



Managerial capabilities as facilitators of digital transformation? Dynamic managerial capabilities as antecedents to digital business model transformation and firm performance

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ABSTRACT

Digital business model transformation (DBMT) necessitates new managerial capabilities, yet the existing literature lacks an empirical understanding of managerial capabilities as antecedents to strategic change and firm performance. This paper builds on dynamic managerial capabilities theory to argue that managerial human capital—composed of leadership and entrepreneurial skills—is a critical facilitator of DBMT and resultant firm performance. Further, the research model proposes that managers' social capital and cognition positively moderate the relationship between human capital and DBMT. The study's findings from a sample of German Industry 4.0 firms provide new insights into the significance of managerial capabilities in a digital economy. This study advances management literature by demonstrating that the benefits of managers' human capital for DBMT are contingent on its form: entrepreneurial skills facilitate digital transformation integral for firm performance, while leadership skills have no impact on firm performance—neither directly nor indirectly through DBMT. Thus, this study provides strong evidence of the importance of entrepreneurial skills in driving DBMT to increase firm performance. Further, the findings offer a nuanced account of the interrelationships between dynamic managerial capabilities, revealing that higher levels of social capital and lower levels of cognition increase the positive effect of entrepreneurial skills on DBMT. This study altogether reaffirms the significance of managers' dynamic capabilities for strategic change enabled by DBMT and their performance benefits, yet it reveals that the effect mechanisms differ from those found in nondigital research settings.

1. Introduction

Ongoing digitalization continues to alter competition fundamentally, and thereby pressures managers to digitally transform the business model (BM) to keep pace with technological developments (Korherr, Kanbach, Kraus, & Mikalef, 2022; Kraus et al., 2021). Digital BM transformation (DBMT) has consequently become a—if not *the*—fundamental challenge facing managers today (Palmié, Miehé, Oghazi, Parida, & Wincent, 2022; Warner & Wäger, 2019). Although the literature suggests that managers with strong dynamic capabilities possess the necessary skillset to facilitate organizational change in fast-paced environments (Matarazzo, Penco, Profumo, & Quaglia, 2021; Teece, 2007a), empirical research on the links between individual-level managerial capabilities and firm-level strategies is scarce and largely fragmentary (N. George, Karna, & Sud, 2022; Heubeck & Meckl, 2022a).

Scholars' hitherto excessive focus on macro-level antecedents to organizational change, such as firm-level dynamic capabilities (e.g., Augier & Teece, 2009; Ferreira, Coelho, & Moutinho, 2020), no longer suffices in the context of digital transformation. Additionally, digital transformation has rendered many formerly value-promising managerial capabilities obsolete (Korherr et al., 2022; Warner & Wäger, 2019).

This study builds on Adner and Helfat (2003) dynamic managerial capabilities (DMCs) theory to examine managers' individual-level dynamic capabilities as drivers of firm-level heterogeneity. This micro-foundational perspective highlights the role of individual managerial capabilities in the context of organizational change and proposes three distinct managerial resources as subcomponents of DMCs: managerial human capital (composed of entrepreneurial and leadership skills), managerial social capital, and managerial cognition (Adner & Helfat, 2003; H. Guo, Xi, Zhang, Zhao, & Tang, 2013). DMC theory is

Abbreviations: BM, business model; DBMT, digital business model transformation; DMC, dynamic managerial capability; VUCA, volatility, uncertainty, complexity, ambiguity.

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consequently particularly suitable for gaining empirical insights into the highly complex, albeit fundamental, task of DBMT (Sousa-Zomer, Neely, & Martinez, 2020; Vial, 2019) and the specific managerial capabilities that facilitate this process (Wrede & Dauth, 2020; Wrede, Velamuri, & Dauth, 2020).

This study contributes to strategic management literature by bridging the existing divide between micro- and macro-level research (Felin, Foss, & Ployhart, 2015; Foss, 2016). At the micro level, the study postulates that strong individual-level managerial capabilities facilitate executives' abilities to sense and seize opportunities and threats (Helfat & Martin, 2015a, 2015b). The research model subsequently links the micro to the macro level. Specifically, it hypothesizes that capability heterogeneities between managers (i.e., differences at the micro level) translate into visible differences between firms' strategies (i.e., at the macro level). This argumentation is rooted in the conjecture that strong DMCs improve the managerial capacity to configure, assimilate, and develop a firm's resource portfolio as the basis for implementing strategic change (Adner & Helfat, 2003; Helfat & Martin, 2015b). Therefore, individual-level capabilities within managers are central antecedents to firm-level strategies, making managers into firms' primary change agents (Adner & Helfat, 2003; Beck & Wiersema, 2013).

Against the backdrop of today's digital economy, this study hypothesizes that strong DMCs facilitate DBMT as the basis for superior firm performance. This study's findings add valuable evidence to the severely understudied role of individual-level managerial dynamic capabilities in driving DBMT as the foundation for superior firm performance (Sousa-Zomer et al., 2020; Warner & Wäger, 2019). Thus, this study contributes to strategic management literature by advancing a microfoundational perspective on DBMT. This understanding is eminently critical in light of the increased difficulty of achieving successful digital transformation (Sousa-Zomer et al., 2020; Verhoef et al., 2021) in conjunction with the imperative for new managerial capabilities necessitated by digital competition (Vial, 2019; Warner & Wäger, 2019). Additionally, the findings offer the potential to guide practitioners toward sustainable competitive advantage. This argumentation leads to the following research question:

Do DMCs lead to superior firm performance by facilitating DBMT?

Findings from German Industry 4.0 firms confirm the significance of DMCs as facilitating antecedents to DBMT. Specifically, this study demonstrates that managers with strong entrepreneurial skills—i.e., explorative capabilities required to pursue innovative ideas (Al-Mulla, Ari, & Koç, 2022; Ireland, Hitt, Camp, & Sexton, 2001)—are critical for achieving DBMT as the basis for superior firm performance. Additionally, the results show that the magnitude of managers' influence on DBMT through their entrepreneurial skills is contingent on their social capital and cognition levels. In contrast to existing research (e.g., H. Guo et al., 2013; Sirmon, Hitt, Ireland, & Gilbert, 2011), this study reveals that in an age of digital competition, leadership skills—i.e., exploitative capabilities geared toward the efficient commercialization of existing value potentials through efficient resource management (Hitt, Ireland, & Hoskisson, 2017; Ireland et al., 2001)—are not integral for driving DBMT.

These findings reflect the added complexity and dynamism of today's digital economy, in which entrepreneurial skills are essential to keep firms' BMs at pace with technological and environmental changes. Although the results show that DBMT benefits firm performance, leadership skills—unlike entrepreneurial skills—do not facilitate digital change. The research, therefore, demonstrates that in an age of hyper-competition, explorative rather than exploitative skills are integral for DBMT as the basis for superior firm performance. Further, the study advances DMC theory by offering new insights into the interactions between the three DMC subcomponents. Specifically, the results support the notion that strategic change is an inherently social process (H. Guo et al., 2013; Landry, Amara, & Lamari, 2002) by showing that managerial social capital reinforces the positive effect of entrepreneurial skills on firm performance via DBMT. Related to the third DMC

subcomponent, the results suggest that strong entrepreneurial skills are more beneficial for DBMT under conditions of low rather than high levels of cognition. This finding underscores that entrepreneurial management is pressured to reach timely decisions in today's dynamic environment. Therefore, the findings support Zhou, Yang, Sun, Liu, and Liu' (2021) conjecture that firms can often only attain competitive advantages when managers combine their entrepreneurial skills with their existing knowledge to expedite decision-making processes. In sum, this study advances strategic management literature by providing a holistic perspective on digital transformation. The research model links individual managerial capabilities (i.e., the micro level) to strategic change enacted through DBMT as well as subsequent organizational performance (i.e., the macro level). Beyond linking micro- and macro-level research, this study also uncovers how the three DMC subcomponents interact on the individual level, and how these interactions translate into firm-level outcomes.

The remainder of the paper is structured as follows. Section 2 outlines the theoretical background by describing the construct and digitalization of BMs. Subsequently, DMC theory is outlined, and its three capability subcomponents are delineated. Section 3 derives the research hypotheses by linking DMCs to firm performance via DBMT. Section 4 describes the research methodology and sample. In Section 5, hypothesis test results are presented. Section 6 discusses the findings, their implications for literature and management practice, and the study's limitations. The paper concludes with a summary note in Section 7.

2. Theoretical background

2.1. Business model

2.1.1. The general business model concept

With the pervasive spread of information and communication technologies, particularly the internet as an enabler of e-commerce, the BM concept has attracted the interest of scholars and practitioners alike as the missing link between technology and commercialization (Amit & Zott, 2001; Martín-Peña, Díaz-Garrido, & Sánchez-López, 2018). Different BM definitions have emerged over the years due to the concept's multi-layered and interdisciplinary nature (e.g., Chesbrough & Rosenbloom, 2002; Zott & Amit, 2010). Although the BM concept still remains vague, owing to the plethora of approaches to defining BMs (Hanafizadeh & Yarmohammadi, 2016; Martins, Rindova, & Greenbaum, 2015), and the lack of agreement on its components (Jensen, 2013; Massa, Tucci, & Afuah, 2017), scholars fundamentally concur that BMs provide a holistic description of how firms operate to commercialize their value offerings (Baden-Fuller & Haefliger, 2013; Massa et al., 2017). Further, the BM concept is central to innovation literature (Hanafizadeh & Marjaie, 2021; Marikyan, Papagiannidis, Rana, & Ranjan, 2022), as BMs are necessary to commercialize innovation, while they can also be subject to innovation themselves (Molina-Castillo, Rodríguez, López-Nicolas, & Bouwman, 2022; Zott, Amit, & Massa, 2011).

Three distinct BM dimensions have emerged in the literature: (1) *value proposition* describes what type of value a firm offers—such as products or services—on which market, and through what kinds of distribution strategy (Massa et al., 2017; Morris, Schindehutte, & Allen, 2005); (2) *value creation* outlines the potential for generating value through value chains, cycles, or networks, as well as the resources, capabilities, and processes used during value creation (Clauss, 2017; Stabell & Fjeldstad, 1998); and (3) *value capture* reflects the methods a firm employs to seize the commercial value of its offerings through distinct revenue streams and models (Casadesus-Masanell & Zhu, 2013; Morris et al., 2005).

2.1.2. The digital business model concept

Digital transformation affects entire business logics, as it goes further than the mere digitization of organizational processes (Barroso &

Laborda, 2022; Verhoef et al., 2021). Specifically, digital transformation entails “the use of new digital technologies (social media, mobile, analytics or embedded devices) to enable *major business improvements* (such as enhancing customer experience, streamlining operations or creating new business models)” (Fitzgerald, Kruschwitz, Bonnet, & Welch, 2013, p. 2). Due to its widespread implications for organizations, industries, and society, digital transformation fundamentally changes existing BMs and enables firms to formulate new BMs by questioning their proven recipes for success (Martín-Peña et al., 2018; Sousa-Zomer et al., 2020). Digital BM innovation significantly differs from classical BM innovation (Trischler & Li-Ying, 2022; Volberda, Khanagha, Baden-Fuller, Mihalache, & Birkinshaw, 2021). Digital transformation necessitates the development of new BMs, as digital technologies can either add significant value to existing BMs (Barroso & Laborda, 2022; Grooss, Presser, & Tambo, 2022), or might even question their viability (Martín-Peña et al., 2018). Specifically, digital transformation calls for ambidextrous BMs that simultaneously balance efficiency and flexibility (Fengel, Kindermann, & Strese, 2022; Park, Pavlou, & Saraf, 2020). Therefore, DBMT continues to call for new managerial capabilities to master its inherent complexity (Konopik, Jahn, Schuster, Hoßbach, & Pflaum, 2022; Korherr et al., 2022), turning it into one of the most challenging, yet integral, management duties (Palmié et al., 2022; Warner & Wäger, 2019).

