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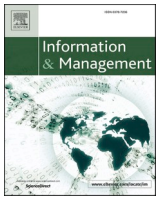

Organizational culture, digital transformation, and product innovation

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ABSTRACT

This research fills a knowledge gap by introducing a new conceptualization of digital transformation through a multidimensional digital transforming capability. It further examines the influence of four cultural types on this capability and its subsequent impact on product innovation. Empirical findings reveal that adhocracy, followed in descending order of influence by clan, market, and hierarchy cultures, is positively related to digital transforming capability, which in turn is positively related to product innovation in terms of new product newness, meaningfulness, and performance. Additionally, new product newness and meaningfulness each positively mediate the effect of digital transforming capability on new product performance.

1. Introduction

This study aims to explore the complex relationships among organizational culture, digital transformation (DT), and product innovation. Existing literature suggests that DT can substantially improve business practice and firm competitiveness [e.g. 1,2]. Consequently, research on DT has gained considerable attention, as reflected in various systematic literature reviews [e.g. 3–5] and editorials [e.g. 6,7].

Several research gaps remain, however. First, existing studies often adopt a narrow definition of DT, framing it primarily as organizational changes driven by digital technologies alone [e.g. 3,6,8]. This view typically emphasizes the adoption and use of digital technologies to achieve major business improvements [6,9,10], or defines DT as "a process that aims to improve an entity by triggering significant changes to its properties" through the use of digital technologies [8, p.121]. Such a limited perspective overlooks the multifaceted nature of DT in practice. Given this constrained conceptualization, there is a pressing need to explore DT from a multidimensional perspective in both research and practice, incorporating a more holistic understanding of how multiple factors influence the transformation process [5,11,12].

Prior studies have indicated that DT is influenced by a variety of organizational factors [5], including digital technologies [e.g. 3,8], business strategy [e.g. 3,4,8,13], financial investment [e.g. 5,14], process optimization and technological integration [e.g. 4,14], resource complementarity [15], organizational change [e.g. 3,14], organizational culture [e.g. 8,14–16], and skill development [e.g. 4,8]. Although these studies mostly discuss these factors in isolation, they collectively indicate that DT is inherently multifaceted [e.g. 5,6,10], extending beyond the mere impact of digital technologies [e.g. 12,17,18] to encompass the "combinations and connectivity of innumerable, dispersed information, communication and computing technologies" [19, p.471]. Some prior studies imply that DT is the organizational change enabled by the combined effect of multiple digital properties [e.g. 5,20,21], suggesting the need to understand DT holistically.

Furthermore, a review of 279 DT studies highlights that the literature on DT is quite diverse and fragmented, "lacking common agreement on exactly what DT is" [3, p. 1160]. De Bem Machado et al. [22] observe that the emphasis of definitions of DT varies according to the perspective taken: technological, organizational, or social. Markus and Rowe [7] suggest that DT is not yet sufficiently theorized to provide a comprehensive understanding of the phenomenon. Similarly, in the context of DT and innovation management, Appio et al. [6] indicate that DT is multifaceted and that the current understanding is highly fragmented. Consequently, several scholars have called for more relevant theoretical and empirical research [e.g. 6,7,23], including development of a rigorous definition of DT [5].

In summary, although DT is inherently complex and multidimensional, many existing definitions tend to prioritize the adoption of digital technologies, often overlooking critical factors that influence the broader scope of DT. This narrow focus on technology adoption risks constraining organizations' understanding of DT, limiting their ability to fully harness its potential. A more holistic view of DT—encompassing

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not only digital technologies, but also such elements as organizational culture, strategy, skills, and talent development—is crucial for maximizing its value.

Beyond the research gaps discussed, practical challenges faced by organizations during DT also underscore the need for a new conceptualization. The Boston Consulting Group (BCG) [24] reports that approximately 70% of DT initiatives fail. Successful DT efforts, according to BCG, are frequently driven by "an integrated strategy," "high--caliber talent," and a "business-led modular technology and data platform," among other factors. Similarly, a Gartner survey [25] highlights five major challenges organizations encounter when implementing DT initiatives, among them "siloed strategies," "risk-averse culture," and "digital skill gap." These findings reinforce the importance of conceptualizing DT beyond the mere adoption of technology.

To address this research gap, our first research question explores: *What might be an alternative conceptualization of DT that is defined multidimensionally*? This approach is likely to lead to a more comprehensive understanding of the phenomenon, integrating both technological and nontechnological drivers to help organizations navigate and thrive in a digital economy.

Second, although organizational culture is widely recognized as critical to DT initiatives [e.g. 3,15,21,26–28], a clear research gap remains in how specific cultural dimensions influence the success of DT. Although prior studies highlight that neglecting organizational culture often leads to DT failure [13,16,27,28], the relationship between organizational culture and DT outcomes remains underexplored [15,26] and underdeveloped [29]. In particular, the omission of culture in several key literature reviews and DT research agendas [4,7] signals an area in need of further investigation, despite the widespread acknowledgment of its importance.

Most existing research treats organizational culture in a general manner using a one-size-fits-all approach, failing to account for the coexistence of different cultural types with organizations [e.g. 26, 30–32]. This leads to a limited understanding of how distinct cultural dimensions may affect DT, based on the established framework of clan, adhocracy, hierarchy, or market cultures [33,34]. The framework proposed by Cameron and Quinn [34] suggests that each of these cultural types could play a specific role in shaping DT outcomes. For example, adhocracy cultures promote the agility and innovation essential for responding to rapidly changing digital environments. Clan cultures, emphasizing collaboration and employee development, are well positioned to foster digital skill-building and internal engagement. In contrast, market cultures prioritize competitiveness and performance, emphasizing a results-driven approach to technology adoption, whereas hierarchy cultures contribute the structure, stability, and systematic planning critical for the successful execution of complex DT initiatives.

The present study addresses this significant research gap by investigating the nuanced effects of distinct cultural types on DT processes and outcomes. This focus on cultural differentiation helps to move beyond the one-size-fits-all approach often seen in the literature and contributes a more precise understanding of how different cultural types support or hinder DT [26]. Consequently, our second research question is: *How and to what extent does organizational culture affect DT?* Answering this question is vital for enabling organizations to tailor their DT strategies in alignment with their unique cultural configurations, maximizing the potential for success across varied organizational contexts.

Third, there is a need to better understand how firms engaging in DT can combine their core assets with digital technologies to develop new products and services [6], given the unparalleled opportunities for product and service innovation that digital technologies offer [e.g. 35, 36]. Prior studies suggest that a key element of product innovativeness is its perceived usefulness to customers [37,38], which can be assessed by product newness and meaningfulness [e.g. 39,40]. However, most work on DT and innovation focuses on the business model level (see, e.g., the review by Verhoef et al. [4]), with a dearth of studies on digital product innovation from either the IT/IS perspective [41] or the product innovation management perspective [6,36]. Specifically, there is little research examining the impact of DT on new product newness and meaningfulness. Wang, Gongtai et al. [42] observe that existing literature on digital product innovation pays little attention to product meaning. Thus, our third research question is, *How and to what extent does DT affect product innovation*?

To answer the three research questions, we draw on the tenets of dynamic capabilities (DCs) [43–45] and prior research on organizational culture, DT, and product innovation. For the first question, we build on extant DT studies and the tenets of DCs in general and the higher-order dynamic capabilities in particular [45,46] and propose a new DT definition in terms of a multidimensional digital transforming capability. For the second research question, we draw specifically on four different organizational culture types— clan, adhocracy, hierarchy, and market [34]—and examine the extent to which each is distinctively associated with DT. Finally, building on extant research on DT and product innovation, we advance our understanding of the association between digital transforming capability and product innovation in terms of new product newness, meaningfulness, and performance.

Our paper thus contributes to the under-researched associations among organizational culture, DT, and product innovation. First, by extending the work on DCs to DT and developing a new DT conceptualization based on a multidimensional digital transforming capability, our study enriches the literature on both DCs and DT. Second, our study extends the literature on organizational culture and DT by developing a nuanced understanding of how each of the four cultural types uniquely affects digital transforming capability and DT, thereby highlighting the role of organizational culture in facilitating DT. Third, this study advances our knowledge of the impact of DT on product innovation.

2. Theoretical development

In this section we review relevant literature on organizational culture, provide an overview of DCs and their links to DT, develop a new DT conceptualization based on a new digital transforming capability, and review relevant literature on product innovation.

