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An integrated PLS-SEM model on the interplay of antecedents and moderators driving corporate entrepreneurship activity in South Africa

***Boris Urban*[1], *Thanusha Govender*[2]**

Abstract

PURPOSE: *Corporate entrepreneurship (CE) is a multi-faceted phenomenon, and although there is extant research on CE, there are knowledge gaps that warrant a deeper understanding. Indeed, focusing solely on independent variables overlooks the extent to which CE activities are mutually and reciprocally supportive. We align our article with research calls for theory building, which provides a novel understanding of the dynamic complexity of the CE process.* ***METHODOLOGY:*** *In this regard, we formulate and empirically evaluate an integrated CE model that reflects the integrative complexity of the antecedents driving CEA. The study context is the South African banking sector, where primary data (n = 312) is obtained via a structured survey. Four meta-hypotheses and several sub-hypotheses, reflecting the organizational, individual, and environmental level antecedents, are tested using partial least squares structural equation modeling (PLS-SEM).* ***FINDINGS:*** *The main study finding validates that corporate strategy is the bedrock of CEA. The results also reveal that entrepreneurial strategy, entrepreneurial structure, transformational leadership, organizational resources, and an entrepreneurial mindset are significant predictors of CEA.* ***IMPLICATIONS:*** *Practical implications highlight that it is important for managers to consider the configuration of the predictors within the CE model, which function as pathways to entrepreneurial corporate strategy.* ***ORIGINALITY AND VALUE:*** *Our study makes a unique contribution by developing and testing an integrated and comprehensive model reflecting the dynamic complexity of the antecedents driving CEA. It is anticipated that the results will allow researchers to compare and examine comparable antecedents to CEA and their applicability in global country contexts.*

Keywords: *corporate entrepreneurship, antecedents, entrepreneurial strategy, organizational resources, transformational leadership, entrepreneurial mindset, partial least squares structural equation modelling, PLS-SEM, South Africa.*

INTRODUCTION

The domain of corporate entrepreneurship (CE) has steadily evolved over the last 50 years and is widely viewed as contributing to the advancement of a firm's corporate strategy, enhancing our understanding of the complex and dynamic nature of entrepreneurship within established organizations (Glinyanova et al., 2021; Ireland et al., 2009; Kreiser et al., 2021; Urban, 2021). CE typically varies in firms due to the mix of individual, organizational, and environmental antecedents, which combine together to influence entrepreneurial activity (Kuratko et al., 2014; Lenart-Gansiniec et al., 2023; Weiss et al., 2023). In this regard, scholars have observed that corporate entrepreneurship activity (CEA) is a result of both internal

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and external triggers of organizational change and have designated a 'pro-entrepreneurship organizational architecture' as a crucial element of a CE strategy (Ireland et al., 2009. Kuratko et al., 2014; Suder, 2024; Urbano et al., 2022).

Although extant research is available on CE, there are research gaps that warrant a deeper understanding, particularly as CE has been studied from different fields using diverse theoretical approaches (Kuratko et al., 2021; Urbano et al., 2022). While many studies have identified a spectrum of antecedent sets for CEA, this has mostly been ascertained through isolated research studies underpinned by competing theories and research inconsistencies (Bloodgood et al., 2015). Indeed, as has been noted by scholars, the whole "corporate entrepreneurial ecosystem is materially different from the sum of the atomized parts of which it is constituted off" (Anderson et al., 2012, p. 961). Studying individual elements of CE as independent variables overlooks the extent to which CE activities are mutually and reciprocally supportive (Lampe et al., 2020; Urban, 2021).

Against this backdrop, where much fragmentation limits our understanding of the CE phenomenon, the purpose of our article is to develop an integrated and comprehensive model reflecting the dynamic complexity of the antecedents driving CEA. Secondly, we align our article with research calls for CE theory building, which deepens the academic understanding of the dynamic complexity of the corporate entrepreneurial process (Kreiser et al., 2021; Lenart-Gansiniec et al., 2023; Reyes-Gómez et al., 2024). Following Urbano et al. (2022, p. 545), we adopt a broad definition of CEA formulated as those "firm initiatives that aim at creating and adding new business, or at fostering innovation, change and renewal." In this regard, we assess and predict the relative importance of three sets of antecedents, namely organizational level factors, individual level factors, and environmental level factors, to ascertain the effect of their interrelationships in relation to CEA, using partial least squares structural equation modeling (PLS-SEM).

Past studies have focused on a number of antecedents driving CEA, which include entrepreneurial strategy, entrepreneurial structure, transformational leadership, organizational resources and capabilities, entrepreneurial mindset, entrepreneurial persona, social networks, entrepreneurial culture, entrepreneurial reward practices, environmental dynamism, and hostility (Covin & Slevin, 1991; Crawford & Kreiser, 2015; Glinyanova et al., 2021; Guth & Ginsburg, 1990; Ireland et al., 2009; Kreiser et al., 2021). Leveraging such prior work and relying on different theoretical models, we make a clear contribution by synthesizing and integrating various antecedents of CEA and examining their direct and moderating effects and interactions across individual, organizational, and environmental levels of analyses. This is the first time, to our knowledge, that such an elaborate array of CE predictors have been treated as an interrelated system, and the proposed model is certainly an expanded original formulation.

Our study takes place in South Africa which has one of Africa's most sophisticated economies, yet also has one of the highest inequality rates in the world (Dana et al., 2022; Urban & Townsend, 2021). We agree with researchers who note that Africa remains a fertile ground to test CE theory and has the potential to further theory development in this field of research (Dana et al., 2022; Urban, 2021). We also take note that CE scholars have noted that future research could especially consider the service sector (Urban and Townsend, 2021). Banking and the broader financial services sector play a "crucial role in contributing towards Africa's growth agenda, as the banking industry across Africa is the second fastest growing and most dynamic industry across the continent where it has made significant inroads into the advancement of banking technology, digitization, and innovation" (Urban & Townsend, 2021, p. 5). Moreover, because of COVID-19 it has been cautioned that "African banks cannot afford to leave their performance recovery to chance and if they do, it will inevitably lead to multiple years of returns below the cost of capital" (McKinsey, 2021, p. 6). Consequently, by focusing our study on the South African banking industry sector, it is anticipated that the finalized structural model emerging from our empirical analyses will provide a useful contribution to managers by providing them with a set of reliable and valid predicters, which lays the tracks for the formulation of a successful CEA.

The continuing sections of the article are organized as follows. The next section describes the theoretical background and literature review. The third section refers to the methodology employed to test the hypotheses. Section four displays the results and interprets the statistical findings. Section five discusses the results and integrates the findings with theory. The last section in this article provides a conclusion, offers study implications, and sets out the study limitations and directions for future research.

THEORETICAL BACKGROUND AND LITERATURE REVIEW

The corporate entrepreneurial ecosystem

The overarching theoretical basis for this article was based on the complex dynamic systems theory (Crawford & Kreiser, 2015; Lenart-Gansiniec et al., 2023; Reyes-Gómez et al., 2024), which is leveraged as a framework for conceptualizing antecedents driving CEA (Ireland et al., 2009; Kuratko et al., 2014). Employing this theoretical framework will not only "evaluate dependencies but will equally evaluate interdependencies, as the model is aimed to capture the complexity of social organizational reality and transformational intrapreneurial change" (Kraus et al., 2011, p. 61). Through this theoretical lens, CE is theorized as a multi-dimensional behavioral construct in which the external environment, in the form of dynamism and hostility environmental conditions, triggers intrapreneurial organizational action as a result of employees who have a pro-entrepreneurial disposition, exhibiting entrepreneurial behavior due to the existence of an internal environment conducive to CEA (Glinyanova et al., 2021; Ireland et al., 2009; Kreiser et al., 2021).

The dynamic complex adaptive corporate entrepreneurial ecosystem is made up of three layers, namely, the individual employee layer, the organizational layer, and the environment layer (Lenart-Gansiniec et al., 2023; Urbano et al., 2022). Change induced by the environment, organizational setting, or employee acting as a change agent might result in a wave of change in other parts of the ecosystem. For instance, a recent study demonstrates how through relational interlinks with internal and external stakeholders, firms combine the exploration of new market opportunities with the exploitation of existing core competencies to develop new competitive advantages (Weiss et al., 2023). Consequently, the necessity for an organization to transform depends on the optimal configurational patterns of CE drivers, which can change over time (Anderson et al., 2012; Kraus et al., 2011).

A literature review on the analysis of the antecedents of CEA (Urbano et al., 2022), reveals that at least three distinct types of factors at various levels can influence CE, namely the individual, organizational, and environmental. Within this dynamic complex adaptive corporate entrepreneurial ecosystem, several key frameworks emerge, such as Covin and Selvin's (1991, p.8) work who regard, "firm performance as a function of both organizational, as well as individual level behavior, moderated by the environmental context and operating paradigm of incumbent firms." Some theoretical models, such as Zahra et al. (1999), pursue similar approaches by grouping the antecedent factors at these various levels of analysis. Other scholars, including Guth and Ginsberg (1990) and Kuratko et al. (2014), perceive CE as a result of internal and external organizational change triggers. Ireland et al. (2009, p. 24) delineate a "pro- entrepreneurship organizational architecture as elements of a CE strategy shaped by an entrepreneurial vision and dominant logic". Acknowledging the wide range of research on the antecedents of CEA, we identify and discuss several types of factors at the three observed levels to inform the study hypotheses, namely at the organizational, individual, and environmental levels. See Table 1 for a theoretical domain analysis with core conceptual model deductions and theoretical reasoning provided, which is used in the formulation of the hypotheses.

Table 1. Theoretical domain analysis of the study constructs

Theoretical domain	Core conceptual model deductions	Theoretical rationale
Corporate Entrepreneurship	CEA is regarded as a multi-dimensional behavioral construct, where "firm performance is a function of both organizational, as well as individual level behavior," and is moderated by the environmental context (Covin and Slevin, 1991, p.8)	CE, like other organizational occurrence is best understood as an open system, as it accounts for the "dynamic complexity of corporate entrepreneurship" as a construct (Miller & Friesen, 1982). It is an "adaptative system of interrelated cogs working together to achieve collaborative goals both of the organization and that of the employee where the outputs generated over time is a result of non-linear effects" (Bloodgood et al., 2015, p.384).
Leadership	Given the different perspectives offered across various models, managerial impact across all levels has been included into the conceptual model as managers across all levels play a critical role within the CE process.	Considering the complexity of "getting things done" and the proximity of influence, the leadership construct is more closely aligned vis-a-vis managerial support, and it has been further narrowed down to 'transformational leadership,' which is included as an exogenous construct in the conceptual model given the specific competency profile of transformational leadership in relation to positively motivating entrepreneurship behaviors (Pan et al., 2021; Verma & Mehta, 2020).