Due to digital BMs’ holistic and interdisciplinary nature, various conceptualizations have evolved over the years (Martín-Peña et al., 2018; Remané, Schneider, & Hanelt, 2022). Digital BM definitions emphasize that BMs are digital if they employ digital technologies in proposing, creating, or capturing value (e.g., Bock & Wiener, 2017; Weill & Woerner, 2015), or if digital technologies have fundamentally altered any of the three BM building blocks (e.g., Veit et al., 2014; Verhoef & Bijmolt, 2019). Thus, decision-makers need to recognize that digital technologies are “an integral part of the business and organization” (Trischler & Li-Ying, 2022). On the firm-internal level, digitalization necessitates the integration of digital technologies into a holistic BM design that considers their interdependent nature (Pattij, van de Wetering, & Kusters, 2022; Verhoef et al., 2021). On the firm-external level, organizations can benefit from participating in digitally-enabled business ecosystems (El Sawy & Pereira, 2013; Müller, Buliga, & Voigt, 2018) or create reciprocal customer interactions (Nyrhinen, Uusitalo, Frank, & Wilksa, 2022).

In sum, digital BMs are characterized by (1) intangible and individualized value offerings, (2) the use of digital technologies to upgrade and complement value offerings or capture value, and (3) digitally-enabled efficiency and scale increases throughout the entire value creation process (Parida, Sjödin, & Reim, 2019; Remané et al., 2022). Digital BMs entail the holistic implementation, combination, and usage of digital technologies and resultant data (Grooss et al., 2022; Verhoef et al., 2021). Digital transformation offers opportunities for creating an open, platform-based, and ecosystem-embedded activity system that transcends organizational boundaries and transforms the BM’s underlying mechanisms of value proposition, creation, and capture (Martín-Peña et al., 2018; Verhoef & Bijmolt, 2019).

2.2. Dynamic managerial capabilities theory

DMC theory shifts the dominant focus of dynamic capabilities theory from the level of firms to the level of individual managers. According to this microfoundational perspective, organizational heterogeneities originate from idiosyncratic managerial capabilities, because managers are tasked to “build, integrate, and reconfigure organizational resources and competences” (Adner & Helfat, 2003, p. 1012). The primary task of managers lies in appropriately orchestrating a firm’s resource portfolio to initiate and realize strategic change (Helfat & Martin, 2015b). Managers’ dynamic capabilities are most valuable in changing conditions as they allow firms to align organizational strategies with their competitive environment (Beck & Wiersema, 2013; Helfat & Martin, 2015b). In sum,

DMC theory fundamentally proposes that managers’ individual-level capabilities influence strategic change by shaping strategic decision-making (Adner & Helfat, 2003; Beck & Wiersema, 2013). These distinct organizational strategies conversely determine firm performance under conditions of change (N. George et al., 2022; Helfat & Martin, 2015b). Adner and Helfat (2003) find that while “corporate strategy does in fact matter” (p. 1023) for firm performance, “corporate managers matter” (p. 1023) for strategic decision-making, as well. Thus, DMC theory provides a multi-level perspective by linking individual-level managerial capabilities to firm-level strategic change as the determinant of firm performance in dynamic environments (Helfat & Martin, 2015a, 2015b). Fig. 1 summarizes these interrelationships.

Strategic differences between firms can be attributed to variances in the ability of individual managers in (1) *sensing*—identifying strategy-relevant opportunities and threats by comprehensively scanning the environment to make proficient decisions; (2) *seizing*—exploiting commercial opportunities or reacting to threats by introducing new products, services, or processes; and (3) *reconfiguring*—altering a firm’s resource portfolio to realize organizational strategies efficiently (Matsiak, Rugman, & Bausch, 2018; Teece, 2007a). In the digital age, these three capability types, together with a fitting organizational strategy, allow firms to realize and sustain competitive advantage (Sousa-Zomer et al., 2020; Teece, 2014). Specifically, strong sensing capabilities enable the accurate prediction of technological trends (Warner & Wäger, 2019) and help refine digital transformation processes (Sousa-Zomer et al., 2020). Strong seizing capabilities ensure that managers make astute investment decisions to commercialize previously identified opportunities contingent on the respective characteristics of the organization (Teece, 2007b, 2016). Finally, strong reconfiguration capabilities are required to harness both sensing and seizing capabilities, as reconfiguration is concerned with the actual realization of strategic change (H. Guo et al., 2013; Teece, 2007a). Especially in the context of the digital economy, these skills underpin successful digital transformation due to their benefits for resource portfolio orchestration and strategic renewal (Sousa-Zomer et al., 2020; Warner & Wäger, 2019).

Three distinct subcomponents underpin DMC: managerial human capital, managerial social capital, and managerial cognition (Adner & Helfat, 2003). As summarized in Fig. 1, all DMC subcomponents originate from the interactions between managers’ inborn abilities and learned experiences (Beck & Wiersema, 2013), and influence firm-level outcomes individually and through their cumulative effect (Adner & Helfat, 2003; Helfat & Martin, 2015b).

The first DMC subcomponent, *managerial human capital*, includes knowledge, expertise, and skills acquired through either formal or informal training (Beck & Wiersema, 2013; Castanias & Helfat, 2001). Two distinct human capital types are prevalent in the management literature due to their inherent link to innovation: leadership and entrepreneurial skills. *Leadership skills* refer to managers’ explorative capabilities that facilitate the efficient orchestration of a firm’s resource portfolio (H. Guo et al., 2013; Ireland et al., 2001). *Entrepreneurial skills* entail the explorative capabilities managers utilize to delve into new markets, design new products, or address latent customer needs (Ireland et al., 2001; Smith & Gregorio, 2017). Therefore, leadership skills solidify competitive advantage, while entrepreneurial skills lead to new competitive advantages or protect existing ones (Smith & Gregorio, 2017; Teece, 2007a). This dual-edged notion of managerial human capital is also inherent to DMC theory, highlighting that managers must demonstrate both leadership and entrepreneurial capabilities to realize efficient strategic change (Teece, 2007a, 2016).

Managerial social capital constitutes the second DMC subcomponent and refers to the relationships managers develop with other actors through shared experiences, continuous interactions, and repeated communication (Adler & Kwon, 2002; Beck & Wiersema, 2013). Social capital is closely linked to the managerial abilities for sensing and seizing opportunities as well as reconfiguring resources, as it provides access to critical resources, capabilities, and information (Adler & Kwon,

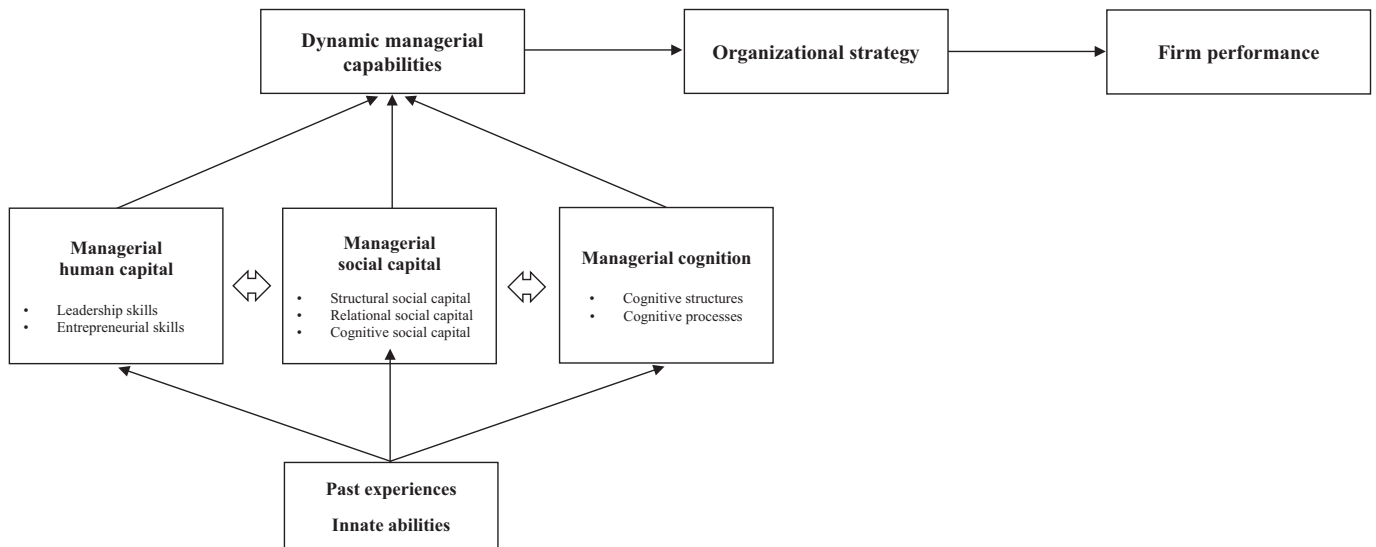


Fig. 1. DMC underpinnings and their components, based on Beck and Wiersema (2013, p. 411).

2002; Blyler & Coff, 2003). Thus, social capital allows managers to benefit from the capital of socially-connected actors—such as the DMCs of other managers—and enhances learning through recombining different types of information, knowledge, and skills (Beck & Wiersema, 2013; Blyler & Coff, 2003). Three dimensions of social capital that shape individual and collective actions have gained prominence in the literature: (1) *structural social capital*, which refers to the general characteristics of the network, such as the types of network members and the communication channels they use; (2) *relational social capital*, which reflects the nature of social interactions and degree of network attachment; and (3) *cognitive social capital*, which depicts the unique shared values, beliefs, norms, and attitudes prevalent in specific social networks (Nahapiet & Ghoshal, 1998).

Finally, DMCs are composed of *managerial cognition*, which builds the cognitive foundation for strategic decision-making (Adner & Helfat, 2003; Tripsas & Gavetti, 2000). Managerial cognition comprises *cognitive structures*—simplified or abstracted versions of reality—and *cognitive processes*—how managers attend to, recognize, interpret, and store information (Colman, 2015; Walsh, 1995). The growing interest in managerial cognition can be attributed to its dual-edged nature. Cognitive processes and structures are essential for increasing decision-making speed, yet may also severely harm decision-making quality by limiting information searches and biasing cognitive processing (Tripsas

& Gavetti, 2000; Walsh, 1995).

3. Hypotheses development

This section develops a multi-level research model that conjectures the connections between individual-level DMCs and firm-level outcomes, specifically DBMT and firm performance (see Fig. 2).