2.1. Organizational culture

Although there are many different definitions of, and perspectives on organizational culture [e.g. 16,47], this study adopts the definition of organizational culture as a "complex set of values, beliefs, assumptions, and symbols that define how a firm conducts its business" [48, p.657]. A thorough review of the literature on organizational culture and its impact on performance reveals that a one-size-fits-all approach is ineffective [26,30], as organizations often embody multiple cultural types simultaneously [31,32].

One of the most influential and widely used models for analyzing organizational culture is the Competing Values Framework (CVF) [49]. The CVF evaluates organizational culture along two key dimensions: flexibility versus control and internal versus external [47]. Based on these dimensions, Cameron and Quinn [34] identified four distinct culture types: clan, adhocracy, market, and hierarchy. These cultures often compete with one another [34,47] and are considered to represent the broad spectrum of cultural dimensions found in organizations [16, 34,47,50].

The CVF has been used extensively in research to investigate how different organizational cultures influence change initiatives and overall performance [e.g. 47,49,51,52]. Consequently, these four culture types—clan, adhocracy, market, and hierarchy— are particularly well suited for our study on how organizational culture affects DT. Given the multidimensional and complex nature of DT [11,12], it is likely that each cultural type influences DT outcomes in unique ways [26].

These culture types have been used widely in relevant studies, including research on innovation [50,52,53], digital culture and

digitalization [16], environmental practices [49], deviant working behavior [54], and firm performance [55]. This demonstrates their versatility and applicability in examining the cultural factors that shape organizational change and performance, making them ideal for exploring the cultural dimensions of DT in this study.

2.1.1. Adhocracy culture

According to Cameron and Quinn [34], an adhocracy culture values innovation, transformation, and agility, prioritizing "external positioning with a high degree of flexibility and individuality" (p. 67). This allows an organization to adapt quickly to environmental changes. The innovative nature of an adhocracy fosters a focus on new technologies that can enhance its dynamic capabilities for capitalizing on new opportunities [31]. This emphasis on innovation is critical for the success of DT [56], as it generates new ideas in unpredictable environments and helps overcome resistance to DT [26].

2.1.2. Clan culture

A clan culture values commitment, communication, and human development, emphasizing "internal maintenance with flexibility, concern for people, and sensitivity to customers" [34, p.67]. This leads to a strong sense of community and shared purpose. Fostering a clan culture is important for an organization aiming to pursue DT, as it involves redefining value propositions and requires the engagement of the entire organization [23]. This culture can create a friendly and supportive work environment in which different teams and departments can collaborate effectively to embark on DT [26].

2.1.3. Hierarchy culture

A hierarchy culture values efficiency, timeliness, consistency, and uniformity, prioritizing "internal maintenance with a need for stability and control" [34, p.67]. This culture is often found in highly structured organizations that have well-defined roles and clear hierarchies. It helps optimize processes, create policies, and establish rules, thereby leading to efficient operations and reliable business performance. Although these characteristics might seem counterintuitive to organizational change [31] and DT [26], they provide clear procedures and control mechanisms that can help ensure that DT initiatives are systematically implemented and aligned with organizational goals [16].

2.1.4. Market culture

A market culture values market share, goal achievement, and profitability, prioritizing "external positioning with a need for stability and control" [34, p.67]. This culture is highly competitive and focused on achieving measurable results. This drive for performance and results can propel DT efforts by aligning technological advancements with business objectives and market demands, thereby gaining a competitive edge [26].

2.1.5. The impact of the four cultural types in existing literature

Cameron and Quinn [34] suggest that each successful organization has a distinguishable and dominant organizational culture, be it clan, adhocracy, hierarchy, or market, and at the same time, the other three cultural types also are likely to be present in varying degrees in the organization to enable the organization to meet its diverse needs in a dynamic environment [33,34]. Prior studies suggest that the four cultural types affect IT adoption differently [e.g. 57,58]. Although some studies demonstrate that all four cultural types affect hospital performance [59,60] or open innovation [61], Yang et al. [62] indicate that adhocracy culture nurtures innovative behavior. Successful execution of a particular strategy type is significantly influenced by a cultural type that matches the strategy type to provide crucial behavioral norms that are necessary for success [63,64]; adhocracy or clan culture greatly improves a firm's market responsiveness, which is a firm-level strategic action [65]. Additionally, Ogbeibu et al. [66] suggest that adhocracy positively influences and market and clan negatively influence employee creativity in the Nigerian manufacturing industry, while hierarchy has no effect.

In summary, although the literature acknowledges the critical role of organizational culture in influencing DT [e.g. 3,15,21,26–28], research on this link is limited [15,26] and underdeveloped [29]. A literature review of the use of the four cultural types in relevant studies suggests that these cultural types are more appropriate for understanding how DT is affected [15,26,30] in a dynamic environment [33,34].

2.2. Dynamic capabilities

Organizational capabilities can be broadly classified into dynamic and operational/ordinary [67,68]. Whereas operational/ordinary capabilities allow a firm to focus on maintaining its status quo [69], the firm can achieve and sustain a competitive advantage if it has DCs, especially higher-order DCs, "the sensing, seizing, and transforming competencies that aggregate and direct the various ordinary capabilities" [46, p.41]. Although some scholars have understood sensing, seizing, and transforming competencies as a cluster or three general types of DCs [e.g. 70,71], Teece [45,46] suggests that transforming depends on seizing, which in turn depends on sensing; a firm's sensing, seizing, and transforming competencies work in sequence to provide a dynamic capability [72].

The perspective of DCs is deemed particularly relevant in environments of rapid technological change [43–45]. DCs are seen to provide a relevant theoretical perspective for understanding DT [e.g. 10,72,73], as DT depends on disruptive digital technologies [8,74] and is closely associated with firm DCs [e.g. 2,10]. Matarazzo et al. [75] used DCs to study DT in Italian SMEs but divided DCs into sensing, learning, integrating, and coordinating after Pavlou and El Sawy [76] rather than following Teece, David J [46], as we propose.

We believe that DCs [45,46] provide a particularly relevant theoretical foundation to explain how a firm can leverage its various digital competencies to achieve DT/organizational change in a digital environment replete with digital disruptions [8,16].

2.3. A new conceptualization of DT

2.3.1. Existing DT definitions and the need for a new definition

DT research broadly includes studies on digitization, digitalization, and DT [4,17]. According to Verhoef et al. [4], "*digitization* (italics in original) is the encoding of analog information into a digital format"; "*digitalization* describes how IT or digital technologies can be used to alter existing business processes"; and "*digital transformation* is the most pervasive phase, and describes a company-wide change that leads to the development of new business models" (p.891). Despite this clarification, many prior DT studies focus on digitization and/or digitalization [e.g. 2, 73] and do not clearly define what they mean by DT. Others define DT as a multilevel concept encompassing individual, organizational, and societal perspectives [e.g. 8,17], leading to considerable confusion in research [17]. At the organizational level, DT often is defined as changes enabled by digital technologies alone [e.g. 3,6,8]. As such, several scholars, including Markus and Rowe [7], Appio et al. [6], and Wessel et al. [23], suggest that DT currently is insufficiently theorized and propose that more robust theoretical development is needed to fully comprehend the DT phenomenon.

Our study has identified several critical issues and limitations within current conceptualizations. First, existing definitions of DT often overlook its multifaceted and complex nature [e.g. 5,6,10]. They tend to focus primarily on digital technologies while neglecting the influence of various organizational and social factors that also play a significant role in shaping DT [e.g. 12,17,18,22]. These factors often affect DT in an interconnected manner [e.g. 20,21]. Second, DT encompasses organizational changes triggered by disruptive digital technologies [e.g. 8,16, 74], resulting in a digital environment characterized by "volatility, complexity, and uncertainty" [72, p.329], which presents both

opportunities and threats [8,16]. In such rapidly changing technological environments, firms need strong DCs to modify, aggregate, and direct their ordinary capabilities [e.g. 10,72,73]; otherwise, they may face catastrophic consequences [77,78]. Consequently, we agree with Kao et al. [5] regarding the need to develop a new definition of DT incorporating multiple dimensions, and we believe that the new definition should be underpinned by the theory of DCs.