Theoretical domain	Core conceptual model deductions	Theoretical rationale
Organizational culture	Organizational culture is included as an exogenous construct in the conceptual model that enables an organization to adapt quickly to constant market shifts and display business response flexibility and market leadership through creativity and innovation (Sarros et al., 2008).	A positive organizational culture drives risk-taking, propensity for innovation, and the continuous search and exploitation of new opportunities based on emerging trends, market dynamics and consumer behavioral patterns (Ireland et al., 2009). The organizational culture can shape the entrepreneurial posture of a business and drive organizational level entrepreneurship.
Organizational strategy	Organizational strategy acts as a primary driver of entrepreneurial behavior and entrepreneurial transformation and is a key construct in the model (Ireland et al., 2009).	Organizational strategy is included as an exogenous construct in the conceptual model as a driving force that initiates the entrepreneurial transformation process (Ireland et al., 2009). Strategy is an organizational-level driver of CE as CEA is delivered through the cohesion amongst the vision and strategic intent of a company, its strategic choices and risk appetite of the incumbent, which is brought to life through the decisions and actions of the leadership of the business and the enduring behaviors of the employees of the organization (Covin and Slevin, 1991; Ireland et al., 2009; Kuratko et al., 2014, Miller, 1983).
Organizational structure	Organizational structure is a critical antecedent of corporate entrepreneurial behavior as it provides employees with a sense of empowerment and allows them to collaborate easily across the organization (Kuratko et al., 2014).	The organizational structure of a company denotes the hard wiring of an organization's ways of working characterized through its facilitation of communication flows throughout the organization, the arrangement of authority and workflow relationships within an incumbent and the allocation of jobs and accountabilities within a company (Covin and Slevin, 1999; Ireland et al., 2009).
Reward	Reward practices are included as an exogenous construct in the conceptual model as reward is pivotal motivational level for employee entrepreneurial behavior.	Reward practices incentivise people to behaviour intrapreneurially, take accountability and ownership (Bloodgood et al., 2015; Kuratko et al., 2014). To exceed an employee's expectation, the reward system must demonstrate effective coverage across pivotal extrinsic and intrinsic effects, thereby motivating entrepreneurial behavior (Kuratko et al., 2014).
Resources	Organizational resources and capabilities act as a crucial pro-organizational architecture construct.	Resource availability is one of the most crucial organizational antecedents and are associated with the firm's overall entrepreneurial orientation and strategy (Kreiser et al., 2021; Urbano et al., 2022).
Entrepreneural mindset	The proposed conceptual model will expand the definition of entrepreneurial cognitions posited within the Ireland et al. (2009) study, to include entrepreneurial metacognitions as defined by the study conducted by Haynie et al. (2010).	An entrepreneurial mindset is highly developed ability cognitions that enable employees to engage in entrepreneurial action. Haynie et al.'s (2010) conceptualization of the entrepreneurial mindset is adopted in terms of categorizing metacognition's five theoretical dimensions, as: (1) goal orientation, (2) metacognitive knowledge, (3) metacognitive experience, (4) metacognitive choice, and (5) monitoring.
Entrepreneurial personality 'persona'	A collection of traits was obtained through an inductive investigation of the commonly measured personality traits in research on entrepreneurs (Kuratko et al., 2021; Salmony & Kobach, 2022).	Even though some CE studies have highlighted an entrepreneur's individual characteristics as a foundational driver of entrepreneurial behavior (Kuratko et al., 2021), research has been inconclusive around the detail on which characteristics form the exact premise for entrepreneurial behavior (Kuratko et al., 2004). The themes that cover most of the main theoretical contributions to the entrepreneurial traits literature, are the study focus area in terms of: Creativity, Self-Efficacy, Locus of control, and Achievement motivation.
Social networks	The inclusion of the social network construct within the conceptual model is based on theory insofar as entrepreneurial behaviors depend on the fit of the underlying social capital resources available at different levels in the organization, which combine into complex social capital configurations (Glaser et al., 2021).	Social networks are pivotal in an organizational system, in which organizational information flows and enables a position of enterprise-wide influence. In the context of CE implementation, it significantly improves access to novel and privileged information, access to funds, sponsorship, and idea buy-in, ultimately increasing entrepreneurial effectiveness and impact (Alder and Kwon, 2002; Nahapiet and Ghoshal, 1998).

Theoretical domain	Core conceptual model deductions	Theoretical rationale
Environmental dynamism and hostility and entrepreneurial growth momentum	As the study conceptual model aims to be a predictive implementation model, understanding the relational influence of a large spectrum of environmental attributes will dilute the targeted contribution this study aims to deliver. Hence, the environmental variables were narrowed down to dynamism and hostility, as they provide both the 'yin and yang' of environmental influence (Choi et al., 2020; Uzkurt et al., 2012; Zahra, 1993). Entrepreneurial momentum refers to an organizational system, processes and beliefs that shape employee behaviors and the decisions and actions within an organization to drive sustainable market growth and outperformance of the market regardless of the market fluctuations and the rapid evolution of market trends (Pan et al., 2021).	Theorists maintain that the relationship between resources and the value of such resources varies according to their environment (Choi et al., 2020). Consequently, many scholars adopt a contingency perspective in organizational studies where environmental impact and involvement have been diagnosed and associated with the performance of organizations across different industries and contexts (e.g., Uzkurt et al. 2012). Equally, since the African banking industry is described as both dynamic and hostile (Urban & Townsend, 2021), these two variables are good descriptors of the environmental context within banking across the African continent. The stimulus-reaction phenomenon between environmental triggers and entrepreneurial momentum can be explained by leveraging retention mechanisms whereby incumbents choose and decode stimuli according to theories of action encrypted by previous strategies, the dominant logic of the company and its DNA. As such, member behavior is constrained by their perception of the "rules of the game" (Kuratko et al., 2004). The current organizational "momentum is a pervasive force" within a firm, and firms evolve and react to external stimuli by continuing to "evolve in the same direction" as dictated by the current organizational inertia. As such, "the transformational trigger provides the impetus to behave entrepreneurially when other conditions are conducive to such behavior" (Kuratko et al., 2004; Pan et al., 2021).

Organizational level antecedents

At the organizational level, for CEA to manifest, firms must develop three foundational elements consisting of an entrepreneurial strategic vision, a pro-entrepreneurship organizational architecture, and entrepreneurial processes and behavior as demonstrated throughout the organization (Ireland et al., 2009; Li et al., 2005). CE strategy is conceptualized as a vision-directed, "organization-wide reliance on entrepreneurial behavior that purposefully and continuously rejuvenates the organization and shapes the scope of its operations through the recognition and exploitation of entrepreneurial opportunity" (Ireland et al., 2009, p. 21). On the other hand, organic structures are inclined to be decentralized organizational designs, with distributed divisions of labor and broader spans of control, which function as an essential catalyst for CEA. Such organic structures provide employees with a sense of empowerment and the room to innovate, fail, grow, and collaborate easily across the organization (Kuratko et al., 2014). Similarly, an effective entrepreneurial culture enables an organization to adapt quickly to constant market shifts, exude market prowess, and display business response flexibility and market leadership through creativity and innovation (Sarros et al., 2008). For instance, an organization with a prevailing entrepreneurial momentum has clear, exacting standards for performance and ambitious growth objectives, which are reinforced through organizational trust that facilitates the discovery of innovative ideas and the creation of new value adding capabilities (Pan et al., 2021).

Recent literature highlights resource availability as one of the most crucial organizational antecedents and explains how governance and ownership systems, access to resources, time availability, and knowledge capabilities are associated with the firm's overall entrepreneurial orientation and strategy (Kreiser et al., 2021; Urbano et al., 2022). Kuratko et al. (2021) further hypothesized that reward frameworks are, in fact, a primary determinant of intrapreneurial behavior of top-level and middle level managers within organizations. In this regard, an important organizational perspective is the different role of managers at different hierarchical levels where the level of influence and impact varies across the various levels of management. Specifically, from a top management team perspective, managers are thought to have multiple and critical roles in CEA, because of central involvement in both corporate venturing and strategic renewal forms of CE (Kuratko et al., 2021). In addition, the widely used 'corporate entrepreneurship climate instrument (CECI)' has shown meaningful relationships in terms of five key organizational areas, namely management support; reward and resource availability, organizational structure, and boundaries, risk-taking, and time availability (Kuratko et al., 2014). Moreover, transformational leaders are able to shape the culture of a firm, by developing empowering opportunities for employees and encouraging shared values while permitting followers themselves to be leaders (Chang et al., 2019; Verma & Mehta, 2020). Research confirms that transformational leaders are a necessary organizational requirement for CEA as they can guide and maneuver ever-changing, uncertain environments while enabling firms to respond to challenges as a workforce collective (Kuratko et al., 2014; Sarros et al., 2008; Urban, 2021). Recognizing that research has converged on a number of organizational antecedents as drivers of CEA and in conjunction with Table 1, the following hypotheses are formulated:

H1: Organizational level antecedents in terms of (a) corporate strategy, (b) distinctive culture archetype, (c) organic operating structure, (d) reward practices, (e) organizational resources, and (f) transformational leadership, positively influence CEA.

Individual level antecedents

At the individual level, literature has drawn attention to personality traits, emotional and cognitive factors, including attitudes, values, and beliefs, as playing a decisive role in initiating and sustaining CE activities (Ireland et al., 2009; Lampe et al., 2020; Sarros et al., 2008). Some researchers have focused on personality traits of entrepreneurs and how they compare to other groups in this regard (Kerr et al., 2018), while others have examined the role of capabilities, and entrepreneurial cognition in CE related issues (Kuratko et al., 2014; Urbano et al., 2022). In established disciplines such as psychology, the convergence in personality theory has led to an overarching five factor model of personality (Salmony & Kobach, 2022). This robust model has caused a resurgence of interest in personality traits and their effects on individual behaviors and performance in various occupational settings, including CE (Kuratko et al., 2021). Prior research on entrepreneurial behavior, attitudes, and predispositions is fairly substantial, where efforts to develop a persona of entrepreneurs include the following attributes which are at the forefront of discussions of entrepreneurial persona, namely creativity, self-efficacy, locus of control, and achievement motivation (for a systematic review see, Salmony & Kobach, 2022).