The hypotheses development first proposes that DBMT enhances firm performance, as digital BMs allow firms to develop and sustain competitive advantages (Parida et al., 2019; Sousa-Zomer et al., 2020). Based on this fundamental argumentation, the research model proposes managerial human capital—the first DMC subcomponent—as a central antecedent to firm performance via DBMT. Specifically, the previously defined types of managerial human capital—i.e., leadership skills and entrepreneurial skills—are examined to gain insights into the specific management capabilities that are required for realizing DBMT as the basis for firm performance. This argumentation is rooted in the following two reasons. First, strong managerial human capital drives strategic change by improving managers’ ability to sense opportunities and threats, seize detected commercial potentials, and appropriately reconfigure a firm’s resource portfolio (Helfat & Martin, 2015b; Teece, 2007a). Second, in today’s economy, human capital is regarded as one of the main success factors in driving digital transformation (Korherr et al.,

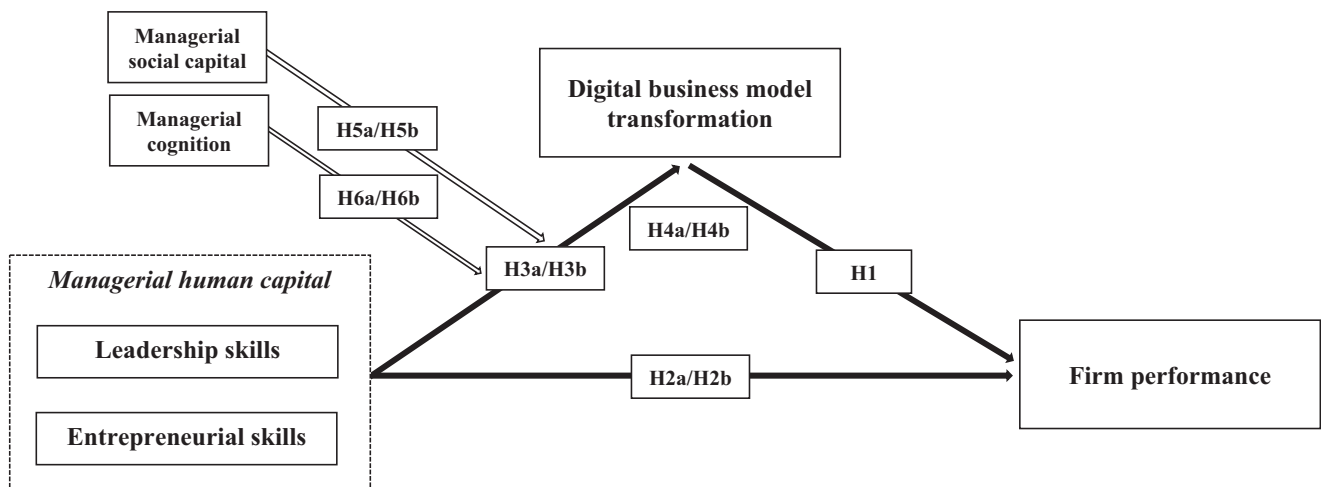


Fig. 2. Theoretical model: DMCs, DBMT, and firm performance.

2022; Matarazzo et al., 2021). This study, therefore, aims to uncover the specific managerial capabilities required for DBMT, which contributes to the emerging capability-based literature on digital transformation (e.g., Konopik et al., 2022; Korherr et al., 2022).

Further, this study aims to advance DMC theory by proposing that the interactions between the concept's three subcomponents shape managerial decision-making related to strategic change. The hypotheses conjecture that strong social capital and cognition strengthen managers' abilities to facilitate DBMT as the basis for superior firm performance. Specifically, strong social capital and cognition are proposed to enhance the human capital–DBMT relationship due to their potential benefits for sensing, seizing, and reconfiguration. This conceptualization reflects Durán and Aguado (2022) conclusion that “it is relevant to explore their [DMCs'] interaction” (p. 24). Further, by addressing Helfat and Martin (2015b) call for research to examine the effects of the interactions between the DMC subcomponents, this study also contributes to the emerging stream of holistic DMC studies (e.g., Heubeck & Meckl, 2022a, 2022b).

The structure of the following hypotheses development section can be summarized as follows. First, the foundational linkage between DBMT and firm performance is established in Hypothesis 1. The research model thereafter complements this firm-level perspective by investigating the role of managers' individual-level capabilities on these two central firm-level outcomes. In line with DMC theory (Adner & Helfat, 2003; Helfat & Martin, 2015b), Hypotheses 2a and 2b propose that the two human capital dimensions have no direct effect on firm performance, while Hypotheses 3a and 3b conjecture that human capital represents a central driver of strategic change through DBMT. Hypotheses 4a and 4b merge these arguments, postulating that leadership and entrepreneurial skills drive firm performance through their benefits for DBMT. Finally, a holistic perspective on DMC is adopted in deriving Hypotheses 5 and 6. The research model proposes that the interactions between the DMC subcomponents are another source of heterogeneity between managers, which manifests in visible firm-level outcomes. Specifically, managers' social capital and cognition are proposed to enhance the positive effect of human capital on DBMT.

3.1. Business model digitalization and firm performance

DBMT is central to the commercialization of digital technologies, making appropriate digital BM design an essential prerequisite for superior firm performance (Fernández-Portillo, Almodóvar-González, Sánchez-Escobedo, & Coca-Pérez, 2022; Purkayastha & Sharma, 2016). Specifically, DBMT enables organizations to initiate timely and proactive responses to new opportunities or emerging threats (Martín-Peña et al., 2018; Verhoef et al., 2021), and improves firm performance by providing additional revenue sources or reducing costs through efficiency and scale increases (Chen, Lachaud, & Zhou, 2022; Karki & Porras, 2021). Further, digital BMs are likely to confer the long-term competitive advantages necessary for enhancing firm performance due to their difficult-to-imitate, innovation-based architecture (Vendrell-Herrero, Parry, Bustinza, & Gomes, 2018). DBMT is consequently a central path to sustaining and improving competitiveness, growth, innovativeness, and profitability (Klötzer & Pflaum, 2017; Matarazzo et al., 2021).

These arguments infer that DBMT directly improves firm performance by allowing firms to capitalize on technological developments, strengthen or defend their competitive position, and proactively participate in open-innovation business ecosystems (El Sawy & Pereira, 2013; Karki & Porras, 2021; Li, 2020). Thus, DBMT ensures that firms can cope with the challenges of the digital environment (El Sawy & Pereira, 2013; Fernández-Portillo et al., 2022). At the same time, firms must consider the interdependent nature of BMs (Parida et al., 2019; Vaska, Massaro, Bagarotto, & Dal Mas, 2021). The digital transformation of isolated BM components will, at the very least, lead to suboptimal commercialization of technology and might even threaten

the viability of the entire BM (Matt, Hess, & Benlian, 2015; Vaska et al., 2021).

Based on these arguments, this study proposes that DBMT allows firms to cope with the pressing need for utilizing and commercializing digital technologies (Klötzer & Pflaum, 2017; Verhoef et al., 2021). Pursuing DBMT allows organizations to holistically digitalize their BM, which ensures that firms can cope with the challenges of the digital economy and exploit new technologies to their commercial benefit (Verhoef et al., 2021; Verhoef & Bijmolt, 2019). Therefore, higher levels of DBMT increase a firm's digital maturity (Westerman, Tannou, Bonnet, Ferraris, & McAfee, 2012), which confers competitive advantage as the basis for superior firm performance (Parida et al., 2019; Sousa-Zomer et al., 2020). This argumentation leads to the following first hypothesis:

Hypothesis 1. DBMT has a positive effect on firm performance.

3.2. Managerial human capital, digital business model transformation, and firm performance

DMC theory is grounded in the fundamental notion that managers affect organizational outcomes by determining strategic change as an intermediate factor (Helfat & Martin, 2015a, 2015b). In other words, DMCs indirectly affect performance through their effects on organizational strategies rather than directly causing performance differences between firms (Adner & Helfat, 2003; Beck & Wiersema, 2013). The firm-level effects of DMCs should consequently be analyzed using a “two-step process that first traces their impact on intermediate outcomes in the form of strategic change and then assesses the impact of such change on measures of firm performance” (Helfat & Martin, 2015b, p. 1288). Accordingly, managers' proficiency in designing efficient and effective organizational strategies and ensuring timely strategic reorientation is contingent on their DMCs. Strong DMCs allow firms to design and implement corporate strategies more efficiently and adaptively (Adner & Helfat, 2003; Helfat & Martin, 2015b).

Following the fundamental argumentation of DMC theory, the following two hypotheses postulate that managerial human capital—the first DMC subcomponent—has no direct effect on firm performance. This argument follows Crook, Todd, Combs, Woehr, and Ketchen Jr.' (2011) finding that the performance advantages of superior human capital are better captured by their impact on intermediate factors, such as innovation or strategy. Thus, this paper proposes that neither superior leadership skills nor entrepreneurial skills underlying managerial human capital directly enhance firm performance. More formally:

Hypothesis 2a. Leadership skills, the first dimension of managerial human capital, have no direct effect on firm performance.

Hypothesis 2b. Entrepreneurial skills, the second dimension of managerial human capital, have no direct effect on firm performance.

Strategic change is at the heart of DMC theory (Bendig, Wagner, Jung, & Nüesch, 2022). Helfat and Martin (2015a) highlight that DMCs occupy a critical role in strategic change through BM transformation, “because putting in place a new business model for an entire organization is likely to require leadership from the top” (p. 425). Thus, how managers affect BM transformation through their dynamic capabilities is a fundamental cornerstone of DMC theory (Helfat & Martin, 2015a, 2015b). Specifically, strong DMCs lead to sustained competitive advantage owing to their benefits for designing value-creating BMs (Bashir, Naqshbandi, & Farooq, 2020; Teece, 2018).

Rooted in the past experiences of an individual manager (Beck & Wiersema, 2013), superior human capital is likely to enhance DBMT by improving the managerial capacity for sensing, seizing, and reconfiguring (Durán, Aguado, & Perdomo-Ortiz, 2022; H. Guo et al., 2013). The literature has acknowledged the integrality of leadership skills in building the foundation for current competitive advantage through, for example, BM innovation (H. Guo et al., 2013; Ireland, Hitt, & Sirmon, 2003). At the same time, a firm's current resource configuration may

also serve as a critical determinant of its future adaptability, as a manager's highly individualized conjecture of the firm's existing resource base shapes the perception of the possibilities for BM transformation (Martins et al., 2015; Massa et al., 2017).

Leadership skills are likely to be a significant facilitator of DBMT owing to three fundamental mechanisms. First, leadership skills improve resource acquisition, coordination, and configuration critical for realizing the highly complex, far-reaching, and interdependent task of DBMT (H. Guo et al., 2013; Sirmon et al., 2011). Leadership skills consequently support strategy execution, paving the way for executing DBMT (Casadesus-Masanell & Ricart, 2010; Verhoef et al., 2021) by ensuring the constant availability of appropriate resources (Heubeck & Meckl, 2022b). Second, leadership skills complement entrepreneurial activities by enabling the exploitation of new opportunities through an appropriate digital BM design (G. George & Bock, 2011; Zott & Amit, 2010). Third, as today's firms find themselves embedded in industry-spanning business ecosystems (El Sawy & Pereira, 2013; Müller et al., 2018), leadership skills are a central enabler of DBMT and are required for efficient network participation owing to their benefits for cross-organizational resource and knowledge exchange (H. Guo et al., 2013; Sirmon et al., 2011). Specifically, superior leadership skills are a prerequisite to the efficient integration and leveraging of external resources (H. Guo et al., 2013), allowing firms to establish value-creating relationships through appropriate BM design (Helfat & Martin, 2015a; Manev, Gyoshev, & Manolova, 2005). These arguments conclude that leadership skills may be critical for facilitating DBMT as a central antecedent to superior firm performance in today's digital economy. More formally:

Hypothesis 3a. Leadership skills have a positive effect on DBMT.

Hypothesis 4a. DBMT mediates the relationship between leadership skills and firm performance. Specifically, leadership skills indirectly enhance firm performance by increasing DBMT.

Managers can also decisively shape the DBMT process through their entrepreneurial skillset as the driving force behind strategic change (Ireland et al., 2001, 2003). First, superior entrepreneurial skills improve a manager's capacity for sensing opportunities and threats, as entrepreneurial managers are more alert toward external developments, tolerant of ambiguities, better at creating new means-ends-hypotheses, and generally more receptive to change (Shane & Venkataraman, 2000; Tang, Kacmar, & Busenitz, 2012; Tasheva & Nielsen, 2020). Entrepreneurial skills consequently facilitate opportunity recognition and recombination conducive to DBMT (Wood & McKelvie, 2015; Zhou et al., 2021). To reap the commercial benefits of a detected opportunity, managers are required not only to discover an opportunity but also to commercialize it. Entrepreneurial skills are integral for seizing detected opportunities due to an entrepreneur's strong desire for achievement (Shane & Venkataraman, 2000; Smith & Gregorio, 2017).