2.3.2. A new DT conceptualization

Building on Teece [45,46], we propose that successful DT is contingent on the organization possessing a DC, which we refer to as "digital transforming capability". Note that we use digital transforming capability as a shorthand expression for a capability that encompasses sensing, seizing, and transforming: a higher-order DC needs to cover all three of these to be effective. However, although the sensing-seizing-transforming separation is clear from a process perspective, the aspects constituting this capability need to be treated holistically. For example, sensing has to be looking out for the "right" developments—ones that the firm is capable of seizing.

From the literature, we identify three necessary aspects: digital strategy, digital skills, and digital technology use. Digital strategy drives all three aspects of DT capability. Although, as Teece, David J [46] point out, it is most central to the seizing step, it is the strategy that determines that the first (digital) sensing step is needed, as in the last part of the definition by Porfírio et al. [79] "Digital strategy is a synergetic sum of information technology (IT) and information systems (IS) strategic initiatives, driven by managers' decisions to exploit these available infrastructures" (p.610). Equally, the strategy directs the final implementation, the "transform" step.

Yeow et al. [80] emphasize that digital strategy explicitly recognizes the embeddedness of digital technologies throughout the firm and that digital technology use is integrated with business strategy to "generate differential value" [19, p.472]. Thus, digital strategy supporting business strategy is seen to be a factor in the success of DT [81] and a key pillar of digital transforming capability; it must be developed to adequately address the opportunities and risks of DT to result in the desired organizational change [79].

Additionally, the firm also must have appropriate and sufficient digital skills and the competency to leverage [1] digital technologies to realize the digital strategy [20] and remain successful [82,83]. This crucially affects the "transform" step, but there also must be some digital skills at the awareness level for the sensing step and to understand the resource issues in the seizing step. Otherwise DT may fail, as in the case of adopting advanced manufacturing technology for innovation [84]. Ciarli et al. [11] argue for the need to develop a holistic understanding of the interrelationship among digital technology use, new skills required to use technologies to innovate, and firm innovation. Benitez et al. [1], while focusing on digital leadership capability and its impact on innovation performance, examine the digital skills of employees. Sousa-Zomer et al. [10] show empirically that "digital savvy skill" is a key element in developing digital transforming capability. Building on these studies, we believe that digital skills should be included as the second pillar of digital transforming capability.

The third pillar of digital transforming capability is digital technology use, which provides the basis of firm products and services [85]. The use of disruptive digital technologies is central to the "transform" step of the DC, but the use of existing digital technologies also can contribute to the sensing and, to a lesser extent, seizing steps. In general, digital technology use is likely to result in significant changes in organizational structures, management, and business processes [3]. However, digital technology use is "necessary but insufficient" [86, p.30]; it must be appropriately integrated and directed. That may explain, at least partially, why the adoption of digital technologies is seen to be challenging for organizations [84], evidenced by the reported 30% success rate of DT projects [e.g. 10,87].

Fig. 1 shows how the three pillars support the three steps of the DC.

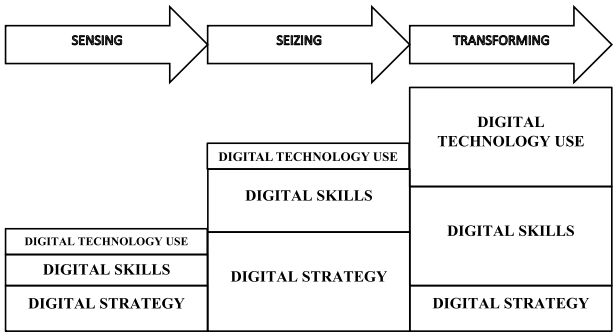

Fig. 1. Digital strategy, digital skills, and digital technology use supporting digital transforming capability.

The sizes of the rectangles roughly indicate the relative extent of support that each pillar provides to each step. The overall support increases through the three steps.

Therefore, recognizing that DT is complex and multidimensional [6,10], we conceptualize "DT" as *organizational change enabled by a firm's digital transforming capability of integrating its digital strategy, digital skills, and digital technology use.* Unlike many existing technology-centric definitions of DT, which predominantly emphasize the adoption and implementation of new technologies, our conceptualization acknowledges the interconnectedness of technological, organizational, and social aspects [22]. Our definition highlights that DT is not merely about technology adoption, but also about how technology interacts with broader organizational elements to drive meaningful transformation. Specifically, our framework emphasizes that successful DT depends on three critical competencies—digital strategy, digital skills, and digital technology use— all of which must work in tandem to produce sustainable organizational change. Grounded in DC theory [45,46], this multidimensional conceptualization offers a more comprehensive theoretical understanding of DT. It provides a richer explanation of the significant organizational changes driven by DT, including innovations in business models, the redesign of processes, and the enhancement of competitive advantage. By moving beyond a narrow focus on technology adoption, this DT conceptualization allows for a deeper exploration of the strategic and social transformations that are essential for organizations to fully leverage digital technologies in practice.

2.4. Product innovation

Whereas innovation is defined as "a new technology or combination of technologies that offer worthwhile benefits" [88, p. 424], product innovation is concerned with developing new products/services for customers, which is key to superior firm performance in dynamic environments [89]. The extent to which a new product/service is perceived as useful to customers is a key element of product innovativeness [37,38], which can be captured by product newness and meaningfulness [39,40]. Product newness refers to the extent to which customers perceive the firm's products as being novel and innovative [90], which reduces customer loyalty [40]. On the other hand, product meaningfulness is about the degree of usefulness and appropriateness of the product to customers [91], which increases customer loyalty [40]. This suggests that the two dimensions should be examined separately [90].

A firm's product innovativeness is seen to contribute to its new product performance/success [e.g. 92,93], which also is influenced by other managerially controllable factors [94], such as the firm's workforce time agility and task agility (skills) [95], market orientation [e.g. 90,96], and marketing and technological capabilities [97,98].

Recently, digital technologies have been seen to offer unparalleled opportunities for product/service innovation [e.g. 35,36], yet "the positive effect of digital technologies for innovation seems almost

unquestioned so far" [99, p.328]. Digitalization "can also reinforce extant knowledge structures by creating new technological barriers to knowledge discovery" [100, p.104]. There is a dearth of studies on digital product innovation viewed through the lens of either IT/IS [41] or product innovation management [6,36]. More research is needed to develop a better understanding of how a firm engaging with DT can combine its core assets with digital technologies to develop new products/services [6].

3. Hypotheses

3.1. Linking the four cultural types and digital transforming capability

Although each successful organization has a distinguishable and dominant organizational culture—clan, adhocracy, hierarchy, or market [34]—all four cultural types can coexist to some extent within an organization [33,34,64], as demonstrated by, for example, Gregory et al. [59] and Lee et al. [60] in the context of U.S. hospitals and by Ghafoori et al. [26] in the field of DT. Importantly, the four cultural types offer crucial cultural norms and values in an organization to shape the employees' perceptions and behavior, which is necessary for the organization to effectively meet diverse demands in a dynamic environment [26,34,63,64].

Organizational culture has been long recognized as an important antecedent in the fields of business and management [e.g. 33,61,101]. Recent studies, both practice-oriented [e.g. 20,102] and conceptual [e.g. 16], suggest that DT fails if firms do not pay sufficient attention to organizational culture. Martínez-Caro et al. [103] show empirically that what they call "digital organizational culture" affects business digitization ("the changes digital technologies can bring about in a company's business model") and thus organizational performance. In the field of operations and supply chain management, Ghafoori et al. [26] empirically demonstrate that data-driven DT is positively influenced by developmental (adhocracy), group (clan), and rational (market) cultures.

Building on prior studies, the four cultural types conceivably can be potentially linked, to varying extents, to digital technology use, digital strategy, and digital skills, the three pillars of digital transforming capability. First, organizational culture is generally seen as a critical antecedent to the success or failure of IT/IS adoption [e.g. 84,104]. In particular, empirical studies demonstrate that specific cultural types are related to various IT/IS adoptions. For example, in the context of marketing information processing, a clan culture dominates the other three types in predicting organizational information processes, because the latter are seen as "people processes," relying on such core values as participation, teamwork, and cohesiveness [105, p.318], which are crucial in the seizing and transforming steps. Firms with a strong adhocracy culture that fosters risk-taking are more likely to sense (and thus adopt) new technologies, such as e-business, compared to those with a hierarchy culture that rests on "internally oriented and formalized values" [57, p.56]. Adhocracy and hierarchy cultures have a positive and negative effect, respectively, on e-commerce adoption, whereas clan and market cultures have no effect [58].