Moreover, prior studies report that the employee value drivers of CE relate to entrepreneurial persona and entrepreneurial mindset (Kuratko et al., 2004; Kuratko et al., 2021). Kuratko et al. (2021, p.133) conceptualize CE as an "environment where the entrepreneurial mindset of individuals is sought after, supported, and nurtured for the purpose of carrying out innovative activities". We extend this conceptualization further by locating the entrepreneurial mindset within the broader cognitive science domain, specifically within metacognitive theory (Haynie et al. 2010). Haynie et al. (2010, p. 217) describe the entrepreneurial mindset as "metacognitive processing or thinking patterns, where the underpinnings of a mindset are deep-seated in higher-order mental processing that enable the entrepreneur to think beyond or reorganize existing knowledge structures and heuristics, promoting adaptable cognitions in the face of novel and uncertain decision contexts". For the purpose of our study, we follow Haynie et al.'s (2010) operationalization of the entrepreneurial mindset in terms of categorizing metacognition's five theoretical dimensions as: (1) goal orientation, (2) metacognitive knowledge, (3) metacognitive experience, (4) metacognitive choice, and (5) monitoring.

Another crucial factor driving CE is social networking, where extensive literature highlights the importance of networks to entrepreneurs as it allows access to opportunities and important resources (e.g., Chang et al., 2019). Social networking is constituted of various elements such as the structural element of the network, the relational strength of the network, as well as the resources that would be made available through the network (Gedajlovic et al., 2013). Particularly important for CEA are 'social network theories of innovation,' which explore the link between social network capital and organizational innovation (Alder and Kwon, 2002; Glaser et al., 2021). Increasing research on the social networking-organizational innovation link has advanced beyond examining tangible forms of capital (human and financial), to examining the importance of 'social ingredients,' or intangible forms of social capital such as the relational strength of the network, and the cognition or perception of the individual in the network relationship (Alder and Kwon, 2002; Chang et al., 2019; Gedajlovic et al., 2013; Glaser et al., 2021). Consequently, in recognizing the centrality of the entrepreneurial persona, the entrepreneurial mindset, and networks in fostering CEA, we formulate hypotheses for these variables, in conjunction with the theoretical rational provided in Table 1.

H2: Individual level antecedents in terms of (a) entrepreneurial persona relating to creativity, self-efficacy, locus of control, achievement motivation, and the (b) the entrepreneurial mindset relating to goal orientation, metacognitive knowledge, metacognitive experience, metacognitive choice, and monitoring, positively influence CEA.

Environment level antecedents

At the environment level of analysis, most studies focus on antecedents relating to industry-level variables such as the degree of market dynamism, hostility, and heterogeneity (Zahra, 1993; Zahra et al., 1999). Prior research has shown that the external environmental factors are capable of affecting the failure and success of firms and can serve both as opportunities as well as challenges to firms (Choi et al. 2020). According to Covin and Slevin (1991, p. 11), the "external environmental forces of dynamism and hostility, has a deterministic influence on the existence and effectiveness of entrepreneurial activity," thus concluding that the external environment and the entrepreneurial process are intertwined. We rely on the environmental dimensions of dynamism and hostility, which are consistent with earlier research and theory building on the nexus between entrepreneurship and the environment, predominantly as these two dimensions have in the past shown modest correlations (Zahra, 1993), signifying that unique aspects of the environment are captured with each dimension.

Research shows that dynamism relates to unpredictable and rapid change, which has the probability to cause uncertainty for firms who operate in such environments, while hostile environments are categorized by heightened competition and environments which stifle the exploitation of opportunity (Uzkurt et al., 2012). The impact of environmental dynamism and hostility has been studied in several different industries and contexts, including CE leadership and top management team capability, new product development, and exporting strategy (Uzkurt et al., 2012). In terms of CEA some researchers find that competitive intensity positively influences innovations "as more than half of product and technological innovations emerge in response to competitive, market or other environmental pressures" (Uzkurt et al., 2012, p. 18). Zahra (1993) posited that even though the environmental context plays a crucial role in CE, the relationship between environmental antecedent variables and CEA is not necessarily a linear relationship. Hence, we consider that dynamism and hostility will also have a positive moderating influence on CEA when firms have an underlying growth momentum or orientation. The notion of entrepreneurial momentum or growth orientation relates to the firm's adaptability to environmental shifts and shocks, which requires balancing trade-offs to unlock the innovative potential within the firm while simultaneously removing any of the firm constraints (Pan et al., 2021). This compels the firm and employees to tightly manage the incongruous tensions of effectively running its core business and delivering value while being malleable to augment the core business with capabilities and solutions based on an evolving opportunity set shaped by the rapidly changing environmental context (Pan et al., 2021). An organisation with a prevailing entrepreneurial momentum has clear, high standards for performance and ambitious growth objectives for the business. This cascades into stretch and go-getting goals for all employees, which are supported by enabling processes and organizational systems. Hence, the entrepreneurial momentum of a firm enables exponential growth, which is fuelled by innovation, market prowess, and a greater risk appetite for change (Pan et al., 2021). Arguably, the entrepreneurial momentum of a firm accounts for the heterogeneity in the different research findings in terms of environmental hostility and dynamism, which do not always negatively influence CEA, but rather, the direction of that relationship differs depending on the existing entrepreneurial momentum within an organization. Indeed, in dynamic environments within which levels of demand change promptly, opportunities become more ample, and innovations should increase (Pan et al., 2021; Urbano et al., 2022).

H3: The relationship between environment level antecedents in terms of (a) dynamism and, (b) hostility and CEA will be positively moderated by (c) entrepreneurial momentum

H4: The relationship between individual level antecedents, organizational level antecedents and CEA will be positively moderated by environment level antecedents in terms of (a) dynamism and, (b) hostility and (c) entrepreneurial momentum.

Study model

Based on the literature review and relying on the dynamic complex adaptive corporate entrepreneurial ecosystem theory, four hypotheses and subsequent sub-hypotheses were formulated reflecting the organizational, individual, and environmental levels relevant to CEA. All of the hypothesized relationships are illustrated in Figure 1, and their theoretical rationale is explained in Table 1. In Figure 1, the various antecedents at the different levels of analyses may be viewed as a set of interrelated processes that together describe CEA. This perspective reflects the underlying complex dynamic systems theoretical framework of our study where an effective CE ecosystem requires adaptation in terms of the various levels of analyses. As such, the organizational antecedents of CEA were narrowed down to entrepreneurial strategy, entrepreneurial culture, transformational leadership, reward practices, organizational structure, and organizational resources. The individual antecedents of CEA were narrowed down to entrepreneurial persona, network ties, and entrepreneurial mindset. Lastly, the environmental antecedents of CEA were steered towards the external environmental forces of dynamism and hostility, and entrepreneurial momentum. As per the pathways in Figure 1, all the various antecedents at the different levels of analyses represent the causal chain of CEA and are best viewed as an iterative process. While the selection of the antecedents in the formation of the hypotheses is by no means all-inclusive, it is recognized that numerous individual, organizational and environmental antecedents directly or indirectly influence how CEA is established and moderated at the firm level, and that no single set of antecedents can explicitly determine the outcome of the dynamic complex process of CEA (Kraus et al., 2011; Urban, 2021).

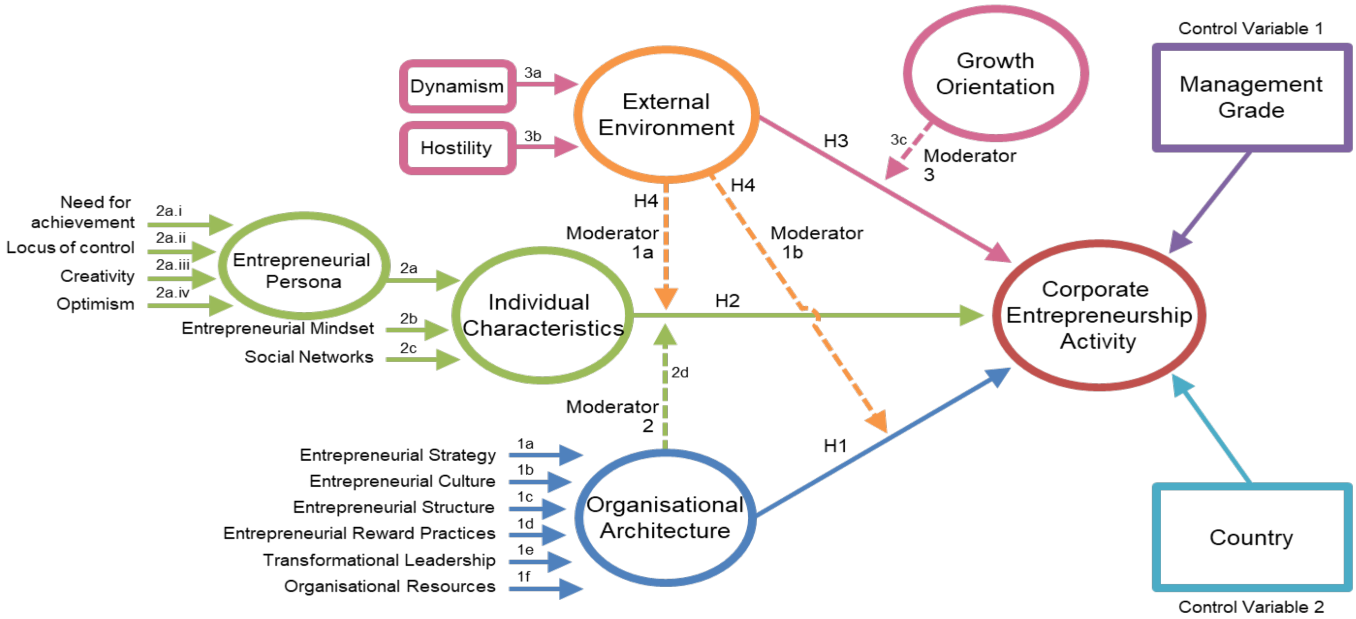

Figure 1. Study model showing hypotheses

RESEARCH DESIGN

Sampling and data collection

We assessed our theoretical model by collecting survey data from various levels of management located at different banks in South Africa. The rationale for focusing on the banking sector is that it has become urgent for banks to become more adaptable and innovative, particularly with the move to technologically enabled banking solutions (Urban & Townsend, 2021). To ascertain the population dataset, the total number of banks in South Africa, including local branches of foreign banks, was established using data obtained from the South African Reserve Bank (SARB, 2019). This analysis concluded that the study population is a total of 19 Banks in South Africa, where, according to the South African Reserve Bank's Prudential Authority, "the banking sector is dominated by five large banks, which collectively hold 90.5 percent of the total banking sector assets as of 31 March 2019" (SARB, 2019, p. 182). These 'big five' banks, representing the total population dataset, have more than 10,000 employees and are headquartered in South Africa (SARB, 2019). We choose to target managers of units in the various banks to gather the data to test our hypotheses.