These arguments infer that entrepreneurial skills are an essential driver of DBMT required to appropriate value from new products, services, or processes, as entrepreneurial skills improve managerial capacity for sensing and seizing opportunities (Hitt et al., 2017; Ireland et al., 2001). In an era of ubiquitous digitalization, superior entrepreneurial skills will likely make managers more skilled in exploring new opportunities and facilitating DBMT to exploit these opportunities. As DBMT causes more fundamental changes than other strategic change types (Fernández-Portillo et al., 2022; Vaska et al., 2021), entrepreneurial skills are likely to be particularly critical to mastering digital transformation (Matarazzo et al., 2021; Zhou et al., 2021). These arguments lead to the following two hypotheses:

Hypothesis 3b. Entrepreneurial skills have a positive effect on DBMT.

Hypothesis 4b. DBMT mediates the relationship between entrepreneurial skills and firm performance. Specifically, entrepreneurial skills indirectly enhance firm performance by increasing DBMT.

3.3. Moderation effects of managerial social capital and cognition

The interactions between the DMC subcomponents may cause additional heterogeneities in managers' abilities to facilitate DBMT that originate from their human capital. Thus, the effects of managerial human capital on firm performance via DBMT are likely to be affected by the other two DMC subcomponents: managerial social capital and managerial cognition.

Social capital may increase the positive effect of managers' human capital on their abilities to sense and seize opportunities as well as to reconfigure resources. DBMT, as the outgrowth of strategic change and innovation, is an innately social process that benefits from increased interactions between interconnected actors (H. Guo et al., 2013; Landry et al., 2002). First, the ability of managers to sense opportunities and threats through their human capital is strengthened by social capital, because high social capital levels increase the exchange of complementary and potentially divergent knowledge and information (Alguezaui & Filieri, 2010; Gant, Ichniowski, & Shaw, 2002). Thus, social capital sharpens opportunity identification (Peng & Luo, 2000), causing managers to consider different types of information or direct their attention to otherwise overlooked opportunities (Geletkanycz & Hambrick, 1997; Kemper, Schilke, & Brettel, 2013). Second, social capital may also enhance the positive effects of leadership and entrepreneurial skills on opportunity seizing. High social capital levels not only benefit information exchange but also instill greater trust, reciprocity, and collaboration between actors, leading to increased support for strategic change (Alguezaui & Filieri, 2010; Martin & Bachrach, 2018). Therefore, due to the holistic nature of DBMT that requires support from all actors and departments of an organization (Trischler & Li-Ying, 2022; Vaska et al., 2021), social capital might be particularly beneficial for managers with superior human capital by motivating key actors to support DBMT (H. Guo et al., 2013). Third, resource reconfiguration might also be improved by managers' social capital, because strong social capital increases power, influence, and legitimacy critical for making alterations to a firm's resource portfolio (Adler & Kwon, 2002; Nahapiet & Ghoshal, 1998). Thus, social capital may determine the extent to which managers can utilize their human capital to enhance DBMT by drawing on sufficient and appropriate resources to realize strategic change. Early identification and the subsequent appropriation of commercial value from opportunities through opportunity seizing and resource reconfiguration is particularly critical in today's highly volatile, uncertain, complex, and ambiguous (VUCA) business environment (Heubeck & Meckl, 2022a; Vlačić, Almeida Santos, Silva, & González-Loureiro, 2022). These arguments infer that social capital will likely enhance the positive effect of leadership and entrepreneurial skills on firm performance via DBMT, leading to the following two hypotheses:

Hypothesis 5a. Managerial social capital positively moderates the direct path between leadership skills and DBMT, enhancing the indirect effect of leadership skills on firm performance via DBMT.

Hypothesis 5b. Managerial social capital positively moderates the direct path between entrepreneurial skills and DBMT, enhancing the indirect effect of entrepreneurial skills on firm performance via DBMT.

Given the VUCA of the digital economy, managerial cognition is also likely to occupy a critical role in opportunity sensing and seizing as well as resource reconfiguring, because cognitive structures and processes imprint information processing (Vlačić et al., 2022; Walsh, 1995). While sensing opportunities and threats, high cognitive abilities allow managers to attend to and interpret a broader range of information (Helfat & Martin, 2015a; Tripsas & Gavetti, 2000). In seizing opportunities and reconfiguring resources, managerial cognition may also shape the influence of leadership and entrepreneurial skills on DBMT. Although managers' decision-making is, at least to some extent, always based on cognitive simplifications, high levels of cognition will allow managers to reach more comprehensive decisions on DBMT. Highly cognitively

skilled managers have a more realistic view of their firm's current BM and are better at realigning their cognitive processes and structures with objective reality through in-depth information processing (Heubeck & Meckl, 2022a; Walsh, 1995). In light of the increased demands on information processing imposed by today's VUCA economy, managers are pressured to continuously refine their cognitions to make astute decisions related to digital transformation (Abatecola, Cristofaro, Gianetti, & Kask, 2022; Heubeck & Meckl, 2022b). These arguments infer that the way managers perceive their firm's BM and the extent to which they actively adapt this subjective conceptualization to new environmental realities will determine the extent to which their skills rooted in leadership and entrepreneurial skills are applied toward facilitating DBMT. This highly individual perception of how the firm proposes, creates, and captures value as well as how those elements are interlinked with each other and the external environment—the *BM schema*—shapes the manager's ability related to sensing, seizing, and reconfiguration (Martins et al., 2015; Reuter & Krauspe, 2022; Tikkanen, Lamberg, Parvinen, & Kallunki, 2005). Superior managerial cognition may enable managers to utilize their leadership and entrepreneurial skills more proficiently during DBMT, as it leads to more realistic and updated BM schemas as well as makes managers more willing to use their capabilities in driving DBMT (Martins et al., 2015; Zhou et al., 2021). This argumentation leads to the following two hypotheses:

Hypothesis 6a. Managerial cognition positively moderates the direct path between leadership skills and DBMT, enhancing the indirect effect of leadership skills on firm performance via DBMT.

Hypothesis 6b. Managerial cognition positively moderates the direct path between entrepreneurial skills and DBMT, enhancing the indirect effect of entrepreneurial skills on firm performance via DBMT.

4. Research methodology and sample

4.1. Data collection and sample description

Study data were collected from firms operating primarily within smart and digital automation industries—the German Industry 4.0 sector. These firms are particularly suitable in light of the research goal, as ongoing globalization and digitalization necessitate DBMT to keep pace with the pervasive speed with which these industries utilize digital technologies. Thus, Industry 4.0 firms are digital pioneers that implement digital technologies into their entire value chain to make their production processes more efficient and scalable while simultaneously improving flexibility, decentralization, and customizability (Liao, Deschamps, de Loures, & Ramos, 2017; Schneider, 2018).

Following the key informant approach (Lechner, Dowling, & Welpel, 2006), 2750 firms exhibiting at the following international trade shows were contacted to collect this study's data: *Hannover Messe* (industrial transformation), *Smart Production Solutions* (smart and digital automation), *EuroShop* (retail trade), *Medica* (medical industries), and *Photokina* (digital imaging). This procedure yielded 205 returned questionnaires (7.02% response rate). The returned questionnaires were filtered using the following criteria: (1) responses that were started but not answered (70 responses); (2) responses from low-level managers with no managerial duties (20 responses); (3) incomplete responses regarding DMCs (28 responses); (4) missing data on DBMT (2 responses); (5) missing firm performance data (15 responses); and (6) missing data regarding the control variables (14 responses). Of the 205 initially returned questionnaires, 56 were ultimately usable for regression analysis.

4.2. Measurement of variables

4.2.1. Study variables

The operationalization of the three DMC subcomponents followed Heubeck and Meckl (2022b) multidimensional measurement scales. The independent variable, *managerial human capital*, was captured by the

theoretically deduced duality of *leadership skills* and *entrepreneurial skills*. As summarized in Appendix 1, the study used a German-translated version of the items developed by Chandler and Hanks (1998) and H. Guo et al. (2013). The first moderator, *managerial social capital*, was operationalized by drawing on its three underlying dimensions—the structural, relational, and cognitive—using an individual-level adapted version of the original items developed by Carr, Cole, Ring, and Blettner (2011). The second moderator, *managerial cognition*, was conceptualized in the BM context. For this purpose, the study used an adapted version of Schrauder, Kock, Baccarella, and Voigt' (2018) eleven-item scale. Managerial cognition captured the degree to which the respondent draws on automated versus controlled information processing during BM reevaluation, with small values indicating automated processing and large values implicating that managers deliberately process BM-related information in a controlled processing mode (Heubeck & Meckl, 2022b).

DBMT was operationalized by asking respondents to evaluate their firm's primary BM on the product- and data-centric BM continuum. In the first step, respondents were given the following two general definitions:

The *product-centric BM* refers to the traditional manufacturing firm, focusing on the design, production, marketing, and distribution of physical products in combination with product-related services in its BM. The *data-centric BM* entails the firm actively utilizing data in its BM to increase efficiency, flexibility, and agility in the production process to drive sales (Klötzer & Pflaum, 2017; Pflaum & Schulz, 2018).

In a second step, respondents were asked to evaluate their firm's primary BM on each dimension of the BM canvas (Osterwalder, Pigneur, & Tucci, 2005) on a five-point Likert scale. Appendix 2 lists the full operationalization of each BM dimension. In the final step, DBMT was calculated using a respondent's BM evaluation to derive the cumulative digitalization intensity of a firm's BM (scale from 0 to 100) by drawing on the individual assessment of the nine BM canvas dimensions.

The dependent variable, *firm performance*, was captured by the widely-used proxy of return on equity (ROE) (Daniel, Lohrke, Fornaciari, & Turner, 2004; Richard, Devinney, Yip, & Johnson, 2009). Calculated as net profit divided by shareholder's equity, the accounting measure ROE captures value generated for a firm's owners (Armour & Teece, 1978; Richard et al., 2009). Generally, managers and shareholders use ROE as one of their primary indicators of firm performance (Bower, 1986; Richard et al., 2009). Thus, managers aim to maximize ROE to act in the shareholder's best interests (Fisher & Hall, 1969; Hall & Weiss, 1967). In the specific context of digital transformation, firm performance is primarily measured using profitability-based, outcome-related performance indicators (L. Guo & Xu, 2021; Verhoef et al., 2021). Even though firms also assess firm performance during digital transformation using different performance metrics, financial measures—such as ROE—remain a dominant performance indicator for transforming incumbents (Verhoef et al., 2021). In the context of this study's sample of Industry 4.0 firms, which represent traditional manufacturing companies that digitally transform their BM to realize the benefits of technological developments (Kagermann, Wahlster, & Helbig, 2013; Müller et al., 2018), ROE is, therefore, a suitable performance indicator and used in other empirical studies of Industry 4.0 firms as well (e.g., Corò, Plechero, Rullani, & Volpe, 2021; Heubeck & Meckl, 2022a; Lin, Wu, & Song, 2019).

4.2.2. Control variables

The model included several control variables at the managerial and firm levels. The first two management-level controls, *management age* (focal year minus birth year) and *management gender* (dummy: male = 0; female = 1), were added to the model because previous research has demonstrated that age and gender lead to differences in risk-taking between younger and older managers as well as male and female managers (e.g., Faccio, Marchica, & Mura, 2016; Rodenbach & Brettel,

2012). Third, *management level* captured the respondents' hierarchical position as owner/shareholder, top manager, or middle manager. A manager's hierarchical position shapes executive power, influence (Haynes & Hillman, 2010), and information exchange (Ethiraj & Levinthal, 2004) critical for strategic change and firm performance. Next, *functional background* was included to account for the influence of experience and knowledge gained in specific functional areas—output, throughput, and peripheral functions (Hambrick & Mason, 1984)—on executive decision-making (Boone & Hendriks, 2008; Waller, Huber, & Glick, 1995). Finally, *level of education* was added to the model as another influence on managerial decision-making, as higher education leads to more in-depth knowledge yet may also cause tunnel vision or inflated confidence in personal abilities (Barker & Mueller, 2002; Musteen, Barker, & Baeten, 2006).