Second, prior studies indicate the four cultural types are associated with organizational strategy; for example, "different culture types provide the norms for behavior that are essential to the successful execution of different strategy types" [63, p.239]. Adhocracy and clan cultures greatly improve a firm's market responsiveness, which is a firm-level strategic action [65], and firm performance is significantly affected by the fit between organizational culture (a hybrid of the four cultural types) and product market strategy [64].

Third, there is also evidence to suggest that the four cultural types could be associated with employee skills. Ogbeibu et al. [66] suggest that employees' creativity skills are affected positively by adhocracy culture, which helps organizations develop an entrepreneurial and creative workforce, are affected negatively by market and clan cultures, and not at all by hierarchy culture. Therefore, the four cultural types are likely to relate to digital transforming capability, albeit to different degrees of effectiveness owing to the different values offered by each.

3.1.1. Linking adhocracy culture to digital transforming capability

Adhocracy culture prioritizes innovative outputs, transformation, and agility; it tends to stimulate organizational innovation [16,33], risk-taking strategies to use digital technologies [16,102], and employee creativity [66]. Thus, an adhocracy culture is likely to have a strong effect on an organization's digital transforming capability. Specifically, this culture's innovative and risk-taking nature allows the organization to rapidly form its digital strategy in response to emerging technologies and market trends; to foster a learning environment in which employees are encouraged to develop new digital skills essential for leveraging disruptive digital technologies; and to support the early adoption and innovative application of emerging technologies, thereby driving the DT initiative forward. For example, Kopalle et al. [106] empirically demonstrate the significant role of an adhocracy culture in supporting legacy firms in developing new digital strategies for embracing the digital ecosystem via a digital customer orientation. Other firms emphasizing an innovation-oriented culture include Alibaba and Google, which continuously experiment with new digital products and services, thereby maintaining a dynamic and innovative edge in the market [56,107].

3.1.2. Linking clan culture to digital transforming capability

Clan culture's special relevance to digital transforming capability is its emphasis on human resource development [33,34], which will encourage organizations to leverage internal communication and collective decision making to develop digital strategies that are widely supported across the entire organization [26]. Its focus on teamwork encourages continuous learning and proficiency in using digital technologies through peer support and knowledge sharing [16]. Its collaborative values facilitate the integration of digital technologies to enhance teamwork and streamline processes [16], thereby ensuring cohesive and effective DT. Organizations with a strong clan culture, such as Southwest Airlines, prioritize collaborative tools and platforms that enhance employee engagement and operational efficiency [108].

3.1.3. Linking market culture to digital transforming capability

The core values of market culture, namely competitiveness and productivity [34], are also conducive to digital transforming capability. This culture tends to drive the alignment of digital strategies with market demands, ensuring that digital initiatives are targeted at gaining competitive advantages [16,26]. The competitive nature of market culture motivates employees to develop digital skills to enhance performance. Focusing on results and customer satisfaction, this culture encourages the adoption of digital technologies to improve operational efficiency and customer engagement through, for example, performing digital experimentation, gaining competitive intelligence, and making data-driven decisions [16,26]. One example of a firm with a market culture is Amazon [109], which continuously optimizes its digital platforms to enhance customer experience and maintain market leadership.

3.1.4. Linking hierarchy culture to digital transforming capability

Finally, organizations with a hierarchy culture emphasizing the core values of efficiency, timeliness, consistency, and uniformity [34], exemplified by such firms as McDonald's and UPS [16], can help develop digital strategies to ensure consistency and control, facilitating the systematic implementation of digital initiatives; support the development of digital skills through formal training and standardized processes; and leverage digital technologies to enhance and standardize such business processes as monitoring, control, data security, and data assurance. Conversely, a strong hierarchy culture can hinder the development or adoption of a new digital strategy and technologies. For instance, Kodak, once a giant in photography, had a hierarchy culture

resistant to the adoption of a digital mindset, disruptive technologies such as digital photography (even though it was pioneered by Kodak), and in turn digital innovation, resulting in significant workforce reduction, market share loss, and ultimately, bankruptcy [110]. On balance, we believe that a hierarchy culture needs to be present in a supporting role for an organization pursuing DT to leverage digital technologies effectively. This supplementary culture can facilitate "internal maintenance with a need for stability and control" [34, p.67] while ensuring that the organization's innovation potential, guided by a digital strategy and enabled by digital technologies, is not stifled. Thus, we propose the following hypotheses:

H1: Adhocracy culture (**H1a**), clan culture (**H1b**), market culture (**H1c**), and hierarchy culture (**H1d**) are, in decreasing order of influence, positively related to digital transforming capability.

3.2. Linking digital transforming capability and product innovation

Although prior studies have shown that new product newness and meaningfulness are directly associated with new product performance [92,111] or organizational performance [39,112], there are few studies on the direct impact of DT on product innovation. Conceptually, Lokuge et al. [101] and Hund et al. [113] indicate that digital technologies facilitate organizational innovations, whereas Gaglio et al. [114], based on a survey, find that digital communication technologies have a positive effect on product and process innovations in micro and small South African manufacturing firms. However, Usai et al. [99] indicate that digital technologies have almost no direct impact on innovation performance. Soto Setzke et al. [115] show that different configurations of DT strategies can lead to both successful and unsuccessful digital service innovation.

Focusing on new product newness, Blichfeldt and Faullant [35] show empirically that digital technology use can lead to radical product and service innovation in the process industries. Garcia and Calantone [116], based on a literature review, indicate that technology plays an important role in new product newness. They argue that radical innovations "embody a new technology that results in a new market infrastructure" and "cause discontinuities on the firm and customer level" (p.120), thereby creating new customer demand. Additionally, they find anecdotal evidence indicating that radical innovation needs the support of development strategies. Concerning new product meaningfulness, Deng et al. [117], based on a survey, show that it can be facilitated by the application of core technologies to solve problems to meet customer needs. Yet Wang, Gongtai et al. [42] suggest that research on digital product innovation places insufficient emphasis on the significance of product meaning.

Scholars have suggested that more research is needed to understand the relationship between digital technology use and innovation management [6,36,41,99] because the effects of digital technology use on new products and new service innovations remain unclear [35,100]. We believe this lack of clarity stems in part from the fact that digital technology use is only one pillar of digital transforming capability. It is notable that other studies that have taken a broader approach to DT, such as that of Benitez et al. [1] on the effect of digital leadership capability, have found a positive impact on innovation.

Based on this discussion, it is plausible that digital transforming capability is likely to enhance an organization's ability to integrate digital technologies into its product development processes, leading to more innovative and competitive products. Specifically, and most importantly, a clear and well-defined digital strategy will allow an organization to enhance its product newness by aligning its innovation goals with emerging market trends and customer needs, thereby prioritizing digital initiatives that can lead to the development of new products or significant enhancements to existing products [19,118]. A digital strategy can ensure that new products not only are innovative, but also "offer personalized products and services" [118, p.50] or resonate with customers by addressing real needs and delivering superior value [13,118], through integrating customer insights into the product development process [119,120]. By setting clear objectives and performance metrics, a digital strategy ensures that new products achieve desired outcomes, such as digital innovation [121], market penetration, customer satisfaction, and financial returns [122].

Second, employees with advanced digital skills are more capable of leveraging new technologies [123] and methodologies to create innovative new products [124,125] that are highly relevant and meaningful to the target audience. Skilled employees can better understand and interpret customer needs [126], thereby enhancing product development processes, reducing time to market, and improving overall product quality, leading to better performance [127,128].

Third, cutting-edge digital technologies such as artificial intelligence and blockchain can drive the restructuring of entire innovation processes [129] and provide a foundation for entirely new product categories or significant enhancements to existing products, driving innovation [130,131]. Additionally, digital technologies enable the collection and analysis of vast amounts of data, providing deep insights into customer preferences and behaviors. This can ensure that new products are not only innovative, but also deeply aligned with what customers value [132], thereby leading to superior product and process innovation performance [99,133] and creating competitive advantage [134].