Following the Protection of Information Act (POPI Act) of the Republic of South Africa, the privacy and anonymity of participants are rigorously protected, making access to potential respondents extremely difficult to access. All participants in the sampling frame were assigned a random number via an online survey that could be accessed via a Qualtrics webpage link. We sent follow-up reminders to complete the survey between 2 and 4 weeks after the initial invitation. We kept track of how many invitations to complete the questionnaire were sent out, and our received sample of n=312 from 1170 invitations represented a 18.1% response. This procedure culminated in responses from various managerial grades across the total population dataset, and the sample included (a) employees that are decision-makers within the organization regarding CEA, and (b) hold an average span of control of 10 employees per manager. In this regard, academics have acknowledged the role that management at multiple levels plays in achieving a CE activities (Brown et al., 2001; Ireland et al., 2003; Kuratko et al., 2014; Weiss et al., 2023).

Furthermore, the sample size was verified using the" partial least squares structured equation modeling (PLS-SEM) heuristic statistical tests to identify the minimum number of respondents required, namely the '10 times' PLS-SEM analytic heuristic and the power analyses tests" (Hair et al., 2017). The minimum sample size was calculated at 156, which was considered a fair representation (one percent of the target population) to enable robust data modeling and analysis. As the study was based on voluntary participation, an over-sampling factor of 100 percent was applied to the target sample size, thus increasing the sample size to 312 to account for non-responses. During the data collection phase, the rights and protection of all respondents were upheld to ensure ethical practices were maintained. Participation was purely on a voluntary basis, whereby consent was obtained from all respondents, and anonymity was ensured at all stages of the research process, with no biometric data or personally identifiable data captured or recorded.

Sample characteristics reveal that the profile of managerial levels amongst the sample of respondents showed that the majority of respondents were part of the senior management cohort (66%), followed by middle management (18%), and then as team leader (16%). Initially, we intended to use country as an additional control variable to consider the effect of the bank's footprint in Africa via their foreign branches, but due to the 99 percent skewness of the data, towards South Africa, this parameter was dropped as a control variable.

Measurement of constructs

Existing measurement scales were used to collect responses. All measures were operationalized based on the theoretical discussions in the literature (the full instrument is available). The survey questionnaire was designed so that participants could not complete the next survey without completing the preceding one. Prior instruments were employed using the Likert scale and Bipolar scale formats. Annexure A identifies all the study variables as per the study model, with columns indicating primary and secondary latent measurement constructs, the research scale, scale type and sources as well as previously established reliability of the scales.

Consistent with previous CE studies, control variables focused on various levels of management, where there is a theoretical basis for expecting these variables to have a relationship with either the IVs or DV, or both. See Annexure A.

Data analyses

PLS-SEM can be used successfully to test complex models where other approaches would fail due to the high number of relationships, constructs, and indicators (Alexandre et al., 2009). The model was employed which is a Type 1 model of a reflective-reflective higher order latent variable model, whereby a disjoint two-stage approach was adopted to estimate the measurement and structural parameters of the high order constructs within the model leveraging SMART PLS 3, as a software package. As such, the measurement (outer) model was analysed in three tiers, namely a) first order construct, stage 1, b) second order construct, stage 2 and c) third order construct, stage 2, whereby a battery of diagnostic tests pertaining to reliability, multi-collinearity and validity were systematically tested for each construct within each tier of the model for inclusion into the confirmed structural model that informs the finalized path model (Hair et al. 2017). A model fit analysis was conducted to ascertain the fit of the structural model for theory examination of CEA. The finalized path model was assessed based on the relevance of the path coefficient and significance of the hypothesized path relationships by employing the bootstrapping technique, which together served as a proxy of the empirical model's predication capabilities (Hair et al. 2017).

Common method variance was controlled for which can bias results when relationships between variables captured from one single source are examined, a concern in our study (Podsakoff & Organ, 1986). To minimize such bias, the research instrument was carefully crafted to separate each latent variable scale from one another. Equally, social desirability and consistency motif method biases were controlled by ensuring the anonymity of respondents throughout the research cycle. Furthermore, bias was mitigated by evaluating the construct validity of the measurement model using confirmatory factor analysis (CFA), discussed in the following section. Two statistical tests confirmed that the data set does not exhibit common method bias, firstly, convergent validity was established, and secondly, no first order correlations were greater than 0.70, which is significantly below the threshold of 0.90 (Podsakoff & Organ, 1986). Moreover, since our model specification was quite complex, respondents could not have anticipated the results. As mentioned, we ensured the confidentiality of data collected and communicated this clearly to our respondents by encouraging them to answer the questions honestly.

RESULTS

Measurement model assessment

Descriptive statistics were calculated where the mean scores and standard deviations revealed a uniform spread around the construct's average score and the standard deviation parameters of the first order constructs are within the range of 0-2, representative of the variation in responses away from the construct's average score. Pearson's correlation was applied to both the measurement model and the structural model, to determine and eliminate highly correlated manifest and latent variables (Hair et al., 2017). Correlation coefficients for the respective constructs, were positively but mostly moderately correlated with each other, for instance: Reward and CEA ($r = 0.38$; $p < .05$), while Strategy and CEA showed a larger correlation coefficient ($r = 0.50$; $p < .01$) (See annexure B).

Taking into consideration the scale makeup of all latent variables (Annexure A) and as illustrated in the empirical model, Figure 1, a reflective measurement model is represented. The accuracy of the measurement model is improved through the utilization of multi-item scales for each latent construct, which has been employed to epitomize the varied aspects of the construct, thereby significantly reducing the measurement errors of the latent constructs, due to casual effects of the latent variable that have been omitted from the model (Hair et al., 2017).

The use of PLS-SEM, as a specific category of SEM, was leveraged to holistically evaluate the plausibility of our study model. Due to the complexity of the hypothesized model, it was "operationalized at a higher level of abstraction, thus creating a hierarchical component model (HCM)," that incorporated 22 first order latent constructs, four second order latent constructs, and two third order latent constructs. Based on the relationship between the higher-order components and the lower-order components, the measurement model was a reflective-reflective HCM (Hair et al., 2017). Since the model had third order constructs, stage 1 included one layer, namely the first order model, and stage 2 included two layers, namely the second order and third order models. Hence, a three-tier analysis was undertaken, and the effect of each layer of analysis was statistically validated to determine which layer functioned as a significant value driver of CEA. Both the outer (measurement) and inner (structural) models were subjected to reliability, validity, and collinearity testing, respectively (Hair et al., 2017). See Table 2 for third-order model results.

Convergent validity for indicator variables is established when the 'outer loadings of the indicator variable is statistically significant and greater than 0.70, thus equalling an indicator reliability that is greater than 0.50, whereas the convergent validity on the construct level is tested by examining the 'average variance extracted (AVE) and validity is established when the AVE values for each measured construct is greater than 0.50 (Hair et al., 2017). Based on the initial AVE analysis across the first order latent variables, the following indicator variables were deleted from the measurement model as their AVE scores were less than 0.50: A04, A06, A08, A10, LC06, C07, MK03, MK06, MK09, MK10, M04. Moreover, the elimination of specific items was required due to poor loadings on the extracted components as per the initial factor loading analysis. As a result, several latent constructs from the higher order construct level were removed as the factor loadings were significantly below the minimum threshold. Figure 2 shows the measurement model Stage 3 impact illustration of these poor loadings. Nonetheless, the final AVE scores across the first order latent variables, see Table 2 were all greater than the minimum threshold of 0.50, which is an acceptable threshold to conclude convergent validity, as indicator variables scores converge to assess the underlying latent construct (Hair et al., 2017).

A tri-modal discriminant validity approach was employed. The outer-loadings of the construct were evaluated to determine whether the measurements are larger than any of its cross-loadings. The Fornell-Larcker criterion was employed whereby the square root of each construct's AVE should be greater than its highest correlation with any other construct, and finally, the Heterotrait-Monotrait ratio (HTMT) of the associations was examined whereby, "the true correlation between latent constructs is determined based on the notion that they are perfectly reliable. Validity is established if the HTMT confidence interval does not include 1 (Hair et al., 2017, p.116). The cross-loading analysis for indicator variables were observed to be less than its outer loadings, and thus, discriminant validity was established based on the cross-loadings assessment (Hair et al., 2017).

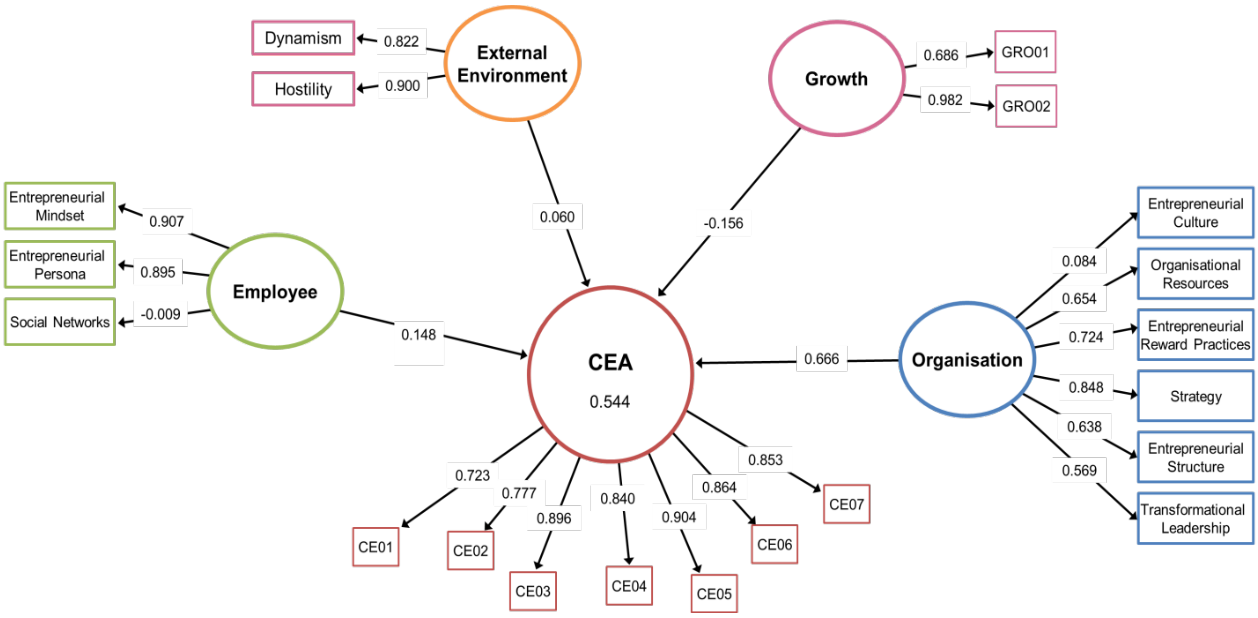

Figure 2. Measurement model Stage 3 impact illustration

An assessment of the square root of AVE scores across all first order latent constructs, denotes values that are larger than its association with other first order latent constructs, thus discriminant validity is established based on the Fornell and Larcker (1981) principle. The HTMT ratio for first order latent constructs was observed to be less than 0.7, which is significantly below the maximum threshold of 0.9, thus, discriminant validity was established based on the HTMT ratio criterion (Fornell & Larcker, 1981). The standardized root mean square residual (SRMR) assessment was used to determine the model fit as it is deemed as an absolute measure of fit that is defined as the root mean square discrepancy between the observed correlations and the model-implied correlations. Analyzing the model fit data, see Table 3, the structured model exhibits a good fit as both the saturated and estimated model were less than 0.10 (Hair et al., 2017).

