizational-level process). The organization's transformation process (organizational-level process) is the foundation of the business ecosystem's processes of value co-creation, orchestration, and resource mobilization (business ecosystem-level process).

A lower-level result contributes to higher-level results. For example, an individual employee's creativity (individual-level result) contributes to the organization's digital innovation (organizational-level result). The organization's digital innovation (organizational-level result) contributes to industrial competitiveness and resilience in the business ecosystem (business ecosystem-level result).

Paradigm 2: The elements at higher level establish the business context for lower levels.

A higher-level actor is the institutional or organizational context in which the lower-level actors operate. For instance, the suppliers, customers, competitors, government agencies, and

universities and research institutes within the business ecosystem (business ecosystem-level actors) create a knowledge pool from which the focal company's departments (organizational-level actors) can select collaborators for innovation. Similarly, a functional department (organizational-level actor) sets up an organizational environment within which individual employees (individual-level actor) carry out their work.

A higher-level determinant sets the context for the lower-level determinants. For example, societal values and expectations of sustainability (business ecosystem-level determinant) encourage the organization to integrate sustainability into its vision and mission (organizational-level determinant). In turn, the organization's sustainability vision and mission (organizational-level determinant) shape the values and attitudes of its employees (individual-level determinant).

A higher-level process establishes the context for the lower-level processes. For example, the shift in the business ecosystem's value co-creation network, orchestrating models, and resource configuration (business ecosystem-level process) drive companies to sense, adapt, and transform their business operations by aligning with the orchestrator's vision, specializing in complementary areas, leveraging the provided infrastructure, and actively collaborating with new actors. The organization's transformation (organizational-level process), in turn, encourages individual employees to change their mindsets and learn new knowledge and skills (individual-level process). Moreover, a competitive market (business ecosystem-level result) pushes the organization to foster innovation (organizational-level result). The innovation in the organization (organizational-level result), in turn, empowers individuals to take risks and pursue deeper, more significant innovations (individual-level result).

Paradigm 3: Higher- and lower-level elements co-evolve.

This paradigm is a logical consequence of Paradigm 1 and Paradigm 2. In this co-evolutionary relationship, changes and developments at one level influence and shape dynamics at another, creating a continuous feedback loop that drives DT in the focal company. For example, individual creativity and organizational creativity co-evolve as employees' innovative ideas contribute to the organization's overall creative output, which in turn fosters a culture that supports further individual innovation (Cetindamar Kosanoglu and Abedin, 2021; Gao, Zhao, et al., 2021). Similarly, individual cognitive capacity and organizational absorptive capacity co-evolve. Employees' ability to absorb and apply new knowledge improves as the organization invests in training and knowledge-sharing mechanisms. At the same time, the organization's absorptive capacity grows, creating an environment where individuals can learn more effectively. Individual learning advances organizational learning (Kim, 2009), while organizational learning provides a framework that shapes individual learning experiences, guiding how individuals acquire, share, and apply knowledge within the organization (Vera & Crossan, 2004). Additionally, institutional regulation and organizational transformation also co-evolve. Regulatory changes drive organizational transformation, while innovations and advancements made by organizations, in turn, influence how regulations are shaped and enforced.

5. Contributions, limitations and future research

The MMI model contributes to the digital transformation and innovation literature by introducing a multi-level (individual, organizational, and business ecosystem) and multi-dimensional (actor, determinant, process, expected results) integrated framework. It

emphasizes both same-level mechanisms and cross-level interactions that shape an organization's DT. The model integrates theoretical insights from behavioral science and creativity studies, organizational and management studies, and industrial and evolutionary economics in novel ways. The MMI model focuses specifically on DT, rather change or transformation in general. The model is grounded in DT literature and examples, making it specifically useful for managers seeking to effectively navigate and manage the DT process.