When digital strategy, skills, and technology use are integrated to create a digital transforming capability, this capability can lead to breakthrough innovations (product newness), innovations that are not only technologically advanced, but also deeply aligned with customer needs and preferences (meaningfulness), and that are developed efficiently, meet high-quality standards, and achieve desired market performance [102]. Thus, this capability is likely to enhance new product newness and meaningfulness directly, which in turn affects new product performance. At the same time, this capability also is likely to influence new product performance directly, as the latter could be affected by factors other than product newness and meaningfulness, such as a firm's workforce time agility and task agility (skills) [95], IT usage [135], strategic orientation [136], and technological capabilities [97,98]. Thus, we propose the following hypotheses:

H2: Digital transforming capability positively affects new product performance.

H3: New product meaningfulness positively mediates the relationship between digital transforming capability and new product performance.

H4: New product newness positively mediates the relationship between digital transforming capability and new product performance.

Fig. 2 shows the complete research model.

4. Research methodology

4.1. Measurement

To ensure the validity of the measurement scales for the constructs included in our research model, whenever possible we selected indicators that have been validated by prior studies. We used six items to measure each of the four types of organizational culture, taken from Scaliza et al. [61]. We measured digital transforming capability as a self-developed higher-order formative construct defined by three lower-order reflective constructs: digital strategy, measured using five items modified from Kane et al. [20]; digital skills, measured using three items modified from Benitez et al. [1] and Mikalef and Gupta [137]; and digital technology use, measured by three items modified from Wiesböck et al. [77]. We measured new product meaningfulness by adopting four items from Kim et al. [138] and Im and Workman Jr [90] and measured new product newness by adopting three items from Droge et al. [139] and Frishammar and Sven Åke [140]. Finally, we measured new product performance using four items taken from Story et al. [141]. Appendix A lists the constructs and their indicators.

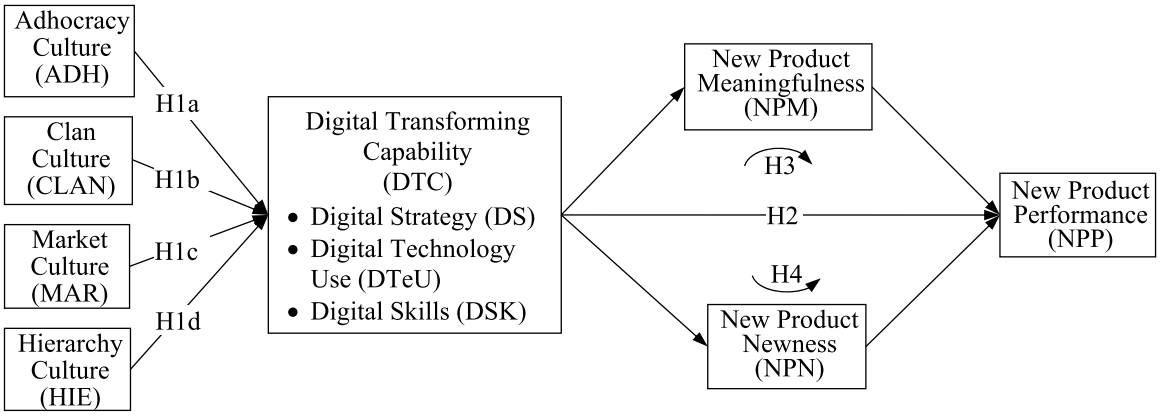

Fig. 2. The key constructs and their hypothesized relationships.

4.2. Sample and data collection

Based on the research model illustrated in Fig. 2, we developed a questionnaire survey, using a 5-point Likert scale to measure all items. The survey encompassed several dimensions, including respondent and company profiles, organizational culture, DT, and product innovation. To ensure the clarity and accuracy of the survey, as well as the relevance, comprehensiveness, and mutual exclusivity of the response options, we conducted a pretest. This pretest involved seven firm managers from the US, who resembled the actual survey respondents, and three academic subject experts. This pretest led to several minor adjustments, including improvements in formatting and presentation, as well as modifications to the questions. For instance, we revised a more formal and technical question—"Overall, we have formulated an exhaustive strategic framework to harness digital technologies for the comprehensive transformation and optimization of business processes"—into a more direct and accessible question—"Overall, we have a comprehensive strategy to use digital technologies to transform the business."

Data collection was done using a single key informant approach, as recommended by Bagozzi et al. [142], targeting middle and senior firm managers in the US. These individuals were selected because of their likely expertise in DT and new product development. We engaged a professional data collection service firm to gather data from April 6 to June 7, 2022. Following Dillman's Total Design Method [143], the survey was accompanied by a personalized cover letter explaining the study's purpose and significance, an assurance of anonymity, and detailed instructions. Additionally, respondents were offered a summary report of the study findings.

Given the difficulty of deriving probability samples even under the best possible conditions, we collected nonprobability samples that could yield dependable outcomes similar to those attained with probability samples [144]. To ensure that the research model was adequately developed and tested, a sufficient number of responses must be collected to build an adequate model. Following the suggestion made by Hair, Joseph F. et al. [145], the 250 responses met the minimum sample size of 191 required for detecting the lowest R^2 value of 0.15 at $p < 0.001$, where the greatest number of arrows pointing at a construct is 4.

4.3. Respondents

Appendix 2 summarizes the respondents' demographic characteristics. Some 60% of the respondents had 5 years' tenure or longer, and roughly 53% of respondents were in a senior position, giving adequate experience and knowledge to answer the survey questions. In terms of firm size, 30.8% of the respondents were from firms with fewer than 50 employees, 28.8% were from firms with 50 to 249 employees, and 40.4% were from firms with 250 or more employees. This distribution of respondents across firm sizes seemed to underrepresent respondents from small and medium-sized enterprises, which account for 99% of all companies, and to overrepresent respondents from larger firms. This could have resulted in responses more closely reflecting the practices of larger firms compared to smaller firms. As for industry sectors, 12% of the respondents were from manufacturing, 21.2% were from the technology sector, 14.8% were from professional services, and 13.6% were from retail/wholesale. The representation of industry sectors seems diverse but with a notable underrepresentation of certain sectors, such as professional services (28%[1]), manufacturing (17%*), and retail/wholesale (15.6%*). Regarding the nature of businesses, 26% of respondents were from firms conducting B2B activities, 38.4% were from firms conducting B2C activities, and 35.6% were from firms conducting both B2B and B2C activities. This distribution could have introduced bias based on the differing dynamics of these business models, potentially leading to the results being more reflective of B2C firms because of their greater representation and to overlooking nuances unique to B2B firms.

4.4. Common method bias

Before data collection, we used the recommended procedural methods [146,147], such as defining questions clearly, assuring anonymity, and separating questions from constructs, with the aim of reducing common method bias. After data collection, we checked the potential issues of common method bias by examining the eigenvalues of the sample [148] and performing the partial correlation procedure [149], using managers' tenure as a marker variable because theoretically it is not associated with the research constructs. The results of our analysis suggest an absence of serious common method bias, as the largest eigenvalue of the sample was 30.59%, below the suggested threshold of 40% [148], and the correlation matrix condensed in Appendix 4 indicates that tenure was not significantly related to the other constructs, while the zero-order and partial correlations were consistent.

5. Results

We tested our hypotheses using variance-based partial least squares structural equation modeling (PLS-SEM), as implemented in the SmartPLS 4 software. PLS-SEM is suggested to be appropriate for exploratory theory building [150,151], complex research models [152,153], and/or when formative constructs are used [154]. Our research model includes higher- and lower-order constructs, as well as formative and reflective constructs, and seeks to examine novel relationships among organizational culture, digital transforming capability, and

[1] The statistics were collected from https://axiomalpha.com/biggest-industry-sectors-in-the-usa-by-revenue-and-number-of-businesses/

product innovation. Thus, PLS-SEM is appropriate for empirically testing our research model.

5.1. Measurement model

Four indicators were dropped as their loadings were low: HIE3, HIE6, MAR2, and NPM4. Although seven loadings from the sample were below the expected threshold of 0.7, the scores of each construct's composite reliability and average variance extracted (AVE) met the recommended thresholds of 0.7 and 0.5, respectively (Appendix 3). The Cronbach's alpha values for new product newness and meaningfulness also were below the recommended 0.7, but their composite reliability values were satisfactory at 0.72 and 0.79, respectively. As suggested by Hair et al. [155], composite reliability is a more suitable measure because it takes into account the different weights of the indicators, whereas Cronbach's alpha assumes equal weighting for all indicators. Thus, construct reliability is supported.