In terms of reliability, the 'Composite Reliability (CR)' method was employed, considering some of the shortcomings existing on Alpha values when utilizing PLS-SEM (Hair et al., 2017). A lower bound score of 0.7 (on a scale from 0 to 1) was required to ascertain acceptable levels of reliability of a composite variable. The final CR scores across the third order latent variables, remained within the range of 0.71 and 0.94, which stood at an acceptable threshold to conclude internal consistency reliability, see Table 2 (Hair et al., 2017). In summary, as shown in Table 2, the findings demonstrate that measurement models satisfy all the minimum criteria.

Table 2. Confirmatory factor analysis results for third-order latent constructs

Model Index Fit	Acceptable threshold	CEA	Organisational	Individual	Environment	Growth
χ^2/df	<=3.00	1.77	1.81	1.91	1.21	0.96
RMSEA	<=0.08	0.06	0.03	0.05	0.06	0.00
IFI	>=0.90	1.00	1.00	1.00	1.00	1.00
TLI	>=0.90	0.99	0.99	1.00	0.99	1.09
CFI	>=0.90	1.00	1.00	1.00	1.00	1.00
SRMS	<=0.10	0.01	0.05	0.05	0.03	0.02
Average Variance Extracted (AVE)	>=0.50	0.63	0.58	0.83	0.51	0.53
Composite Reliability	>=0.70	0.91	0.82	0.91	0.71	0.89
Cronbach Alpha	>=0.50	0.90	0.73	0.80	0.73	0.89

Structural model and hypotheses testing

Similar to the measurement model, the structural model was assessed for collinearity. The collinearity of predictor variables was assessed by calculating the tolerance (TOL) values and the variance inflation factors (VIF) of the predictor variables. If the TOL values are greater than 0.20 and the VIF values are less than 5, the predictor variables will not exhibit any high levels of collinearity. If high levels of collinearity are presented, strategies of creating higher-order constructs, eliminating, or merging indicators will be considered (Hair et al., 2017). To test for collinearity within the structural model, every group of predictor latent construct for each component part of the structural model was analyzed. Based on the VIF analysis (not shown, but available), all predictor variables contained within the inner structural model have a VIF score of less than 5 (range from 2.124 to 1.502), indicating no multi-collinearity issues (Hair et al., 2017).

The relationships within each sub-component part of the structural model represented the hypothesized relationships among the constructs, as displayed in Figure 3. The results of the relationships within each sub-component part of the structural model are reflected in Table 3 to Table 5, which represent the hypothesized relationships among the exogenous constructs and endogenous constructs. The two-tailed bootstrapping testing approach was applied to evaluate the significance of the path coefficients. The evaluation of the relationships between constructs was conducted using the path coefficients (β), p-values (≤ 0.05), and t-values (threshold of 1.96). Bootstrapping confidence intervals were examined to provide supplementary evidence "on the stability of the path coefficients (Hair et al., 2017).

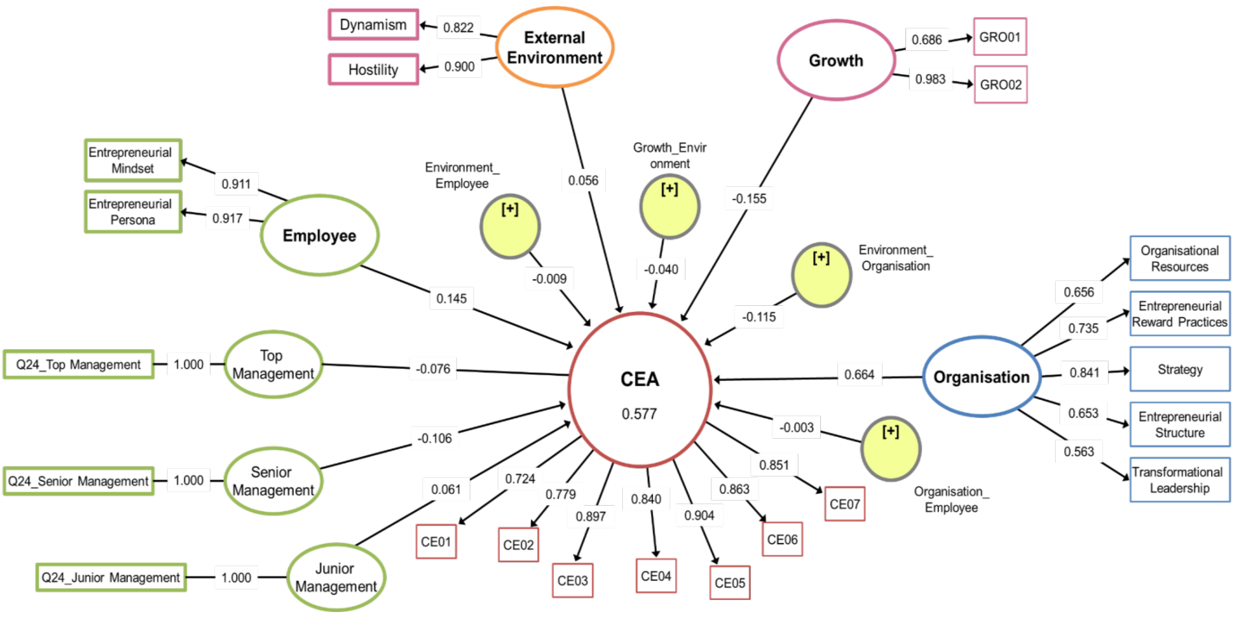

Figure 3. Final structural model

Table 3 shows the path coefficients, which are significant for the relationship between employee and CEA, organization and CEA, and growth orientation and CEA. For H1, the statistical analysis concluded that the path coefficient between organizational-level antecedent constructs and CEA was 0.66, which was statistically significant at $p < 0.01$. The quantum of the path coefficient is evidence of a direct positive, large linear association and exhibits a significantly large effect (0.82) on CEA within the modeled ecosystem; thus, it is a critical predictor of CEA. It is notable that the size of the path coefficient for the significant hypothesized relationship between organization and CEA is an important positive linear relationship within the ecosystem model, whereby its association is large (0.664). Moreover, the size of the path coefficient for the significant hypothesized relationship between growth and CEA is a negative linear relationship that warrants attention within the ecosystem model, even though its association is small (-0.155). H2 results were found to be significant, albeit the quantum of the path coefficient (0.15) demonstrates a small effect (0.04) on CEA.

Table 3. Path coefficients and significance levels of the outer structural model

Path relationship	Path coefficient	2.5%	97.5%	p-values	t-value
Employee to CEA	0.145	0.026	0.254	0.012	2.514**
Environment to CEA	0.056	-0.046	0.174	0.312	1.012
Organisation to CEA	0.664	0.560	0.776	0.000	12.013***
Growth to CEA	-0.155	-0.140	0.078	0.020	2.326**
Management to CEA	0.061	-0.077	0.199	0.384	0.871
Senior management to CEA	-0.106	-0.257	0.056	0.180	1.341
Top management to CEA	-0.076	-0.198	0.063	0.251	1.149

Note: *p<0.10, **p<0.05, ***p<0.01.

Table 4 shows the path coefficients, for which there are no significant path coefficients within the first order structural model. Table 5 shows the path coefficients, which signify the hypothesized relationships within the second order structural model, and which are significant for the relationship between entrepreneurial mindset and CEA, transformational leadership and CEA, strategy and CEA, entrepreneurial structure, and CEA and, organizational resources to CEA. It is observed that the size of the path coefficient for the significant hypothesized relationship between strategy and CEA is an important positive linear relationship within the ecosystem model, whereby its association is moderate to large (0.427). A summary of the path-analyses results, as per the hypotheses, are available in Annexure C.

Table 4. Path coefficients and significance levels of the first order, inner structural model

Path relationship	Path coefficient	2.5%	97.5%	p-values	t-value
Achievement to CEA	0.065	-0.089	0.202	0.376	0.885
Locus of control to CEA	0.003	-0.136	0.161	0.963	0.046
Creativity to CEA	-0.068	-0.190	0.088	0.334	0.967
Optimism to CEA	0.027	-0.126	0.187	0.727	0.349
Dynamism to CEA	-0.011	-0.137	0.131	0.872	0.162
Hostility to CEA	0.072	-0.055	0.193	0.247	1.157

Note: *p<0.10, **p<0.05, ***p<0.01.

Table 5. Path coefficients and significance levels of the second order, inner structural model

Path relationship	Path coefficient	2.5%	97.5%	p-values	t-value
Entrepreneurial persona to CEA	0.007	-0.143	0.143	0.919	0.101
Entrepreneurial mindset to CEA	0.149	0.035	0.297	0.025	2.249**
Social networks to CEA	-0.059	-0.163	0.074	0.321	0.993
Transformational leadership to CEA	0.147	0.035	0.259	0.011	2.541**
Strategy to CEA	0.427	0.302	0.556	0.000	6.606***
Entrepreneurial culture to CEA	-0.126	-0.252	0.108	0.170	1.373
Entrepreneurial structure to CEA	0.175	0.044	0.307	0.009	2.623***
Entrepreneurial reward practices to CEA	0.035	-0.102	0.159	0.591	0.537
Organizational resources to CEA	0.144	0.034	0.260	0.013	2.492**

Note: *p<0.10, **p<0.05, ***p<0.01.

The theoretical model, illustrated in Figure 1, shows the moderator hypothesized relationships (H4), while Table 6 summarizes the moderation analysis results. The relevant moderator is included in the path model by the inclusion of an interaction term variable, i.e. moderator x exogenous variable. In keeping with the overall estimation approach, i.e. disjoint two-stage methodology for the path model, the two-stage moderation approach was adopted, which enhances the ability of the path model to establish moderation significance (Hair et al., 2017). Table 6 shows that the interaction term of 'Environment x Employee' was non-significant; hence, there is no evidence that the proposed moderator variable, environment, has any effect on the relationship between the Employee and CEA. While the interaction between

'Environment x Organisation' shows an effect size of the interaction term greater than 0.025, which is evident of a large effect on CEA, the interaction was non-significant. The interaction 'Organization x Employee exhibits a non significant moderation influence; whereby the effect size of the interaction term is 0.000, which indicates that there is no evidence that the proposed moderator variable, organization, has any effect on the relationship between the Employee and CEA. Similarly, the effect size of the interaction term 'Growth x Environment' was non-significant; hence, there is no evidence that the proposed moderator variable has any significant effect on CEA.