The model considered four control variables at the firm level following previous research (e.g., Danneels, 2008; Youndt, Subramaniam, & Snell, 2004). First, *firm age* may cause differences in resource availability and organizational structures as determinants of decision-making (Audia & Greve, 2006; Rogers, 2004). Second, the model controlled for *firm size*, measured as the logarithm of the total number of employees (Bendig, Strese, Flatten, da Costa, & Brettel, 2018). Similar to firm age, older firms typically benefit from increased resource availability and better reputation, while they tend to be more inert owing to an increasing formalization of organizational structures and processes over time (Audia & Greve, 2006; Rogers, 2004). Third, *R&D intensity*, calculated as R&D expenditures divided by sales, was included in the model to capture the competitive intensity and the management's long-term commitment to sustained innovation (Hagedoorn & Cloudt, 2003; Kor, 2006). The final control variable, *industry classification*, represents a firm's primary industry following the two-digit Standard Industry Classification (Kahle & Walkling, 1996; US Census Bureau, 2022).

4.3. Statistical procedure

In order to test the hypotheses, *IBM SPSS Statistics 26* was used to perform principal axis confirmatory factor analysis (CFA) with varimax rotation. First, the data's eligibility for CFA was assessed using the Measure-of-Sample-Adequacy (MSA) and Kaiser-Mayer-Olkin (KMO) criteria (Hair, Black, Babin, & Anderson, 2014). Second, the optimal number of factors was determined using the Kaiser-Guttman (KG) criterion and scree tests (Thompson, 2004). As a general rule, all constructed factors had to be comprised of at least three items with factor loadings >0.30 (Hair et al., 2014). Third, the quality criteria of the constructed factors were assessed. Reliability stipulates Cronbach's alpha coefficients >0.70 , while validity requires that a factor's average variance extracted (AVE) surpasses 0.50, all factors loadings are >0.50 , and the Fornell-Larcker (FL) criterion is fulfilled (Fornell & Larcker, 1981; Hair et al., 2014; Voorhees, Brady, Calantone, & Ramirez, 2016). Fourth, the general validity of the study was guaranteed by a standardized test situation, objectivity of analysis, and unbiased interpretation of results (Payne & Payne, 2004; Resnik, 2001). Fifth, the hypotheses were tested using linear regression analysis, and the PROCESS macro to test for mediation and moderated mediation effects (Hayes, 2021). To assess the mediating effect of DBMT in the relationship between the two dimensions of managerial human capital and firm performance, the regression used a bootstrapping method based on 5000 bootstrap samples at 90% confidence intervals (Hayes, 2009; Preacher & Hayes, 2004) with the heteroscedasticity consistent standard error and covariance matrix estimator HC4 (Cribari-Neto, 2004). Additionally, Sobel's test probed significant indirect effects (Baron & Kenny, 1986; Sobel, 1982).

To test for the moderation effects of managerial social capital and managerial cognition on the indirect effect of the two managerial human capital dimensions on firm performance through DBMT, a moderated mediation analysis was conducted using mean-centered product terms

(Model 7 by Hayes, 2018b). Additionally, significant interaction terms in the regression model were probed by computing conditional effects using simple slopes at the mean and one standard deviation above and below it (Hayes, 2018a; Preacher, Curran, & Bauer, 2006).

5. Results

5.1. Measurement model

The Bartlett test of sphericity confirmed the data's eligibility for CFA, additionally validated by the MSA and KMO criteria (for this and the following, see Appendix 3). First, CFA confirmed the theoretically proposed dual structure of *managerial human capital*. The first dimension, *leadership skills*, includes Items 2, 4, and 5. Items 1 and 2 were removed from the scale due to significant cross-loading and low factor loading, respectively. The measurement scale of *entrepreneurial skills* was not modified. Second, CFA initially showed the three-dimensionality of *managerial social capital*, but yielded a better fit with the data using a two-factorial solution after removing three items that did not comply with the defined quality criteria. Third, CFA substantiated the tripartite structure of *managerial cognition*. Only the architectural dimension of managerial cognition had to be modified, as Items 1 and 5 showcased factor loadings below the defined threshold. All of these results were confirmed by the KG criterion and scree tests.

Further, all factor solutions satisfy the study's quality criteria. Even though the factors extracted for managerial human capital and managerial social capital fail to comply with the initially defined conditions of convergent validity, they are still considered convergent valid because their Cronbach's alpha coefficients surpass 0.60, and their AVE is between 0.40 and 0.50 (Fornell & Larcker, 1981). Finally, the author complied with all objectivity demands during data generation and interpretation; therefore, the measurement model is adequate.

5.2. Descriptive statistics, bivariate results, and hypothesis test results

The average manager in the sample has worked at their firm for 14.35 years, which attests to their qualification as key informants. Table 1 gives an overview of the participant's demographic characteristics. Descriptive statistics and bivariate results are summarized in Table 2. Table 3 compiles the hypothesis test results presented in more detail in the following, which are visually depicted in Figs. 3 and 4.

Table 1
Demographic characteristics of study participants.

Variable	Absolute frequency	Relative frequency
<i>Management gender</i>	56	100.00%
Male	48	85.71%
Female	8	14.29%
<i>Management level</i>	56	100.00%
Owner/shareholder	19	33.93%
Top management	24	42.86%
Middle management	13	23.21%
<i>Functional background</i>	56	100.00%
Output function	50	89.28%
Throughput function	3	5.36%
Peripheral function	3	5.36%
<i>Education level</i>	56	100.00%
No graduation	0	0.00%
Primary/lower secondary education	0	0.00%
Secondary school	2	3.57%
Academic high school	0	0.00%
Professional education	9	16.07%
Technical college degree	18	32.14%
University degree	27	48.22%

Table 2
Descriptive statistics and bivariate results.

Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 Firm performance	7.960	5.003	1														
2 DBMT	0.315	0.302*	0.302*	1													
3 Leadership skills	0.144	0.786	0.029	-0.105	1												
4 Entrepreneurial skills	0.138	0.831	0.052	0.151	0.202	1											
5 Managerial social capital	-0.008	0.681	-0.001	0.015	-0.054	0.028	1										
6 Managerial cognition	-0.007	0.485	0.138	0.046	-0.028	-0.134	0.284*	1									
7 Management age	45.536	10.380	0.182	0.125	-0.028	-0.134	-0.009	0.259 [†]	1								
8 Management gender	0.143	0.353	-0.049	0.015	0.151	-0.297*	0.175	0.033	-0.135	1							
9 Management level	1.893	0.755	-0.150	0.020	-0.117	-0.072	-0.098	-0.150	-0.074	0.058	1						
10 Functional background	1.161	0.496	-0.166	0.134	0.089	-0.074	-0.225 [†]	0.092	0.032	-0.133	0.338*	1					
11 Education level	6.250	1.014	-0.120	0.242 [†]	0.050	0.070	0.329*	0.081	-0.303*	0.000	0.178	0.208	1				
12 Firm age	43.946	39.466	-0.117	-0.074	-0.099	-0.220	-0.277*	-0.066	0.129	-0.091	0.254 [†]	-0.322*	0.271*	1			
13 Firm size	4.278	2.237	0.171	0.162	-0.151	-0.056	0.002	-0.055	-0.061	0.089	0.561***	0.230 [†]	0.308*	0.347**	1		
14 R&D intensity	3.765	3.734	0.039	0.140	0.163	0.004	0.268*	0.144	-0.050	0.455***	0.195	0.120	0.150	-0.140	0.119	1	
15 Industry classification	4.911	1.947	0.147	0.361**	-0.012	0.050	0.111	0.139	-0.257 [†]	-0.087	-0.143	-0.098	0.150	-0.141	0.017	-0.052	1

Notes DBMT = Digital business model transformation; R&D = Research and development; SD = Standard deviation; *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, $N = 56$.

Table 3
Summary of hypothesis results.

Hypothesis		Result
<i>Direct effects hypotheses</i>		
Hypothesis 1	DBMT has a positive effect on firm performance.	Supported
Hypothesis 2a	Leadership skills, the first dimension of managerial human capital, have no direct effect on firm performance.	Supported
Hypothesis 2b	Entrepreneurial skills, the second dimension of managerial human capital, have no direct effect on firm performance.	Supported
Hypothesis 3a	Leadership skills have a positive effect on DBMT.	Not supported
Hypothesis 3b	Entrepreneurial skills have a positive effect on DBMT.	Supported
<i>Mediation hypotheses</i>		
Hypothesis 4a	DBMT mediates the relationship between leadership skills and firm performance. Specifically, leadership skills indirectly enhance firm performance by causing increased DBMT.	Not supported
Hypothesis 4b	DBMT mediates the relationship between entrepreneurial skills and firm performance. Specifically, entrepreneurial skills indirectly enhance firm performance by causing increased DBMT.	Supported
<i>Moderated mediation hypotheses</i>		
Hypothesis 5a	Managerial social capital positively moderates the direct path between leadership skills and DBMT, enhancing the indirect effect of leadership skills on firm performance via DBMT.	Not supported
Hypothesis 5b	Managerial social capital positively moderates the direct path between entrepreneurial skills and DBMT, enhancing the indirect effect of entrepreneurial skills on firm performance via DBMT.	Supported
Hypothesis 6a	Managerial cognition positively moderates the direct path between leadership skills and DBMT, enhancing the indirect effect of leadership skills on firm performance via DBMT.	Not supported
Hypothesis 6b	Managerial cognition positively moderates the direct path between entrepreneurial skills and DBMT, enhancing the indirect effect of entrepreneurial skills on firm performance via DBMT.	Partially supported

Notes DBMT = Digital business model transformation; supported if $p < 0.10$.

The data shows no multicollinearity, as all variance inflation factors and correlation coefficients are below the thresholds of 2.50 and 0.80, respectively (Johnston, Jones, & Manley, 2018; Kennedy, 2008). First, the results regarding the direct effects hypotheses are presented (see Appendix 4). Effect sizes are classified according to Cohen (1988) as follows: $\beta > 0.02$ corresponds to a weak effect, $\beta > 0.15$ corresponds to a moderate effect, and $\beta > 0.35$ corresponds to a strong effect.

As advanced in Hypothesis 1, DBMT is positively related to firm performance ($b = 9.240, p = 0.008$), with a strong effect size ($\beta = 0.389$). The results also support Hypothesis 2a and 2b by providing evidence that neither leadership skills ($b = 0.843, p = 0.407$) nor entrepreneurial skills ($b = -1.425, p = 0.128$) are directly related to firm performance. Against the predictions of Hypothesis 3a, leadership skills have no significant effect on DBMT ($b = -0.052, p = 0.330$). Hypothesis 3b is supported. Entrepreneurial skills have a significantly positive effect on DBMT ($b = 0.087, p = 0.020$), which is moderate to strong ($\beta = 0.344$).