Convergent and discriminant validity also are supported, because the square root of AVE of each reflective construct was greater than the correlations with other constructs (Appendix 4), and the scores of the heterotrait–monotrait ratio of correlations (HTMT) (Appendix 5) were below the recommended strong threshold of 0.85 [156].

We evaluated the formative measurement model in terms of indicator collinearity, indicator weights, significance of weights, and indicator loadings [145,154]. There was no collinearity issue because the variance inflation factor (VIF) values of all indicators were below the suggested threshold value of 3.3 [157]. The measurement quality of the formative constructs is further supported by the fact that all the indicator weights and the indicator loadings were significant.

5.2. Structural model

Fig. 3 presents the empirical results of our conceptual model. We followed the suggestions of Hair, Joseph F et al. [154] to evaluate our research model regarding the coefficient of determination (R^2), the predictive relevance, the model's out-of-sample predictive power, the path coefficients (β), and the collinearity of predictor constructs.

The R^2 values of all constructs were statistically significant, ranging from 0.23 to 0.63, suggesting the strong explanatory power of the model. The predictive relevance of the research model was verified by the result of the PLSpredict procedure: only 4 out of the 13 indicators exhibited higher prediction errors compared to the naïve LM benchmark [154].

All standardized path coefficients were significant, supporting all our hypothesized paths in H1 to H4 (Appendix 6) and the strength of our conceptual model. In particular, we examined the two mediation relationships based on bootstrapping (5000 samples), following methodological suggestions [145,158]. The direct effect of digital transforming capability on new product performance was significant (β=0.69, p<0.001). This effect remained significant (β=0.35, p<0.001) when the two mediators were included. Digital transforming capability had a significant indirect effect on new product performance through new product meaningfulness (H3: β=0.22, p<0.001) and new product newness (H4: β=0.11, p<0.001). These results indicate that both new product newness and meaningfulness partially mediate the relationship between digital transforming capability and new product performance. Finally, we assessed the collinearity of predictor constructs. All VIF scores were less than 2.0, below the strong threshold value of 3.3 [157], indicating there were no serious collinearity issues.

5.3. Control variables

To better capture and understand the hypothesized relationships, based on prior innovation studies, we controlled for industry [159], firm size [160], firm age [161], respondent's position and tenure [39], and type of business (B2B, B2C) [162], as these variables can affect a firm's innovation activities and performance. However, none of these variables showed a significant effect on our research model. Their effects on new product performance (NPP) in terms of R^2 change (ΔR^2) were not statistically significant, with ΔR^2 values for NPP of 0.01.

6. Discussion

As discussed in the Results section, all our hypotheses are supported by the empirical data. To answer our first research question, "*What might be an alternative conceptualization of DT that is defined multi-dimensionally*?", we have developed a new DT conceptualization that challenges the previous DT definitions regarding DT predominantly as organizational changes enabled by digital technologies alone [e.g. 3,4,17] and advances our current knowledge. Our DT conceptualization refers to organizational change enabled by the digital transforming capability of integrating digital strategy, digital skills, and digital technology use, underpinned theoretically by DCs generally and by the higher-order capability of DCs particularly [45,46]. Although several studies in passing have suggested that DT is multifaceted [6,10] and that organizational change is enabled by the combined effect of digital properties [17,21], this research has significantly advanced our knowledge from those existing studies by theoretically conceptualizing and empirically

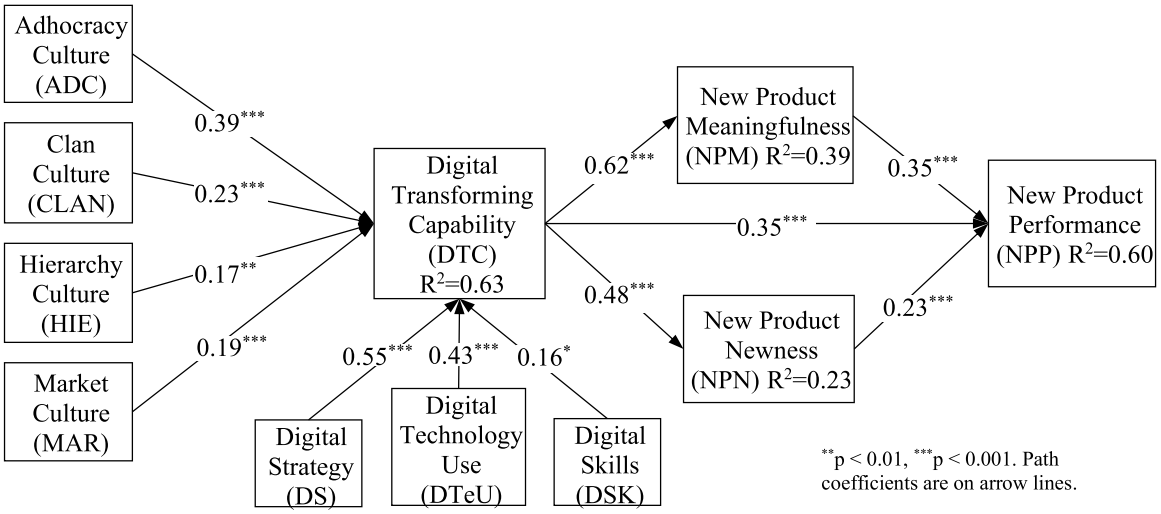

Fig. 3. Empirical results of the conceptual model.

validating DT achieved by a multidimensional digital transforming capability.

Our study is substantially different from the only other study developing a digital transforming capability, reported by Sousa-Zomer et al. [10]. Their capability was defined in terms of people, process, and structure, whereas ours is built on digital strategy, digital skills, and digital technology use, enabling organizations to sense and seize opportunities through transforming digitally. Methodologically, Sousa-Zomer et al. operationalized their digital transforming capability reflectively using people, process, and structure, when arguably it should be defined formatively, because the three constructs are not interchangeable. In contrast, we measured our digital transforming capability formatively based on digital strategy, digital skills, and digital technology use as reflective constructs. We believe this new DT conceptualization, which is largely consistent with the idea suggested by Ciarli et al. [11], can advance our knowledge by offering a more holistic understanding of the DT phenomenon. This allows us to better understand the complex nature of DT and to explain that the effectiveness of DT is determined by the degree of a firm's digital transforming capability. Thus, this study offers a more powerful and comprehensive understanding and explanation of DT phenomena.

We have expanded our understanding of the impact of organizational culture on DT by addressing the second research question, *"How and to what extent does organizational culture affect DT?"* Specifically, our findings from Hypothesis H1 link the four types of organizational culture—adhocracy, clan, market, and hierarchy—to digital transforming capability. All four cultural types were found to positively influence digital transforming capability, although the extent of their impact varies. This nuanced insight moves beyond the traditional views that treat organizational culture as a single, uniform construct.

Although prior research has examined the role of organizational culture in such areas as IT/IS adoption and organizational performance [e.g. 61,101,104], these studies often conceptualized organizational culture monolithically, neglecting the possibility that multiple cultural types can coexist and interact within organizations. Moreover, the specific relationship between organizational culture and DT, particularly its effect on digital transforming capability, has remained underexplored [15,26,29]. Our study challenges these one-size-fits-all frameworks by empirically demonstrating the complex interplay of different cultural types and their distinct roles in shaping DT outcomes.

Unlike earlier studies focusing on individual cultural types in isolated contexts—such as IT adoption [57,105], employee skills [66], or strategy development [65]—our findings align with the work of Gregory et al. [59] and Lee et al. [60], which examined the influence of all four cultural types on U.S. hospital performance. However, we extend this research by offering fresh empirical evidence that highlights how each cultural type distinctly contributes to digital transforming capability, thus advancing the conversation from a firm performance-centric context to the realm of DT.

Furthermore, although previous studies have speculated that DT initiatives are likely to fail without an appropriate organizational culture [e.g. 16,20], others have suggested that different cultural types may have varying effects on organizational performance [e.g. 26,66,105]. Our results reveal a consistent pattern: all four cultural types—adhocracy, clan, market, and hierarchy—positively influence digital transforming capability. Notably, the influence of these cultures varies, with adhocracy having the strongest impact, followed by clan, market, and hierarchy. This suggests that for organizations aiming to achieve successful DT, fostering a dominant adhocracy culture is critical for driving innovation, developing digital strategies, and cultivating the necessary digital skills to leverage disruptive digital technologies. However, the other three cultural types—clan, market, and hierarchy—have essential supporting roles, particularly during the "transform" phase, by helping organizations strike balances between flexibility and control and between internal and external focus [34,47].