Table 6. Summary of moderation analysis

Hypotheses	Interaction term	Strength (Path coefficient)	Significance (t-value)	f2	Supported
H3c: Moderator 3	Growth X Environment	-0.040	0.730	0.004	No moderation effect
H4a: Moderator 1a	Environment X Individual Employee	-0.009	0.151	0.000	No moderation effect
H4b: Moderator 1b	Environment X Organization	-0.115	1.758	0.030*	No moderation effect

Note: *p<0.10, **p<0.05, ***p<0.01.

Recognizing that researchers should routinely consider the assessment of the predictive power of their PLS path models (Shmueli et al., 2019), the empirical model's predictive power was determined by its R^2 value and was symbolic of the combined effects of all the exogenous latent constructs on the endogenous latent construct, CEA. The endogenous latent construct, CEA, had a R^2 value of 0.577. The R^2_{adj} is 0.548, which compensated for adding several non-significant exogenous constructs within the model, which included the external environment, entrepreneurial persona, achievement, locus of control, creativity, self-efficacy, dynamism, hostility, entrepreneurial reward practices, entrepreneurial culture, and social networks. The difference between the R^2 value and R^2_{adj} value was not pronounced enough to warrant dropping any additional predictor variables (Hair et al., 2017). The Q^2 score for the model was greater than 0; hence, the explanatory predictor constructs displayed predictive relevance for CEA (Hair et al., 2017).

The main finding from this study validates that an entrepreneurial corporate strategy is the bedrock of CEA. Its singular effect on CEA is five times larger than any other predictor within the corporate entrepreneurial ecosystem (f^2=0.24), see Annexure B. Employee enablement of the corporate entrepreneurial strategy occurs via the decisions and behaviors of transformational leaders (f^2=0.04) and the entrepreneurial mindset (f^2=0.03) of employees to develop initiatives and formulate strategic plans that enable the delivery of the CEA. The execution of the corporate entrepreneurial strategy occurs via the implementation of an organic organizational structure (f^2=0.05) and the deployment of novel resource recipes (f^2=0.03) to build new capabilities and adjacent capabilities to a firm's core offering. The collective effect, see Figure 4, of the spectrum of predictor variables included within the CE model resulted in a 58 percent explanation of the variation in CEA, which was deemed as showing moderate to substantial predictive power (Hair et al., 2017). The latent exogenous constructs of employee and growth had a small effect on CEA, whereas the organization layer within a corporate ecosystem has a significantly large effect on CEA. The latent exogenous constructs of entrepreneurial mindset, transformational leadership, entrepreneurial structure, and organizational resources, all had a small effect on CEA, whereas an organization's strategy orientation had a medium to large effect on CEA. In summary, the optimal configuration of the antecedents in driving CEA activity is illustrated in Figure 4.

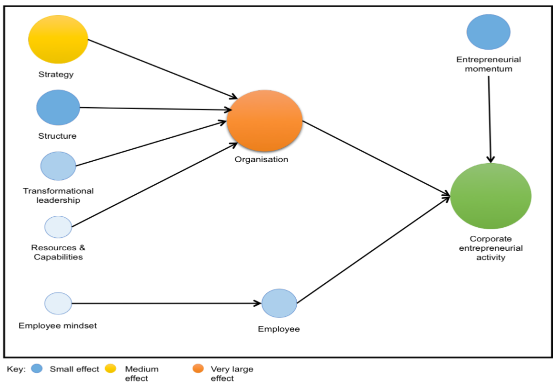

Figure 4. Model illustration of effects of antecedents toward driving CEA

DISCUSSION

Recognizing that researching individual antecedents of CEA ignores the extent to which CE activities are mutually and reciprocally supportive, a comprehensive CE ecosystem model was framed by delineating core relationships through a structured diagnostic of pattern fits that were empirically validated to be primary value drivers of CEA. H1 was partially supported insofar as the existence of a pro-organizational corporate ecosystem characterized by a firm's organizational level antecedent variables of corporate strategy, structure, transformational leadership, and organizational resources all positively influence the extent of CEA. Moreover, a direct positive, moderate to large linear association between entrepreneurial strategy and CEA was observed and as such, this finding aligns with the theoretical proposition theorized by Guth and Ginsberg (1990) and Ireland et al. (2009), whereby CE is enabled through the development and adoption of a corporate entrepreneurial strategy that is consistent with the strategic intent and vision of the firm. This relationship holds particularly true in the CE domain of strategic renewal, involving the transformation of large incumbent companies, as CEA, from approval to resource investment and trade-offs does not happen organically but rather it is driven intentionally by the top management team through the endorsement of a CE strategy. This suggests that entrepreneurial strategy acts as a pivotal value driver of CEA within a corporate entrepreneurial ecosystem framework. Similarly, the positive influence of transformational leadership on CEA was observed from the results. This finding concurs with the principle that transformational leaders are visionary and serve as inspirational motivators within organizations (Pan et al., 2021). These leaders are able to derive higher levels of motivation, empowerment, shared commitment, and performance from employees via their leadership, which acts as an important antecedent to driving CEA.

On the other hand, culture as an antecedent in our model did not significantly influence the degree of CEA. Culture is by nature an organizational driver that unlocks performance value over the medium to long-term (Sarros et al., 2008). Hence, it is plausible that as a cross-sectional study, the results may not have captured a realistic portrayal of how respondents could have reached a point of maturity where they would have been expected to exhibit a deep homogenous cultural pattern with respect to CEA. Similarly, reward practices did not significantly influence the degree of CEA. This finding reflects the mixed research findings in relation to reward practices, which could also be a result of the organizational context (Urban & Townsend, 2021). Given that the banking industry was surveyed and as respondents are governed by a stringent set of regulatory standards, the relevance of reward frameworks in CEA under such conditions could have been compromised. Plausibly there is a lack of performance-based rewards systems in the African banking sector, which, in turn, discourages CEA.

H2, in terms of the extent to which an employee's antecedent qualities of a pro-entrepreneurial cognitive, personality and motivational disposition and network ties are positively related to CEA, was only partially supported insofar as the entrepreneurial mindset was found to be a significant driver of CEA. Hypothesis 2b entailed the evaluation of the impact of an entrepreneurial mindset in driving CEA, which encapsulates an individual's metacognitions and thinking paradigm as a robust precursor of individual level entrepreneurial behavior (Kuratko et al., 2021). Thus, our article contributes to the study of higher-order cognitive processes where a metacognitively aware individual would engage in the process of identifying alternative strategies that maximize the likelihood of achieving his/her goal (Haynie et al., 2010), which in this case, would mean executing the most appropriate strategic drivers to CEA.

Notwithstanding the positive and significant result obtained for the employee's entrepreneurial mindset in relation to influencing the degree of CEA, the employee's antecedent qualities of a pro-entrepreneurial personality, motivational disposition and network ties were found to be non-significant. While previous studies show how pro-entrepreneurial cognitive, personality and motivational disposition enable an individual to navigate the entrepreneurial process, the rigid organizational structure of many large banking institutions with related issues of red-tape, organizational boundaries, and lack of management support may stifle individual personality and motivational disposition making them less predisposed toward CEA.

In terms of H3 and H4, which predicted the extent to which the macro environment, shaped by the intensity of dynamism and hostility within banking environments, influences CEA, it was established through empirical data that H3 and H4 cannot be supported insofar as environmental dynamism and hostility do not play a direct or moderating significant role in CEA in the banking industry in South Africa. Moreover, in terms of H3c, based on the two-stage statistical approach in relation to the moderation analysis, the casual relationship between an underlying growth orientation momentum and CEA was deemed to have a significant weak to moderate relationship. These findings are not altogether surprising given the environmental nuances with respect to the South Africa context where, similar to many countries in Africa, the banking industry is plagued with deep levels of continued market uncertainty, depressed economic conditions, societal and political instabilities, and weakened institutional structures. Perhaps, as prior studies suggest, during such extreme conditions, leaders manage business risk by shifting their priorities towards business survival as a single-minded goal for their firm, thus focusing on effectively running their core business under unprecedented market conditions and not investing in growth and transformation (Pan et al. 2021; Suder, 2024). It is worth remembering that banking institutions are highly regulated companies with a primary focus on managing business risk and thus, a more conservative business approach is applied during times of market instability and uncertainty. Thus, incumbent banks manage market risk uncertainty by maintaining stable business models and acting more cautiously, resulting in them choosing to strategically conserve resources rather than competitively respond by investing in innovation and new business models (Urban & Townsend, 2021). It must also be borne in mind that the influence of the macro environment context in driving CEA in developed countries compared to emerging economies is moderated by less fiscal support and fewer business safety nets in emerging economies, which seems to influence leadership responses in a different manner, making them more risk averse (Dana et al.,2022).

CONCLUSION

Recognizing that prior studies focused on individual elements of CE as independent variables overlook the level to which CE activities are mutually and reciprocally supportive, our study makes a unique contribution by developing and testing an integrated and comprehensive model reflecting the dynamic complexity of the antecedents driving CEA. We have extended the current theoretical domain of CE by predicting and assessing the relative importance of three sets of antecedents to CEA, namely organizational factors, individual level factors and environmental factors, to ascertain the effect of their interrelationships and interdependencies. Based on the study results and from the array of hypothesized predictors of CEA, it was entrepreneurial strategy, entrepreneurial structure, transformational leadership, organizational resources and capabilities, and an entrepreneurial mindset that were proven to be significant predictors of CEA within a corporate South African banking ecosystem.

Contribution

An important contribution of our article has been that through empirical testing, the validity and reliability of different antecedents to CEA have now been established in an under-examined African context, allowing for their theoretical and empirical reach to be advanced. Since mainstream management theories mostly describe the North American and European contexts and are subsequently not always relevant to emerging market environment, without modifications, it is anticipated that the results will allow researchers to compare and examine antecedents to CEA and its applicability in similar country contexts.

Our findings provide a better contextual understanding of CE as well, where South Africa, despite its emerging market status, has a progressive financial services and banking sector, which compares positively with those of industrialized countries (Urban & Townsend, 2021). Such understanding of the leading role of strategy in CEA is highly relevant when considering the entry of Fintech players coupled with intense rivalry, which has subsequently changed the financial services and banking landscape into a more dynamic and competitive industry. Such transformation is further being intensified by digitally driven transformation, threatening the long-term survival of traditional banks. It is an imperative for managers to embrace strategic renewal and the creation of new business models to optimize current revenue streams and create new revenue streams (McKinsey, 2021). The banking industry will need to cultivate and secure a coherent CE strategy and develop entrepreneurial skills and competencies to remain competitive under these circumstances.