The MMI model is among the few studies to explicitly theorize and discuss DT at the individual, organizational, and business ecosystem levels within a single integrated framework. Compared to previous research, the model particularly deepens the understanding of DT by identifying mechanisms related to *cognitive*, *affective*, and *behavioral* determinants at the individual level; *resources* and *capabilities* at the organizational level; and *institutional influence* and *infrastructure* at the ecosystem level – while also relating these determinants to actors, processes, and expected results in an organization's DT process. By drawing on behavioral science, creativity studies, organizational and management studies, as well as industrial and evolutionary economics — and by particularly highlighting the important roles of learning (Lundvall 2016) and institutional influence and infrastructure (Scott 2008; 2013) in DT — we offer an alternative view on DT. This contrasts with socio-technical systems theory (e.g., Imran et al., 2021) and theories focusing on corporate strategy and business models (e.g., Verhoef et al. 2021; Plekhanov et al. 2023). These theoretical choices emphasize perspectives that have received less attention in the existing DT literature (Appio et al. 2021; Dąbrowska et al. 2022; Trenerry et al. 2021; Haskamp et al. 2021; Vigren et al. 2022; Nyoni et al. 2023). Furthermore, the MMI model advances theory by elaborating on cross-level interactions, an area often under-theorized in previous research. Thus, our contribution lies in the novel integration of these theoretical insights into a cohesive framework (Tarafdar and Davison 2018).

Furthermore, the model addresses the limitation of single-level analysis, which often leads to fragmented and ineffective solutions. It offers a holistic perspective for managers to understand DT as a systemic and complex phenomenon that occurs concurrently at individual, organizational, and business ecosystem levels. Additionally, it provides an approach for managers to navigate the dynamic learning process of DT within their organization and leverage complementary resources and capabilities from internal and external stakeholders to foster innovation through DT.

While the MMI model offers a comprehensive framework for understanding DT across multiple levels, it has certain limitations. We identify two main limitations as follows:

Limited operationalization of the model. The strength of the MMI model lies in its comprehensiveness, which also contributes to its limitations. While the model is indented to guide the understanding of DT, its direct implementation in managerial practice may be challenging due to its inherent complexities. The MMI model is grounded in theoretical constructs, which may not always readily translate into practical strategies. Managers need to have some understanding of organizational and institutional theories and practices to effectively apply the model to their organization's DT process. This is particularly true for organizations with limited resources and capabilities. For example, small companies may struggle to fully adopt the model due to a lack of infrastructure or expertise required to manage such a complex framework. Nevertheless, the model provides managers with a meaningful simplification of real-life DT processes and terminology, helping them identify and steer these processes. Furthermore, managers may find it inspiring to comprehend the DT process but challenging to operationalize it at individual, organizational, and business ecosystem levels, as

the roles and mandates of managers alone are often insufficient to lead at all levels. Therefore, we emphasize that DT is a collective process that the entire organization must engage in, rather than leaving it solely to be implemented by, for example, the Chief Digital Officer. Finally, although we have not empirically operationalized the entire framework here, its development is supported by empirical examples, and it is based on well-known theories that have been operationalized in other studies.

Limited guidance on prioritization. In its current form, the MMI model does not provide explicit guideline or template on how to prioritize actions across the different levels. Managers may find it difficult to determine which level—individual, organizational, or ecosystem—should be the primary focus at any given time. For example, in rapidly evolving industries, knowing whether to invest more in individual employee training or in ecosystem partnerships can be difficult without specific guidance. Furthermore, we have not provided metrics for measuring the DT process.

The limitations of the MMI model present a valuable opportunity for future research aimed at transforming this theoretical framework into practical toolkits. The MMI model lays the groundwork for four potential toolkits: the actor analysis toolkit, the determinant identification toolkit, the process design toolkit, and the result evaluation toolkit. Further studies could refine and test these toolkits, ensuring they provide a comprehensive set of resources and techniques tailored to the unique challenges faced by organizations. A key area of exploration involves developing toolkits that assist practitioners, particularly those with limited experience in DT, in navigating its complexities. Future research should focus on creating toolkits that are accessible to both beginners and seasoned professionals. These toolkits should provide a foundational understanding of DT while offering a structured approach to effectively managing the DT process. By breaking down the transformation journey into clear, manageable steps and fostering a shared language among stakeholders, these toolkits could become an essential resource for guiding companies through DT.

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