These insights significantly expand the existing body of knowledge by offering a more detailed and empirically supported understanding of how and to what extent adhocracy, clan, market, and hierarchy cultures influence DT. Our findings move beyond the traditional, simplistic view of culture's impact and provide a more comprehensive framework for understanding its role in DT.

Additionally, our study challenges the conventional view of organizational culture as a monolithic entity by providing empirical evidence that multiple cultural types can coexist within an organization [31,32]. This finding undermines the applicability of a one-size-fits-all approach to organizational culture, as they overlook the multifaceted nature of culture's influence on DT [26,30]. By highlighting the coexistence and interaction of diverse cultural types, our study provides a more nuanced perspective on how culture shapes DT, suggesting that organizations must cultivate a balanced and diverse range of cultural attributes to fully support their DT efforts.

To answer our third research question, "*How and to what extent does DT affect new product newness and new product meaningfulness, and eventually new product performance*?," our findings demonstrate that digital transforming capability has a significant positive direct impact on new product performance, new product meaningfulness, and new product newness. The effect of digital transforming capability on new product performance also is partially positively mediated by both new product meaningfulness and new product newness. First, our findings show that new product performance is directly affected not only by new product newness and meaningfulness, which is consistent with prior studies [92,111] but also by digital transforming capability. This suggests that new product performance is a complex phenomenon, affected by multiple factors [e.g. 95,97,98]. Next, although some studies have suggest that the use of digital technologies either contributes to [e.g. 35, 39,101] or has almost no direct impact on innovation performance [99], most mainly examined only the effect of digital technology use on innovation. Our findings are conceptually different and more useful because we have explored how the integrated multidimensional digital transforming capability, directly and indirectly, contributes to new product performance. Moreover, our findings demonstrate a high explanatory power (R^2=0.60) for the effect of digital transforming capability on new product performance.

Finally, this study is among the first to examine the significance of product newness and meaningfulness in the DT context [42]. More specifically, although previous studies have suggested that new product newness and meaningfulness are each directly associated with new product performance [92,111], this study has advanced the current research by demonstrating that product newness and meaningfulness each positively mediates the impact of digital transforming capability on new product performance. Importantly, our findings also suggest that a product's meaningfulness is more important than newness in this research context. This can be compared with the findings of Im and Workman [90] suggesting that of the two factors, only new product meaningfulness leads to improved performance.

7. Theoretical and practical implications

7.1. Theoretical implications

Primarily, this study offers a more holistic understanding of the DT phenomenon by theorizing the relationships among organizational culture, digital transforming capability, and new product innovation from an integrated digital transforming capability perspective. Using the theory of DCs in general and the higher-order capability of DCs in particular [45,46], we have developed a new multidimensional conceptualization of DT. This conceptualization is based on the digital transforming capability of integrating digital strategy, digital skills, and digital technology use, which could have general applicability to firms. Although the extant literature recognizes that conceptualizing DT is complex, present understanding is fragmented [e.g. 72–74], and DT is often defined merely as the impact of digital technologies alone,

neglecting its complexity and multidimensionality.

Thus, we contribute to the literature on DT by extending the perspective of DCs to DT and developing a new digital transforming capability to define DT. This multidimensional approach is distinctive in several ways. First, it more accurately reflects the complexities of DT. By viewing DT through the lens of capability, we highlight the dynamic nature of DT, emphasizing the importance of continuous development and adaptation across these dimensions. Second, our conceptualization shifts and enriches the understanding of DT by framing it as an ongoing, integrative process rather than a static, isolated event. This perspective encourages organizations to adopt a more strategic and comprehensive approach to DT, ensuring that all dimensions are addressed and aligned for maximum impact. Third, our findings suggest that this new conceptualization of DT, in terms of digital transforming capability, can offer a more meaningful understanding and explanation of how firms may achieve their DT goals to improve product innovation. This approach thereby responds to calls for more DT research [6,7,23].

In addition, our study bridges the gap between DT and organizational culture literature, offering a theoretical integration that clarifies how distinct cultural factors support DT initiatives. Although organizational culture has long been recognized as a key influence on DT [3,21], its specific impact remains underdeveloped in the literature [15,26,29]. Our research demonstrates, both conceptually and empirically, that the four cultural types—adhocracy, clan, market, and hierarchy—have positive, yet varying, effects on digital transforming capability. These findings underscore the pivotal role of organizational culture in facilitating DT while also revealing that a firm's ability to transform digitally is shaped by these cultural types in descending order of influence: adhocracy, clan, market, and hierarchy. This hierarchy of impacts suggests that each cultural type, whether dominant or supportive, provides unique norms and values essential for cultivating the digital transforming capability necessary to navigate and succeed in dynamic environments [34,63,64].

Importantly, our analysis highlights the complexity of the organizational culture's impact on DT, demonstrating the need to consider multiple cultural types to fully understand how culture shapes the DT process. This nuanced approach reveals the intricate ways in which a dominant culture (adhocracy) and three supportive cultural types (clan, market, and hierarchy) collectively contribute to digital transforming capability. Such insights go beyond what could be captured by focusing on a single cultural type. By elucidating these specific cultural mechanisms, we contribute to a deeper understanding of how organizational culture can either drive or hinder DT efforts. This adds a critical dimension to the ongoing discourse on the enablers and barriers of DT.

By examining the influence of different organizational culture types, we advance the field's understanding of how cultural dimensions, such as flexibility (adhocracy), collaboration (clan), competitiveness (market), and structure (hierarchy), uniquely shape an organization's digital transforming capability. This provides a more granular and detailed understanding of how the cultural antecedents are critical for successful DT, offering both theoretical insights and practical implications for organizations aiming to tailor their DT strategies to their specific cultural context.

Finally, we demonstrate how digital transforming capability directly impacts product innovation outcomes, offering empirical evidence supporting the strategic importance of cultivating this capability to drive innovation and maintain a competitive advantage. Although digital technologies are seen to provide unprecedented opportunities for product innovation, the effect of digital technology use on new product innovation remains unclear [35,84,100], because such an effect "seems almost unquestioned so far" [99, p.328]. Research on digital product innovation also gives little attention to product meaning [42]. This study is among the first to show empirically that digital transforming capability is positively and directly associated with new product newness, meaningfulness, and performance. Moreover, this study goes one step further to provide fresh empirical evidence demonstrating that new product newness and meaningfulness each positively mediate the relationship between transforming capability and new product performance. This study also shows that in the context of DT, new product meaningfulness is more important than newness in predicting new product performance.

In summary, our research contributes to the literature by challenging existing theoretical frameworks for DT and offering key theoretical implications for DT-related research. Specifically, we have offered new insights into the nature of DT and developed a new DT conceptualization based on a multidimensional digital transforming capability, introduced a multifaceted view of organizational culture's impact on DT, and proposed that digital transforming capability serves as a bridge between cultural attributes and DT outcomes of product newness, meaningfulness, and performance. This perspective offers a more integrated understanding of how cultural, technological, and strategic factors interact to drive successful DT.

7.2. Practical implications

Our findings provide valuable practical implications for organizations striving to maximize the value of digital technologies. Organizations must recognize that DT goes beyond merely using digital technologies. To fully harness the potential of these technologies, a comprehensive digital strategy and the necessary digital skills are essential. Based on our findings, several important steps are recommended, as described here.

7.2.1. Assessing the level of the company's readiness for DT

The company should begin by evaluating its readiness for DT and identifying areas for improvement in terms of digital strategy, digital skills, and digital technology use. A practical example is Siemens [163], the largest industrial manufacturer in Europe, which evaluated its operational readiness by assessing the current state of digital skills, processes, and technologies. By pinpointing strengths and weaknesses, the company can prioritize efforts to address gaps and build on existing competencies.