Implications

The practical implications of our study highlight that an entrepreneurial corporate strategy is at the center of a corporate entrepreneurial ecosystem. In fact, its singular effect on CEA is circa five times larger than any other predictor within the modeled corporate entrepreneurial ecosystem. Moreover, it is important for managers to consider the configuration of the predictors within the CE model, which function as pathways to entrepreneurial corporate strategy. They need to pay attention to employee enablement via their transformational leadership behaviour and cultivate an entrepreneurial mindset, allowing employees to develop initiatives and formulate strategic plans that enable the delivery of the corporate entrepreneurial strategy. The execution of the corporate entrepreneurial strategy is also only possible through an organic organizational structure and the deployment of novel resources to build new capabilities and adjacent capabilities to enhance a firms' CE activities. Our study has important implications for organizational leaders and management who can better understand which enablers are useful to manage, leading to the CEA. Managers are advised to grow their organizational knowledge regarding which enablers, as delineated in this article, offer the best pathway towards the development of a more robust CE framework.

Limitations and future research

Study limitations relate to the nature of the cross-sectional design, where a longitudinal study would provide more clarity on whether enduring antecedents influence the CEA in the long term. Sampling was also a challenge; due to the absence of sampling frames, no claim of representativeness to the entire sector can be made, and as non-random sampling was used, this may challenge the generalizability of the findings. Future research could evaluate the antecedents to CEA across diverse types of sub-context organizational environments to isolate the predictors of intrapreneurial behavior within the CE ecosystem. Moreover, supplementing the measures used in this study with additional macro-level variables – pertinent to an African context – could also help explain CEA. In this regard future research could potentially leverage institutional theory to determine to what extent the regulatory and normative environments influence CEA in an African emerging market context.

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Annexure A. Study construct measures, scales, sources, and prior reliabilities scores reported

Latent measurement construct	Scale type	Research scale source and prior reliability scores
Entrepreneurial Strategy	Seven-point Likert scale [Very untrue of me to Very true of me]	Entrepreneurial strategy-making scale (Miller, 1983 & Covin and Slevin, 1991), Cronbach alpha of 0.75 (Li et al., 2005)
Entrepreneurial Culture	Bipolar rating scale along a 10-point continuum scale	Entrepreneurial Culture: Stevenson scale (Brown et al., 2001): Cronbach alpha of 0.68 (Brown et al., 2001)
Entrepreneurial Structure	Bipolar rating scale along a 10-point continuum scale	Structure: Stevenson Scale (Brown et al., 2001): Cronbach alpha of 0.78 (Brown et al., 2001)
Entrepreneurial Reward	Bipolar rating scale along a 10-point continuum scale	Reward Philosophy: Stevenson scale (Brown et al., 2001): Cronbach alpha of 0.68 (Brown et al., 2001)
Organizational Resources	Bipolar rating scale along a 10-point continuum scale	Resource Orientation: Stevenson scale (Brown et al., 2001): Cronbach alpha of 0.68 (Brown et al., 2001)
Transformational Leadership: Inspirational motivation Intellectual stimulation Individual consideration	Seven-point Likert scale [Never to Every time]	Transformational Leadership (TL): Multifactor Leadership Questionnaire (Bass et al., 2003): Cronbach alpha of 0.81 (Bass et al., 2003)
Entrepreneurial Employee Mindset: Goal orientation Metacognitive knowledge Metacognitive experience Metacognitive choice Monitoring	Seven-point Likert scale [Very untrue of me to Very true of me]	Entrepreneurial Mindset (EM): MAC (Haynie et al., 2010): Cronbach alpha of 0.885 across all 5 dimensions (Haynie et al., 2010)
Entrepreneurial Employee Persona: Creativity; Self-Efficacy Locus of control Achievement	Seven-point Likert scale [Very untrue of me to Very true of me]	Creativity scale (Tierney et al., 1999): Cronbach alpha of 0.96 (Tierney et al., 1999) General Self-efficacy scale (Chen et al., 2001): Cronbach alpha of 0.82 (Chen et al., 2001) Self-monitoring scale (McShane & Von Glinow, 2003): Cronbach alpha of 0.72 (Hmieleski and Corbett, 2006) Achievement Motivation (McClelland, 1965). Cronbach alpha of 0.78 (McShane & Von Glinow, 2003).
Social Networking	Seven-point Likert scale [Strongly disagree to Strongly agree]	Social Capital: Social Networks (Nahapiet and Ghoshal, 1998): Cronbach alpha of 0.86 (Nahapiet and Ghoshal, 1998)
Entrepreneurial momentum: Growth Orientation	Bipolar rating scale along a 10-point continuum scale	Growth Orientation: Stevenson scale (Brown et al., 2001; Pan et al., 2021): Cronbach alpha of 0.71 (Brown et al., 2001)
Dynamism	Seven-point Likert scale [Strongly disagree to Strongly agree]	Environmental Dynamism (Uzkurt et al., 2012; Zahra, 1993). Cronbach alpha of 0.72 (Zahra, 1993)
Hostility	Seven-point Likert scale [Strongly disagree to Strongly agree]	Environmental Hostility (Uzkurt et al., 2012; Zahra, 1993). Cronbach alpha of 0.72 (Zahra, 1993)
CEA	Seven-point Likert scale [Very untrue of me to Very true of me]	CE Index (Miller and Friesen, 1982): Cronbach alpha of 0.75 (Zahra & Covin, 1995)

Annexure B. Correlation matrix

Latent Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. CEA	1																					
2. EEP: ACH	0.12	1																				
3. EEP: LOC	-0.03	-0.04	1																			
4. EEP: CRT	0.16**	0.45***	-0.24***	1																		
5. EEP: SE	0.19**	0.42***	-0.24***	0.59***	1																	
6. EEM: GO	0.16**	0.50***	-0.28***	0.46***	0.46***	1																
7. EEM: MK	0.20***	0.40***	-0.10	0.34***	0.45***	0.46***	1															
8. EEM: ME	0.06	0.47***	-0.20***	0.51***	0.54***	0.56***	0.51***	1														
9. EEM: MC	0.23***	0.45***	-0.03	0.36***	0.41***	0.55***	0.56***	0.47***	1													
10. EEM: MT	0.19**	0.43***	-0.12	0.51***	0.49***	0.59***	0.66***	0.65***	0.64***	1												
11. SN	-0.02	0.11	-0.16**	0.16**	0.18**	0.08	0.15**	0.13*	0.00	0.14*	1											
12. ESTRAT	0.50***	0.19***	-0.09	0.20***	0.21***	0.14*	0.16**	0.09	0.15*	0.16**	0.15**	1										
13. ECULT	-0.14*	-0.03	0.10	-0.10	-0.13*	-0.12	-0.15**	-0.11	-0.00	-0.07	-0.07	-0.05	1									
14. ESRT	0.38***	-0.09	0.05	-0.02	-0.04	-0.08	-0.04	-0.09	0.01	-0.00	0.06	0.27***	0.28***	1								
15. ERWRD	0.38***	-0.06	0.02	0.08	0.15*	0.01	-0.01	0.00	0.04	0.00	0.13*	0.39***	0.21***	0.52***	1							
16. ORG RS	0.18**	0.09	-0.07	0.09	0.12	0.00	-0.03	0.11	0.04	0.05	0.04	0.26***	0.24***	0.13*	0.22**	1						
17. TL:IM	0.38***	0.05	-0.16**	0.13*	0.08	-0.09	0.10	0.00	0.01	0.00	-0.09	0.39***	-0.10	0.15**	0.18**	0.11	1					
18. TL: IST	0.32***	-0.00	-0.19**	0.26***	0.14*	-0.02	0.11	0.01	0.05	0.10	-0.08	0.33***	-0.05	0.18**	0.18**	0.11	0.80***	1				
19. TL:ICS	0.39***	0.03	-0.09	0.23**	0.13*	-0.03	0.14*	0.05	-0.01	0.09	-0.10	0.32*	-0.09	0.20***	0.20***	0.17**	0.77	0.75***	1			

Latent Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
20. GWRTO	-0.09	-0.15**	0.05	-0.06	-0.05	-0.11	-0.10	-0.04	-0.06	-0.07	-0.05	0.06	0.47***	0.33***	0.25***	0.19***	0.04	0.06	0.10	1		
21. ENV: DYN	0.17**	0.18**	0.10	0.04	0.04	0.02	0.15**	0.01	0.12	0.12	0.07	0.19**	0.03	0.04	0.13*	0.17**	0.01	0.01	0.02	0.09	1	
22. ENV: HOS	0.13*	0.29***	0.12	0.08	0.01	-0.01	0.08	-0.02	0.03	0.02	-0.07	0.11	0.07	0.01	0.06	0.16**	0.10	0.04	0.06	0.02	0.47***	1

Note: *p<0.10, **p<0.05, ***p<0.01. Abbreviations: CEA = corporate entrepreneurship activity; EEP: ACH = Entrepreneurial Employee Persona: Achievement; EEP: LOC = Entrepreneurial Employee Persona: Locus of Control; EEP:CRT = Entrepreneurial Employee Persona: Creativity; EEP: SE = Entrepreneurial Employee Persona: Self-efficacy; EEM: GO = Entrepreneurial Employee Mindset: Goal orientation; EEM: MK = Entrepreneurial Employee Mindset: Metacognition knowledge; EEM: ME = Entrepreneurial Employee Mindset: Metacognition experience; EEM: MC = Entrepreneurial Employee Mindset: Metacognition choice; EEM: MT = Entrepreneurial Employee Mindset: Monitoring; SN = social networks; ESTRAT = Entrepreneurial strategy; ECULT = Entrepreneurial culture; ESRT = Entrepreneurial structure; ERWRD = Entrepreneurial reward; ORG RS = Organizational resources; TL: IM = Transformational leadership: Inspirational motivation; TL: IST = Transformational leadership: Intellectual stimulation; TL: ICS = Transformational leadership: Individual consideration; GWRTO = Growth orientation; ENV: DYN = Environmental dynamism; ENV: HOS = Environmental hostility.