Next, the mediation hypotheses are assessed (see Appendix 5). Hypothesis 4a proposed that leadership skills indirectly enhance firm performance through DBMT, which is not supported by the data ($b = -0.481, 90\%$ lower limit confidence interval (LLCI) = $-1.476, 90\%$ upper limit confidence interval (ULCI) = 0.134). In line with the predictions of Hypothesis 4b, entrepreneurial skills indirectly enhance firm performance via DBMT ($b = 0.805, 90\%$ LLCI = $0.069, 90\%$ ULCI =

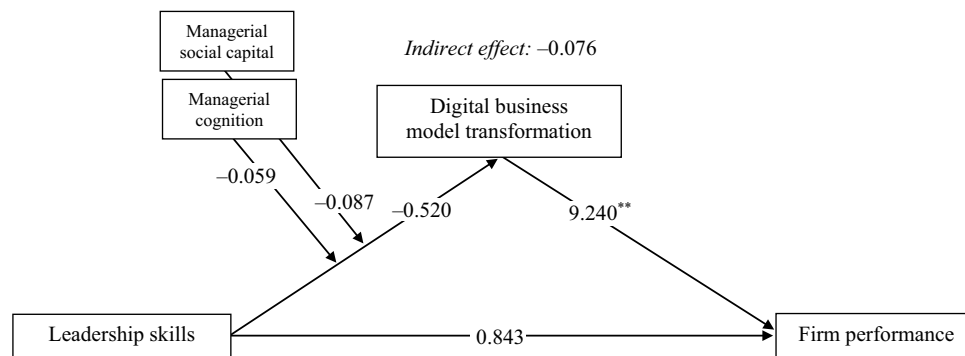


Fig. 3. Regression results with independent variable leadership skills.
 Notes Unstandardized coefficients; *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$; $N = 56$

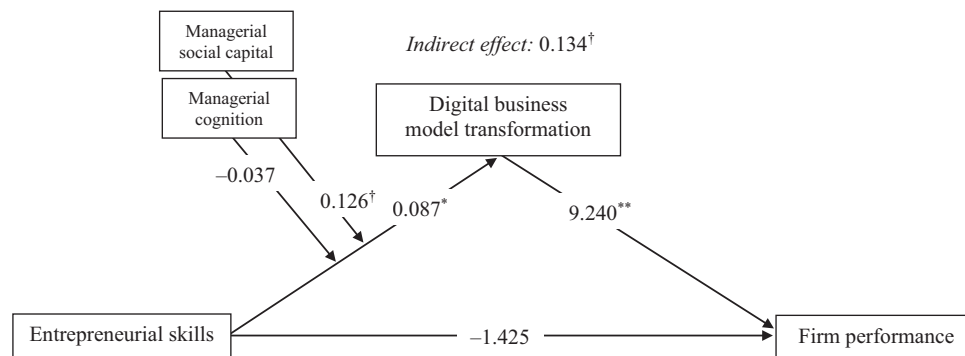


Fig. 4. Regression results with independent variable entrepreneurial skills.
 Notes Unstandardized coefficients; *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$; $N = 56$

1.654) with a nearly moderate effect size ($\beta = 0.134$). Sobel’s test confirms the significance of this indirect effect ($b = 0.804$, $p = 0.079$).

Finally, the moderated mediation hypotheses are examined (see Appendices 6 and 7). The results offer no support for the moderation effect of managerial social capital on the relationship between leadership skills and DBMT ($b = -0.087$, $p = 0.213$), leading to the rejection of Hypothesis 5a. As predicted in Hypothesis 5b, managerial social capital positively moderates the entrepreneurial skills–DBMT relationship ($b = 0.126$, $p = 0.054$). The size of this moderation effect is nearly moderate ($\beta = 0.126$). Specifically, the relationship between entrepreneurial skills and DBMT becomes more pronounced and statistically significant with increasing managerial social capital ($b_{\text{medium}} = 0.815$, 90% LLCI = 0.129, 90% ULCI = 1.619 vs. $b_{\text{high}} = 1.624$, 95% LLCI = 0.389, 95% ULCI = 3.169). At low levels of managerial social capital, the mediation effect becomes smaller and statistically insignificant ($b_{\text{low}} = 0.005$, 90% LLCI = -1.200 , 90% ULCI = 0.789). The data do not support Hypothesis 6a, as managerial cognition does not positively moderate the relationship between leadership skills and DBMT ($b = -0.059$, $p = 0.584$). At first glance, the results offer no support for Hypothesis 6b, which proposed that managerial cognition moderates the entrepreneurial skills–DBMT relationship ($b = -0.037$, $p = 0.666$). Simple slope analysis, however, shows that the moderation effect of managerial cognition on this relationship is significant at low and medium levels of managerial cognition ($b_{\text{low}} = 0.897$, 90% LLCI_{low} = 0.066, 90% UCLI_{low} = 1.798; $b_{\text{medium}} = 0.744$, 90% LLCI_{medium} = 0.008, 90% UCLI_{medium} = 1.516). Therefore, the significance of the moderation effects at low and medium levels of managerial cognition offers partial support for Hypothesis 6b, with the results indicating that the moderation effect becomes smaller and increasingly insignificant with increasing levels of managerial cognition.

6. Discussion and contributions

6.1. Discussion

The digital economy calls for new managerial capabilities to realize digital transformation (Korherr et al., 2022; Warner & Wäger, 2019). Specifically, human capital is highlighted as one of the most critical drivers of digital transformation (Matarazzo et al., 2021; Parida et al., 2019). Nevertheless, both research and practice lack an in-depth understanding of which specific management capabilities drive DBMT (Chatterjee, Chaudhuri, Vrontis, & Jabeen, 2022; Wrede et al., 2020). To bridge the lacuna between micro and macro research (Felin et al., 2015; Foss, 2016), this study built on Adner and Helfat (2003) DMC theory to derive a multi-level research model. This paper first conjectured the linkage between DBMT and firm performance. The adopted macro-level perspective was subsequently complemented by proposing DMCs as a central micro-level antecedent to these critical firm-level outcomes. It was hypothesized that managers with strong human capital possess the necessary capabilities to drive DBMT as the basis for superior firm performance. The research model provided a holistic DMC perspective on DBMT, and how managerial capabilities affect firm performance, by proposing and testing the mechanisms through which the remaining two DMC subcomponents affect the indirect performance-enhancing effects of strong managerial human capital on DBMT. Altogether, the research model offers a holistic foundation for empirically examining the role of managerial-level dynamic capabilities—the micro level—for DBMT and resultant firm performance—the macro level.

This paper’s findings demonstrate that DBMT exerts a significantly positive and strong influence on firm performance. This result supports the notion that DBMT leads to greater firm performance, and thereby reinforces the integrality of digitally transforming a firm’s BM to ensure organizational survival (El Sawy & Pereira, 2013; Verhoef et al., 2021).

The strong relationship between DBMT and firm performance also substantiates that digital transformation has become a critical managerial task to ensure firms' long-term survival in dynamic environments, as proposed by previous research (e.g., Korherr et al., 2022; Warner & Wäger, 2019). Altogether, the strong performance-enhancing benefits of DBMT for firm performance confirm that digital BMs are critical success factors in today's dynamic economy (Verhoef et al., 2021; Volberda et al., 2021). Specifically, DBMT increases firm performance by bridging the mounting gap between organizational strategies and processes as well as between the firm and its digital environment (Al-Debei, El-Haddadeh, & Avison, 2008; Purkayastha & Sharma, 2016).

This research also substantiates the integrality of specific managerial-level dynamic capabilities for DBMT as the basis for firm performance (Korherr et al., 2022; Matarazzo et al., 2021). In particular, strong entrepreneurial skills—the first dimension of managerial human capital—enhances firm performance by facilitating DBMT with a moderate to strong effect. This finding confirms that strong entrepreneurial skills are particularly integral for realizing digital transformation, as conjectured by previous research (e.g., Matarazzo et al., 2021; Zhou et al., 2021). Further, the insignificant direct effects of managerial human capital on firm performance reinforce that DMCs should be analyzed using a two-step procedure: (1) their direct effects on intermediate factors—i.e., organizational strategy and strategic change—and (2) their indirect effects on performance outcomes through organizational strategies (Adner & Helfat, 2003; Helfat & Martin, 2015b).

This study also adds empirical evidence to the interactions between the DMC subcomponents, and how they drive firm performance by affecting strategic change (Beck & Wiersema, 2013; Helfat & Martin, 2015b). First, by confirming a close to moderate, positive moderation effect, the findings show that social capital allows managers to utilize their entrepreneurial skills to promote DBMT and firm performance. This finding infers that although entrepreneurial skills are already beneficial for organizational outcomes, entrepreneurial managers with strong social capital are even more beneficial to digital transformation. Second, the study also offers novel evidence on managerial cognition's role in digital transformation, thereby contributing to cognitive BM research (e.g., Martins et al., 2015; Tikkanen et al., 2005). Although the total moderation effect of managerial cognition is insignificant, conditional effects analysis reveals that decreasing levels of managerial cognition reinforce the positive entrepreneurial skills–DBMT relationship. This result advances a fine-grained understanding of how managers' cognitions affect their strategic decision-making. More particularly, cognition enables entrepreneurial managers to make faster strategic decisions by making information processing more efficient and less complex (Walsh, 1995; Zhou et al., 2021). Due to the moderation effect of low and medium levels of managerial cognition, the study confirms that managerial cognition shapes the capacity of entrepreneurial managers to drive DBMT (Matarazzo et al., 2021; Zhou et al., 2021). This study consequently highlights the integrality of cognitive processes underlying managers' strategic decision-making in driving digital transformation (Heubeck & Meckl, 2022b; Vlačić et al., 2022).

Further, this study adds new evidence to the particular types of managerial human capital that benefit DBMT. The findings reveal that managers' leadership skills do not affect firm performance. In today's digitally-driven economy, entrepreneurial skills rather than leadership skills are thus required for DBMT as the basis for organizational performance. Although the study confirms that strong human capital drives firm performance through DBMT, as proposed by previous scholars (e.g., Korherr et al., 2022; Matarazzo et al., 2021), it shows that in the digital economy, different types of human capital are required. Specifically, this study offers novel insights into the specific managerial capabilities required for DBMT: entrepreneurial skills drive DBMT and subsequent firm performance, while leadership skills have no direct impact on these firm-level outcomes.

6.2. Theoretical contributions

This article advances management literature by bridging the prevalent division into micro and macro research, as requested by researchers (e.g., Abell, Felin, & Foss, 2008; Felin et al., 2015). The empirical results propel an in-depth understanding of the specific managerial capabilities required for DBMT. Eight main theoretical contributions emerge from these results.

First, this study advances BM literature by providing empirical support for the performance benefits of increasing DBMT found in previous studies (e.g., Fernández-Portillo et al., 2022; Matarazzo et al., 2021). The strong effect of DBMT on firm performance confirms that DBMT is a pivotal coping mechanism against the ever-changing demands of today's fast-paced digital economy. As attested by previous research (e.g., Li, 2020; Remané et al., 2022), this study shows that DBMT enhances firm performance by aligning the BM architecture with the competitive environment. Further, DBMT leads to competitive advantage by capitalizing on technological developments (Al-Debei et al., 2008; Li, 2020) or building hard-to-replicate BM configurations (Purkayastha & Sharma, 2016; Vendrell-Herrero et al., 2018).

Second, the strong effect of DBMT on firm performance confirms that digital transformation is the foundation for developing and sustaining competitive advantages required for organizational performance (Parida et al., 2019; Sousa-Zomer et al., 2020). This finding evinces that DBMT allows firms to cope with the increasing demands of today's economy (Klötzer & Pflaum, 2017; Matarazzo et al., 2021). Specifically, digital BMs infer competitive advantage by building or maintaining competitive positioning (Karki & Porras, 2021; Li, 2020) and lead to revenue increases by commercializing new technologies, decreasing costs, or increasing efficiency (Chen et al., 2022; Karki & Porras, 2021). In this vein, the strong effect of DBMT on firm performance confirms that BM transformation is highly interrelated, requiring holistic transformation of all interrelated BM components (Foss & Saebi, 2017; Martins et al., 2015). Altogether, the performance benefits of DBMT found by this study demonstrate that managers are required to transform all BM components, and consider their interrelationships, to spur and sustain superior firm performance.