7.2.2. Developing and communicating a clear digital vision and strategy

Creating and communicating a clear and compelling digital vision is crucial. This vision should articulate the company's long-term goals and how digital technologies will drive business success. To seize the opportunities of DT, an integrated digital strategy should then be developed, aligning with the company's overall business objectives. This includes creating a digital roadmap that outlines key initiatives, timelines, and resource allocations, ensuring that all efforts are strategically coordinated. For example, the chair of Honeywell [164], a diversified manufacturing and technology company, attributed its successful DT to its unified and coherent digital strategy that has been communicated clearly to everyone within the company, focusing on streamlining systems and improving internal and external data and analytics capabilities.

7.2.3. Cultivating a culture of innovation

According to BCG [165], to foster innovation, a company should cultivate a dominant innovation culture, as exemplified by Google's strong culture of innovation, allowing employees in this technology company to spend 20% of their time on projects that interest them, leading to the development of such products as Gmail and Google Maps [166]. However, it is equally important to maintain supporting cultures, including clan (focusing on collaboration and teamwork), hierarchy (emphasizing structure and control), and market (driven by competition and achieving tangible results). This balanced cultural approach ensures flexibility and control, as well as internal and external focus.

7.2.4. Prioritizing digital technology investments

The company should prioritize digital technology investments based

on the digital strategy. This strategic allocation of resources ensures that the most impactful technologies are adopted, providing a strong foundation for DT efforts. This point is underscored by Accenture's recent report, "Reinventing with a digital core," which suggests that professional service companies should invest in, for example, Cloud infrastructure and practices for agility and innovation, data and AI for differentiation, and digital platforms to accelerate growth [167]. Likewise, a McKinsey report [168] indicates that leading service industry firms excel by developing a well-balanced portfolio of fundamental and advanced digital solutions tailored to meet customer needs.

7.2.5. *Investing in digital skill development*

Investment in digital skill development programs is essential to enhance employees' digital competency, as demonstrated by the global digital upskilling initiative of Henkel, a leading manufacturer of consumer and industrial brands, to upskill the entire organization of 53,000 employees worldwide on key future digital capabilities and skills directly linked to its sustainability goals to stay competitive [169]. Continuous learning and upskilling initiatives will equip the workforce with the knowledge and skills needed to effectively leverage digital technologies, thereby driving innovation and operational efficiency.

7.2.6. *Strengthening digital transforming capability*

The company should focus on developing its digital transforming capability to facilitate new product innovation, emphasizing both meaningfulness and newness. However, greater emphasis should be placed on the meaningfulness of new products, to ensure that they meet customer needs and add significant value. This can be demonstrated by the case of GE [170], an American multinational conglomerate, which implemented its DT by developing Predix, a software platform for the Industrial Internet, thereby enabling GE to create new products that added significant value to customers, such as predictive maintenance.

7.2.7. *Using digital transforming capability indicators*

Implementing digital transforming capability indicators provides a valuable toolkit for monitoring the company's progress in DT. These indicators help understand key elements of the digital strategy, digital skills, and digital technology use. By focusing on developing the most relevant capacities, the company can continuously improve and adapt its DT efforts.

By following these steps, companies can ensure that their DT efforts are strategic, skill-based, and effectively integrated across the company. This approach maximizes the potential benefits of digital technologies, driving long-term success and competitive advantage.

7.3. *Limitations and future research*

Our study has several limitations that also offer opportunities and directions for advancing research and practice on DT in the future. First, we focused our effort on examining four specific types of organizational culture as the antecedent of digital transforming capability. Future studies could explore additional cultural dimensions, such as data-driven culture, and their effect on DT outcomes. Furthermore, investigating potential cross-cultural variations in how different organizational culture types influence DT could offer valuable insights. Future studies could also examine the role of leadership, employee engagement, and organizational learning in shaping and sustaining DT, providing a more comprehensive understanding of the enablers of successful DT initiatives. Other antecedents, such as environmental dynamics and entrepreneurial orientation, can be investigated by adapting our conceptual model. Moreover, future studies can investigate potential nonlinear relationships between cultural types and digital transforming capability, as the relative importance of different cultural elements might shift at different stages of digital maturity.

Second, our study examines the impact of DT on new product innovation; its impact on other organizational changes or a broader range of innovation outcomes also can be analyzed based on our new conceptualization of DT, such as process innovation, organizational innovation, incremental versus radical innovation, customer satisfaction, operational efficiency, and market responsiveness.

Third, our data sample has limitations in terms of its representativeness. First, the sample is from the US. Although we believe our model is robust and applicable to different contexts in different countries, additional empirical validation is desirable. Future research could investigate how the relationship between culture, dynamic transforming capability, and product innovation varies across different industries or countries, such as by comparing technology-driven industries with traditional manufacturing sectors. Furthermore, while we acknowledge the sample limitations, a deeper exploration of organizational size and industry characteristics could yield valuable insights. Larger firms may have more resources to develop digital transforming capabilities and drive innovation, whereas smaller firms may face constraints that affect their DT trajectories. Similarly, industry characteristics, such as regulatory environment, competitive intensity, and technological dynamism, could shape the development and impact of digital transforming capability on innovation. Future research could explore how these factors moderate the relationships identified in this study. Additionally, the respondent demographic profile shows the potential issues of over-representation of firm size, industry sectors, and nature in the data sample. This imbalance might affect the generalizability of the findings, as certain industry-specific and business-nature-related factors may not be adequately captured. Therefore, future research should consider using more representative samples to test the research model and enhance its robustness. Investigating how different stages of digital maturity influence firms' DT capabilities and innovation outcomes across industries and firm sizes would also provide meaningful contributions to both research and practice.

Fourth, as a confirmatory study using quantitative methods, this work offers limited in-depth insight into how digital transforming capability is being developed and integrated, and how it is generating a significant positive impact on organizational changes, such as innovation in our study context. Future studies can adopt qualitative methods to provide a more in-depth understanding of digital transforming capability building and its impact from a dynamic process perspective and collect longitudinal data to observe the evolution of this capability and innovation over time or to supplement traditional questionnaire data with big data and machine learning techniques, thereby providing more robust and comprehensive analysis.

Fifth, although our study did not find a significant impact of firm size on product innovation, future research could further investigate if small and medium-sized enterprises might face different challenges and opportunities in DT compared to large corporations, given the likely differences in resources, organizational structures, agility, and digital maturity.

Sixth, and finally, interdisciplinary research also could be conducted to combine insights from information systems, organizational behavior, and strategic management to provide a holistic understanding of DT and innovation. By addressing these future research directions, scholars can build on our findings and contribute to a deeper understanding of the complex interplay between organizational culture, DT, and innovation.

8. Conclusion

This study challenges existing theoretical frameworks of DT by examining the relationships among organizational culture, digital transforming capability, and product innovation. It provides a more holistic view of DT and offers significant theoretical and practical contributions. First, we introduce a new multidimensional conceptualization of DT based on digital transforming capability, integrating digital strategy, digital skills, and digital technology use. This addresses the fragmented understanding of DT and emphasizes its complexity. Our findings suggest this conceptualization better explains how firms

achieve DT and improve product innovation. Second, we bridge the gap between DT and organizational culture literature by demonstrating how different cultural types—adhocracy, clan, market, and hierarchy—impact digital transforming capability. Each cultural type uniquely contributes to DT, enriching the discourses on DT enablers and barriers. Third, we provide empirical evidence that digital transforming capability directly impacts product innovation outcomes. Digital transforming capability is positively associated with new product newness, meaningfulness, and performance, with meaningfulness being more critical in predicting product success.

Our findings also provide several key practical implications for organizations aiming to maximize the value of digital technologies. For successful DT, organizations should foster a dominant adhocracy culture supported by clan, hierarchy, and market cultures to balance flexibility and control. A strong digital transforming capability is essential for driving new product innovation and performance, with a focus on meaningfulness over newness. DT requires a coherent digital strategy and robust digital skills to fully leverage technological potential. The digital transforming capability indicators developed in our research provide a toolkit for assessing and developing key elements of digital strategy, skills, and technology use, helping managers focus on the most relevant capacities for successful DT.

CRediT authorship contribution statement

Guangming Cao: Writing – review & editing, Writing – original draft, Validation, Methodology, Formal analysis, Conceptualization. **Yanqing Duan:** Writing – review & editing, Writing – original draft, Validation, Methodology, Formal analysis, Conceptualization. **John S. Edwards:** Writing – review & editing, Writing – original draft, Validation, Methodology, Formal analysis, Conceptualization.

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.

Supplementary materials

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