Third, by empirically examining the role of different human capital types for DBMT and firm performance, this study reinforces that individual-level managerial capabilities matter for organizational change in dynamic environments. The study's results support the fundamental assumption of DMC theory that "managers matter" (Adner & Helfat, 2003, p. 1023), yet that they differ in their ability to make strategic decisions as the basis for organizational performance in dynamic environments (Beck & Wiersema, 2013). This study provides evidence that differences in the DMCs between managers lead firms to performance variances between firms by determining strategic decision-making. In other words, firm performance originates from distinct organizational strategies that conversely result from heterogeneously distributed DMCs. This study, therefore, advances dynamic capability-based literature in the context of digital transformation (e.g., Konopik et al., 2022; Warner & Wäger, 2019). Specifically, this study puts forward an updated understanding of DMCs in the transformed decision-making context of today's digital business environment. In line with the fundamental assumptions of DMC theory, managers' dynamic capabilities have no direct effect on performance outcomes, but the performance benefits of strong DMCs stem from their effect on strategic change (Adner & Helfat, 2003; Helfat & Martin, 2015b). This study finds that managers' entrepreneurial skills underpinning human capital increase firm performance by facilitating DBMT. In contrast to existing literature (H. Guo et al., 2013; Ireland et al., 2003), the results provide no evidence that leadership skills impact DBMT or firm performance. Thus, although human capital may enhance firm performance by driving DBMT, research has to consider the specific type of human capital when analyzing its potential benefits for strategic change in an age of digital competition. The study thereby advances scholarly understanding of

DMC theory in the unique context of today's economy, demonstrating that although managers can drive DBMT through their skillset, these effects are contingent on the specific types of skills, and not all managerial skills promote DBMT equally. In addition, these findings support the indirect performance advantages of human capital via intermediate factors found in Crook et al.' (2011) meta-analysis of 66 studies, yet demonstrate that the performance-enhancing effects of human capital are contingent on its type.

Fifth, this study concurs with previous research that highlights the imperative for more entrepreneurial capabilities in the process of digital transformation (e.g., Sousa-Zomer et al., 2020; Warner & Wäger, 2019). This study's findings show that the DMCs that contribute most strongly to DBMT are explorative rather than exploitative. These results mirror the significant VUCA associated with digital transformation, which requires managers to make fundamental and rapid decisions regarding BM transformation to cope with technological change (Teece, 2018; Warner & Wäger, 2019). Thus, strong entrepreneurial skills are indispensable for strategic change in today's digital economy.

Sixth, the paper's findings conflict with existing research that views leadership skills required for efficient resource orchestration as a facilitator of strategic change (e.g., H. Guo et al., 2013; Sirmon et al., 2011). The contradictory findings potentially result from the added complexity of digital transformation compared to traditional strategic change (Fernández-Portillo et al., 2022; Volberda et al., 2021). Leadership skills to efficiently manage organizational resources may no longer suffice for realizing strategic change in an age of pervasive digitalization or may even cause inertia in DBMT by causing managers to prioritize exploitation over exploration. Thus, managers depend on their entrepreneurial rather than leadership skills to strike a balance between efficiency and flexibility required for successful DBMT (Fengel et al., 2022; Park et al., 2020).

Seventh, the study provides empirical support for the theoretically-presumed interactions between the DMC subcomponents (Adner & Helfat, 2003; Beck & Wiersema, 2013). The study confirms that DMC subcomponents interact in shaping managers' strategic decision-making and their ability to realize digital transformation. Thus, the interactions between specific DMC subcomponents represent another source of heterogeneity that leads to performance differences between firms. Specifically, the study advances DMC theory by empirically demonstrating that the DMC subcomponents uniquely interact in shaping DBMT: Managerial social capital amplifies the positive effect of entrepreneurial skills on DBMT, and even more so with increasing social capital levels, while entrepreneurial skills exert a more positive impact on DBMT under lower rather than higher managerial cognition levels. For one, the study confirms the integrality of social capital for realizing strategic change (Subramaniam & Youndt, 2005; Zheng, 2010), thereby underscoring the inherently social nature of change processes (H. Guo et al., 2013; Landry et al., 2002). For another, the analysis reveals that managerial cognition enhances the benefits of managers' entrepreneurial skills for DBMT and resultant firm performance. By demonstrating that managerial cognition—at low and medium levels—significantly impacts the extent to which entrepreneurial skills promote DBMT, this study highlights the necessity for swift and efficient decision-making in today's economy, where managers are confronted with significant VUCA (Warner & Wäger, 2019; Weill & Woerner, 2015). In other words, managerial cognition serves as a "useful simplicity" (Walsh, 1995, p. 306), allowing entrepreneurial managers to facilitate DBMT that results in performance increases for the firm.

Further, the findings of the significant moderation effects of managers' social capital and cognition on the entrepreneurial skills–DBMT relationship evinces that when firms "are faced with the complex and changeable entrepreneurial environment and have no complete organizational structure to rely on, how to innovate business models to gain competitive advantage often requires entrepreneurs to make strategic decisions in combination with entrepreneurial environment and previous experience" (Zhou et al., 2021, p. 2). Under conditions of significant

VUCA—as is the case in DBMT—there is no need for an in-depth consideration of all strategy-relevant information, and simplified decision-making rules found in heuristics represent a viable option for improving opportunity sensing and seizing as well as resource reconfiguration in light of increased time pressures (Ehret, Kashyap, & Wirtz, 2013; Zhou et al., 2021). Due to the significant moderation effect of social capital, this study confirms that managerial decision-making is also decisively imprinted by the strength of managers' social relationships, as proposed by previous research (e.g., Wilden, Lin, Hohberger, & Randhawa, 2022; Zheng, 2010). The analysis shows that this moderation effect increases with higher levels of social capital, which confirms the relevancy of fostering social relationships to gain access to information and capabilities spread across the social network (Adler & Kwon, 2002; Nyrhinen et al., 2022) and to recombine these resources to support mutual learning processes (Blyler & Coff, 2003; Kogut & Zander, 1992).

In summary, this study shows that DBMT represents the foundation for firm performance and benefits from distinct DMC configurations. This study's results advance DMC theory by providing a nuanced understanding of how the underlying DMC components affect DBMT. Specifically, managers' entrepreneurial skills are indispensable for strategic change through DBMT. In addition, the benefits of entrepreneurial skills for DBMT are greater under conditions of high social capital and low cognition. The study confirms that DMCs represent a valuable coping mechanism against mounting competitive pressures (Adner & Helfat, 2003; Helfat & Martin, 2015b), yet managers differ in their ability to promote firm performance due to differences in their dynamic capabilities. Altogether, the findings of this paper serve as a fruitful extension of DMC theory in an age of digital competition, underscoring the heightened importance of entrepreneurial skills for facilitating digital transformation as the basis for firm performance, as well as the significance of managers' social capital and cognition for this relationship.

6.3. Managerial implications

This study also provides valuable guidance to managerial practice. First, DBMT constitutes a central pathway to realize superior financial performance by allowing firms to commercialize technologies through their BM or develop BMs that confer competitive advantage through their digitally-enabled architecture. DBMT consequently circumvents potential misalignment between BM design and environmental demands that might compromise financial performance. These findings imply that managers should prioritize digital transformation in their strategic decision-making.

Second, this study substantiates that specific individual-level dynamic capabilities of managers are—both in isolation and in concert—critical drivers of DBMT to realize superior firm performance. Strong entrepreneurial skills are integral to pursuing DBMT due to their benefits for sensing and seizing opportunities and reconfiguring a firm's resource portfolio in a paradigm of digital competition. Thus, firms should be aware of the capability endowment of their managers when making astute staffing decisions that benefit strategic change through DBMT. For example, the findings evince that firms wanting to stimulate DBMT should appoint an entrepreneurial chief executive officer over a managerial one.

Third, specific capability configurations are particularly beneficial for DBMT. For one, managers can leverage their entrepreneurial skills with strong social capital to realize increased DBMT. Firms should consequently consider the social context in which DBMT occurs by designing organizational structures that aid the development and sustenance of social capital. For another, the results evince that entrepreneurial decision-making in the digital economy benefits from simplified abstractions of reality (Walsh, 1995), which allows managers to handle the conflicting task of profound yet swift decision-making in the face of significant VUCA.

Fourth, although the results offer no support for the direct benefits of managers' leadership skills for DBMT, they do not refute the fundamental merits of leadership skills in the context of strategic change. The findings related to DBMT, as a specific outgrowth of strategic change, mirror digital transformation's explorative rather than exploitative nature. However, as digital transformation requires considerable financial resources and is associated with significant failure risks, leadership skills might not directly impact DBMT, yet may still be integral to digital transformation by allowing firms to generate profits from their existing value offerings and allowing managers to orchestrate the firm's resource portfolio efficiently.

Altogether, the study's findings offer several notable recommendations for managerial practice, underscoring the importance of managers and their entrepreneurial capabilities in facilitating DBMT as the basis for superior firm performance. The research also shows that strong social capital and lower cognition levels enhance the abilities of entrepreneurially-skilled managers to transform the BM digitally. Thus, the findings demonstrate that firms should foster an entrepreneurial culture that allows for social interactions and enables managers to develop an entrepreneurial mindset to facilitate decision-making. This study can therefore serve as valuable guidance to firms and managers confronted with the crucial task of digitally transforming their firm's BM to ensure competitiveness in an era of pervasive digitalization.

6.4. Research limitations and recommendations

Although this article has made several significant contributions to management literature, especially concerning the antecedent role of DMCs in facilitating DBMT as the basis for firm performance, it faces some limitations. However, these limitations open up several fruitful pathways for future research.

This study focused on the micro-macro linkage between individual-level capabilities and firm-level outcomes, specifically DBMT as the materialization of strategic change and firm performance as the central performance outcome. Due to this theoretical conceptualization, this study did not explicitly address how individual-level capabilities aggregate at the collective level in influencing organizational outcomes. Future research can therefore examine how pooled DMCs determine the abilities of, for example, top management teams to shape strategic change. Further, the research model conjectured managers' social capital and cognition as moderators of the human capital–DBMT relationship. This argumentation was grounded in the calls for research on the interactions between the DMC subcomponents (e.g., Durán & Aguado, 2022; Helfat & Martin, 2015b). Future research could examine whether managerial social capital and cognition are direct antecedents to organizational strategies and firm performance.

This study also faces limitations from a methodological perspective. First, the sample comprises firms primarily headquartered in Germany, as the country's Industry 4.0 sector presents a suitable research setting in light of the research goal. Nevertheless, future research is needed to assess if the findings are transferrable across countries due to the possible impact of cultural differences on strategic decision-making. Further, the sample predominantly includes male managers performing an output function. Even though this composition is unsurprising due to the prevalence of male executives in the manufacturing industries of developed economies (Cropley & Cropley, 2017; Reshef, Aneja, & Subramani, 2021), and the model included managers' gender as a control variable, future research could explicitly examine the role gender might play in the DMC framework. Finally, future researchers are

encouraged to draw on the study design to conduct more extensive scale surveys over a longitudinal time frame or to retest the model at a future stage to take the inherent dynamism of today's economy into account.

7. Conclusion

Discussions around the sources of developing and sustaining competitive advantages have dominated strategic management literature since its emergence (Helfat et al., 2007; Hitt et al., 2017). Pervasive digitalization has reignited this debate and significantly muddied the waters in finding the "Holy Grail" (Helfat & Peteraf, 2009, p. 91). Although this article offers no definitive answer to this fundamental question, it may pave the way for future management research in ascertaining the origins of competitive advantage not from a micro- or macro-level perspective, but from a holistic view that takes the interlinkages between these often-divided realms of strategic management into account.

The research model bridged the micro and macro levels by providing evidence for the specific DMCs that are pivotal for firms in their pursuit of competitive advantage. The study showed that managers' entrepreneurial skills enable firms to realize DBMT, which is critical to financial performance in today's digital economy. In addition, the research shed light on the interrelationships between the three DMC subcomponents. Specifically, the results demonstrate that high levels of entrepreneurial skills facilitate DBMT even more strongly with increasing social capital. In contrast, lower rather than higher levels of cognition amplify the positive impact of entrepreneurial skills on DBMT. This finding mirrors the significant VUCA managers are confronted with in today's digital economy and underscores the importance of previous knowledge in making fundamental, proficient, yet timely strategic decisions. The research also advanced DMC theory by demonstrating that leadership skills neither facilitate firm performance directly nor indirectly through impacting DBMT. In the transformed context of today's digital economy, this study thus adds new empirical evidence to the specific forms of human capital required to nurture firm performance through strategic change. The results thereby update strategic management theory by shedding light on whether, and the extent to which, individual-level DMCs transcend into firm-level strategies—i.e., DBMT—as the basis for superior firm performance in the current age of digital competition.

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Availability of data and material

The datasets generated during and/or analyzed during the current study are available from the author upon reasonable request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix 1. DMC questionnaire items translated from German

Construct	Dimension	Item
Managerial human capital	Leadership skills	One of my greatest strengths is getting results by organizing and motivating people. One of my greatest strengths is organizing resources and coordinating tasks. One of my greatest strengths is my ability to delegate effectively. One of my greatest strengths is my ability to monitor, influence, and lead people. I make resource allocation decisions that achieve maximum results with limited resources.
	Entrepreneurial skills	I like to think about new ways to do business. I frequently identify opportunities to start new businesses (although I may not pursue them). I often identify ideas that can be turned into new products or services. I keep my eyes open for previously unnoticed entrepreneurial opportunities. I see myself as a creator of entrepreneurial opportunities (entrepreneur).
Managerial social capital	Structural dimension	I always communicate openly and honestly with other company members. As a rule, I completely disclose my plans and intentions. I willingly share information with other company members. When exchanging information, I draw on my internal company relationships.
	Relational dimension	I always have the utmost trust in other company members and their actions/decisions. I always act with integrity in my dealings with other company members. In general, I have a high level of trust with other company members. I am always considerate of the feelings and sensibilities of other company members.
	Cognitive dimension	I feel committed to the goals of the company. I share a common purpose with other company members. I see myself as a discussion partner in determining the company's direction. My vision for the future of the company is in line with that of other company members.
Managerial cognition	Value offering evaluation	When redesigning the business model in part or in whole, I consciously evaluate alternatives to a very high extent with regard to ... customer problems and needs. ... value propositions. ... relationships between value propositions and customer problems/needs.
	Value architecture evaluation	... sales and distribution channels. ... business transactions and the ways of collaborating with partners. ... linking business participants together in novel ways. ... taking over new value propositions or substituting existing parts of the value chain.
	Value capture evaluation	... applying new revenue streams. ... resource requirements for all business aspects. ... the financial benefits for our company. ... all the business-related costs of the project.

Source: Heubeck and Meckl (2022b).

Appendix 2. Operationalization of DBMT

Dimension	Product-centric business model	Data-centric business model
Value proposition	Physical product as potential in combination with product-related services in the sense of an additional value proposition (value-added services)	Products and product-related services lose importance, data is understood as an asset, and data-driven services generate value
Revenue sources	Marketing of physical products as capital goods at a fixed price, additional fees for value-added services are incurred	Marketing of data-driven services based on so-called "as-a-service" payment models (infrastructure, hardware, service, data)
Customer segments	Restriction to financially strong customer segments, customer segments with less financial strength are neglected	Addressing the overall market; lower market segments are addressed via new payment models (see above)
Customer relationships	Customers have limited involvement along the lifecycle due to the hybrid nature of the business with a strong focus on the product business	Potential customers are involved throughout the entire lifecycle of the offering (development, ramp-up, operational business)
Marketing channels	Marketing of products via classic offline and online marketing channels	Smart products as an additional marketing channel; exploitation of usage data by marketing
Key activities	Traditional value creation processes from development through procurement, production, sales, and distribution; additional service processes	Automated collection, storage, processing, evaluation of data, and subsequent exploitation from the company and its environment
Key resources	Software tools, machinery, equipment, materials, human resources, intellectual property rights, etc.	Digital platforms and software products to support the above key activities
Key partners	Actors along the supply chain from primary production to recycling, additionally service companies (finance, information technology, logistics, etc.)	Actors of an entrepreneurial ecosystem beyond the "extended enterprise" (competitors, politics, science, associations, consultants, etc.)
Cost structures	Costs for resources in the area of development, production, and logistics as well as in the area of product-related additional services	Costs for the development and operation of a digital platform as well as the development and sustainable design of an entrepreneurial ecosystem

Source: Adopted from Klötzer and Pflaum (2017); Pflaum and Schulz (2018).

Appendix 3. Result of the confirmatory factor analysis

Constructs and dimensions	Item	Std. FL
<i>Managerial human capital</i> (KMO = 0.775; AVE = 0.436; FL = 0.817; α = 0.773; N = 111)		
Leadership skills	2	0.594
	4	0.611

(continued on next page)

(continued)

Constructs and dimensions	Item	Std. FL
Entrepreneurial skills	5	0.573
	1	0.615
	2	0.659
	3	0.653
	4	0.725
<i>Managerial social capital</i> (KMO = 0.773; AVE = 0.479; FL = 0.968; α = 0.801; N = 109)	5	0.689
	2	0.617
	3	0.787
	1	0.687
	2	0.545
Relational dimension	3	0.541
	1	0.581
	2	0.687
Cognitive dimension	4	0.644
	1	0.768
	2	0.697
Value offering	3	0.614
	2	0.731
	3	0.952
Value architecture	4	0.500
	1	0.563
	2	0.701
Value capture	3	0.801

Notes α = Cronbach's alpha; AVE = Average Variance Extracted; FL = Fornell-Larcker; KMO = Kaiser-Meyer-Olkin; N = Sample size; Std. FL = Standardized factor loadings

Appendix 4. Direct effect regression results

Hypothesis	Dependent variable	Independent variables	b (se)	β
	Firm performance			
Hypothesis 1		DBMT	9.240** (3.327)	0.389**
Hypothesis 2a		Leadership skills	0.843 (1.007)	0.133
Hypothesis 2b		Entrepreneurial skills	-1.425 (0.918)	-0.237
		Managerial social capital	-0.580 (1.377)	-0.079
		Managerial cognition	2.169 (2.011)	0.210
		Management age	0.004 (0.074)	0.009
		Management gender	-3.842 (1.940)	-0.271
		Management level	-1.397 (1.275)	-0.211
		Functional background	-2.729 (1.990)	-0.271
		Education level	-1.582 [†] (0.825)	-0.321 [†]
		Firm age	-0.041* (0.017)	-0.327*
		Firm size	1.195*** (0.333)	0.535***
		R&D intensity	0.077 (0.190)	0.058
		Industry classification	-0.223 (0.404)	-0.087
		Constant	18.694* (8.107)	
		R ²	0.387***	
		F (df)	7.137(14; 41)	
		p	< 0.001	
		N	56	
	DBMT			
Hypothesis 3a		Leadership skills	-0.052 (0.053)	-0.195
Hypothesis 3b		Entrepreneurial skills	0.087* (0.036)	0.344*
		Managerial social capital	-0.039 (0.082)	-0.127
		Managerial cognition	-0.062 (0.113)	-0.142
		Management age	0.005 (0.003)	0.224
		Management gender	0.112 (0.073)	0.188
		Management level	-0.042 (0.050)	-0.149
		Functional background	0.067 (0.079)	0.158
		Education level	0.058 (0.050)	0.279
		Firm age	0.000 (0.001)	0.050
		Firm size	0.007 (0.025)	0.072
		R&D intensity	0.008 (0.009)	0.152
		Industry classification	0.032 [†] (0.019)	0.300
		Constant	-0.505 (0.369)	
		R ²	0.336*	
		F (df)	2.333 (13; 42)	
		p	0.019*	
		N	56	

Notes b = Unstandardized coefficient; β = Standardized coefficient; df = Degrees of freedom; N = Sample size; p = Significance value; R² = Coefficient of determination; se = Standard error; DBMT = Digital business model transformation; R&D = Research and development; with robust standard errors HC4; ***p < 0.001, **p < 0.01, *p < 0.05, [†]p < 0.10

Appendix 5. Indirect effects: bootstrapping regression and Sobel’s test results

Hypothesis	Path	b (se)	Confidence interval		β (se)	Confidence interval		Sobel’s test	
			Lower	Upper		Lower	Upper	b	p
Hypothesis 4a	Leadership skills → DBMT → Firm performance	−0.481 (0.506)	−1.476	0.134	−0.076 (0.077)	−0.222	0.021		
Hypothesis 4b	Entrepreneurial skills → DBMT → Firm performance	0.805 (0.495)	0.069	1.654	0.134 (0.083)	0.012	0.276	0.804 [†]	0.079

Notes DBMT = Digital business model transformation; se = Standard error; b = coefficient; N = Sample size; bootstrap inference for model coefficients with robust standard errors and mean-centered products; bootstrap samples = 5000; confidence interval = 90%; ***p < 0.001, **p < 0.01, *p < 0.05, [†]p < 0.10; N = 56

Appendix 6. Moderated mediation effects

Hypothesis	Interaction	Index (se)	Confidence interval		b (se)	p	Confidence interval		R ² change
			Lower	Upper			Lower	Upper	
Hypothesis 5a	Leadership skills x Managerial social capital	−0.822 (0.815)	−2.262	0.301	−0.087 (0.083)	0.213	−0.203	0.029	0.031
Hypothesis 5b	Entrepreneurial skills x Managerial social capital	1.189 [†] (0.852)	0.082	2.811	0.126 [†] (0.063)	0.054	0.019	0.232	0.090 [†]
Hypothesis 6a	Leadership skills x Managerial cognition	−0.505 (1.084)	−4.424	2.251	−0.059 (0.107)	0.584	−0.347	0.229	0.008
Hypothesis 6b	Entrepreneurial skills x Managerial cognition	−0.317 (0.823)	−1.676	0.938	−0.037 (0.085)	0.666	−0.180	0.106	0.005

Notes se = Standard error; b = coefficient; N = Sample size; bootstrap inference for model coefficients with robust standard errors and mean-centered products; bootstrap samples = 5000; confidence interval = 90%; ***p < 0.001, **p < 0.01, *p < 0.05, [†]p < 0.10; N = 56.

Appendix 7. Conditional effects of significant moderation effects

Hypothesis	Interaction	Managerial social capital	Managerial cognition	Effect (se)	p	Confidence interval	
						Lower	Upper
Hypothesis 5b	Entrepreneurial skills → DBMT → Firm performance	−0.681 (−1 SD)		0.005 (0.615)		−1.200	0.789
	Entrepreneurial skills → DBMT → Firm performance	0.000 (0 SD)		0.815* (0.472)		0.129	1.619
	Entrepreneurial skills → DBMT → Firm performance	0.681 (+1 SD)		1.624** (0.860)		0.389	3.169
Hypothesis 6b	Entrepreneurial skills → DBMT → Firm performance		−0.485 (−1 SD)	0.897 [†] (0.544)		0.066	1.798
	Entrepreneurial skills → DBMT → Firm performance		0.000 (0 SD)	0.744 [†] (0.477)		0.008	1.516
	Entrepreneurial skills → DBMT → Firm performance		0.485 (+1 SD)	0.590 (0.691)		−0.486	1.715

Notes DBMT = Digital business model transformation; se = Standard error; b = coefficient; N = Sample size; bootstrap inference for model coefficients with robust standard errors and mean-centered products; bootstrap samples = 5000; confidence interval = 90%; ***p < 0.001, **p < 0.01, *p < 0.05, [†]p < 0.10; N = 56

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