Annexure C. Summary of hypotheses and path relationship results

Hypotheses	Path relationship	Path coefficient	p-value	t-value	f2	Supported
H1	Organization to CEA	0.664	0.000	12.013**	0.818***	Yes
H1a	Strategy to CEA	0.427	0.000	6.606***	0.243***	Yes
H1b	Entrepreneurial culture to CEA	-0.126	0.000	1.373	0.029	No
H1c	Entrepreneurial structure to CEA	0.175	0.009	2.623**	0.045**	Yes
H1d	Entrepreneurial reward practices to CEA	0.035	0.591	0.537	0.002	No
H1e	Transformational leadership to CEA	0.147	0.011	2.541**	0.040**	Yes
H1f	Organizational resources to CEA	0.144	0.013	2.492**	0.034***	Yes
H2	Individual employee to CEA	0.145	0.012	2.514**	0.044**	Yes
H2a	Entrepreneurial persona to CEA	0.007	0.919	0.101	0.000	No
H2ai	Achievement to CEA	0.065	0.367	0.885	0.005	No
H2aii	Locus of control to CEA	0.003	0.963	0.046	0.000	No
H2aiii	Creativity to CEA	-0.068	0.334	0.967	0.005	No
H2aiv	Optimism to CEA	0.027	0.727	0.349	0.001	No
H2b	Entrepreneurial mindset to CEA	0.149	0.025	2.249**	0.029**	Yes
H2c	Social network to CEA	-0.059	0.321	0.993	0.008	No
H3	Environment to CEA	0.056	0.312	1.012	0.006	No
H3a	Dynamism to CEA	-0.011	0.872	0.162	0.000	No
H3b	Hostility to CEA	0.072	0.247	1.157	0.008	No

Note: *p<0.10, **p<0.05, ***p<0.01.

Biographical notes

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Authorship contribution statement

Boris Urban: Supervision, Conceptualization, Writing Article, Writing – Review and Editing, Revisions. **Thanusha Govender:** Writing – Original Draft Preparation, Data Collection, Methodology, Data Analysis, Software Application.

Conflicts of interest

The authors declare no conflict of interest.

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Pushing coopetition research further: Understanding, relevance, and operationalization of the attributes of coopetition strategies and coopetitive relationships

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Abstract

PURPOSE: *Although coopetition was defined three decades ago and is intensively investigated, its theoretical and research cognition remains far from thoroughly understood. The lack of conceptual consistency prevents researchers from conducting comparable research, leading to more generalizable results, and thus from building coherent knowledge. This study addresses the above shortcoming by the development of operationalizations of two types of attributes assigned to coopetition: strategic attributes characterizing coopetition strategies and relational attributes characterizing coopetitive relationships.* ***METHODOLOGY:*** *In our study, we adopted a two-step research process consisting of qualitative verification of a list of 8 coopetition attributes (2 strategic and 6 relational) identified in prior literature as relevant for coopetition success and the development of integrative conceptualization and measurement approaches for them. The verification was conducted through focus group interviews with scholars experienced in coopetition research and senior managers from firms adopting coopetition strategies. The measurement approaches for the positively verified attributes were developed through the integration of (1) approaches used so far in coopetition literature, (2) approaches used to date in the literature on the features of inter-organizational relationships, and (3) approaches that emerged during the focus group interviews.* ***FINDINGS:*** *This study shows two strategic (i.e., dynamics and paradoxicality) and six relational (i.e., asymmetry, complexity, intensity, mutual dependence, strength, and tensions) coopetition attributes as heterogeneously relevant for coopetition success and offers multi-item operationalizations for them derived from a combination of prior literature and qualitative research.* ***IMPLICATIONS:*** *Our paper shows strategic and relational attributes of coopetition as theoretically and practically relevant for coopetition success.* ***ORIGINALITY AND VALUE:*** *As a contribution, this study offers scientifically grounded operationalizations of eight attributive success factors of coopetition. The developed measurement proposals can find valuable applications in two ways. First, coopetition researchers can use them in their studies, and a consistent measurement approach will allow for the comparison of research results, bringing us closer to drawing more general conclusions. Second, coopetition practitioners can use these proposals when managing coopetition, for instance, to evaluate, monitor, and intentionally shape them to make coopetition (more) successful.*

Keywords: *coopetition, focus group interviews, operationalization, measurement scale, coopetitive relationships, coopetition strategies*

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INTRODUCTION

The concept of coopetition describes the phenomenon of simultaneous cooperation and competition within a single business relationship (Pellegrin-Boucher, Le Roy, & Gurău, 2013; Bouncken, Fredrich, Ritala, & Kraus, 2018; Chión, Charles, & Tavana, 2018; Mathias, Huyghe, Frid, & Galloway, 2018; Crick & Crick, 2019; Chen, Luo, & Wang, 2019; Bengtsson & Kock, 2000; Chatterjee, Chaudhuri, Mikalef, & Sarpong, 2023; Heikkilä, Rissanen, & Ali-Vehmas, 2023) to create and co-create value for all parties involved (Czakon, Rogalski, & Mucha-Kuś, 2014; Rai, 2016; Gnyawali & Ryan Charleton, 2018; Gernsheimer, Kanbach, & Gast, 2021; Klimas, Sachpazidu, & Stańczyk, 2023b; Raza-Ullah, Stadtler, & Fernandez, 2023). It can be said that coopetition occurs when "*competitors join hands with each other and collaborate to pursue a common goal*" (Raza-Ullah, 2020, p. 3).

In the academic literature, coopetition emerged unexpectedly, and equally unexpectedly began to develop rapidly (e.g., Bengtsson & Kock, 2014; Czakon et al., 2014; Bengtsson & Raza-Ullah, 2016; Gast, Filser, Gundolf, & Kraus, 2015; Dorn, Schweiger, & Albers, 2016; Devece, Ribeiro-Soriano, & Palacios-Marqués, 2019). Nonetheless, although coopetition has been extensively investigated in various field studies (Monticelli, Silveira, & Silva, 2018; Lascaux, 2020; Corbo et al., 2022; Yadav, Kumar, & Malik, 2022), there are still open, hence relevant, cognitive gaps (Crick, 2019; Meena, Dhir, & Sushil, 2023).

According to Gnyawali and Song (2016), coopetition research is both promising and challenging due to the opportunities for substantial contributions to management theory and managerial practice. However, it is hindered by a lack of strong theoretical and methodological foundations. The need to take a step back and focus on the cognitive and theoretical underpinnings of coopetition instead of conducting new research, has also been proposed by Chiambaretto, Fernandez, and Le Roy (2022) and Klimas, Ahmadian, Soltani, Shahbazi, and Hamidizadeh (2023a), who independently point to the need for determining, sorting out and integrating common assumptions, conceptualizations and operationalizations in the field of coopetition.

This paper addresses the above proposals and focuses on the conceptualization and operationalization of two types of attributes assigned to coopetition, i.e. strategic and relational attributes (constitutive and first-order in terms of Klimas, Sachpazidu, & Stańczyk, 2023b) thus on a better – and more coherent – understanding of coopetition sensu largo.

Coopetition attributes are claimed to be relevant (Czakon et al., 2014) or even essential for the success of coopetition (Christ, Burritt, & Varsei, 2017). As shown by many systematic literature reviews (e.g., Petter, Resende, de Andrade Júnior, & Horst, 2014; Gast et al., 2015; Bengtsson & Raza-Ullah, 2016; Dorn et al., 2016; Davece et al., 2019; Köseoğlu, Yildiz, Okumus, & Barca, 2019; Gernsheimer et al., 2021) one of the dominant research areas within the field of coopetition there are coopetition outcomes, including the drivers of successful coopetition (e.g. Raza-Ullah, 2021) also labeled as (key/critical) success factors of coopetition (e.g., Chin, Chan, & Lam, 2008; Thomason, Simendinger, & Kiernan, 2013; Bouncken, Gast, Kraus, & Bogers, 2015; Lindström & Polsa, 2016, Resende et al., 2018; Kumar, Connell, & Bhattacharyya, 2021). This paper taps into this area as it focuses on two groups of coopetition attributes considered relevant for coopetition success, namely strategic attributes characterizing coopetition strategies adopted by competitors and relational attributes characterizing coopetitive relationships of coopetitors through which coopetition strategies are implemented.

Coopetition success is understood as the achievement of the mutual goals of coopetitors (Czakon et al., 2014; Crick & Crick, 2023), while the successful coopetition strategy is acknowledged as a truly win-win strategy (Bouncken et al., 2015; Le Roy & Czakon, 2016) allowing cooperating competitors to obtain positive outcomes (Bengtsson & Raza-Ullah, 2016) leveraging firm performance (Crick, 2019). From a broader perspective, acknowledging sustainability-related issues, the successful coopetition strategy generates positive outcomes for competitors and significant benefits for society and the environment simultaneously (Kumar et al., 2021; Bouncken, Kumar, Connell, Bhattacharyya, & He, 2023). Indeed, the drivers of coopetition success have aroused keen interest among researchers who have hitherto acknowledged the significance of heterogenous factors, including external (e.g., environmental conditions - Ritala, 2012), relational (e.g., trust, commitment, conflicts - Resende et al., 2018), and internal ones (e.g., organizational learning - Chin et al., 2008; organizational culture - Klimas, 2016; organizational competencies - Resende et al., 2018; emotional ambivalence - Raza-Ullah, 2021). Among the overlooked drivers, there are, however, the coopetition attributes suggested to be relevant for coopetition success (Christ et al., 2017; Kostis & Näsholm, 2020). Indeed, so far, they remain outside the mainstream of research inquiry (Bengtsson & Raza-Ullah, 2016; Jakobsen, 2020), and our understanding of these attributes remains fragmented (Dorn et al., 2016; Kraus, Breier, & Dasí-Rodríguez, 2020; Klimas et al., 2023b). It should be noted, however, that although some of the coopetition attributes identifiable in the literature have been investigated in past studies on the drives of coopetition success – communication and commitment (Chin et al., 2008), trust, commitment and mutuality (Thomason et al., 2013), trust and commitment (Bouncken et al., 2015), intensity and trust (Raza-Ullah & Kostis, 2020) - this research has not been comprehensive as has not been focused on the wide range and different types of coopetition attributes. Therefore, it is reasoned that coopetition attributes are claimed to be worthy of more profound and comprehensive empirical investigation. Indeed, it is directly claimed by coopetition scholars who call for investigation of such attributes as dynamics (Czakon, Klimas, & Mariani, 2020), balance/stability (Czakon et al., 2014), power and asymmetry (Liu, Li, & Li, 2015).

Moreover, also the general coopetition literature, even points out or mentions coopetition attributes, such as mutual benefits, dynamics, variability, managerial challenges (Czakon et al., 2014), asymmetry (Osarenkhoe, 2010; Monticelli et al., 2018; Jakobsen, 2020), complexity (Czakon et al., 2014; Akpinar & Vincze, 2016; Bouncken et al., 2018), strength (Ritala & Hurmelinna-Laukkanen, 2013; Zrahia, 2018) and paradoxicality (Liu, Yang, & Zhang, 2021), it does not pay great attention to them. Unfortunately, even though scholars use terms denoting some attributes of coopetition, they rarely show their understanding and conceptualization, although these constructs must be clearly defined and explained, including their origins and manifestations (Gnyawali & Song, 2016). Finally, the measures of various attributes related to coopetition have typically not been justified or verified. Moreover, often, they differ and do not necessarily comprehensively capture the significance of individual characteristics. As a result, it is difficult to speak of a common, well-established measurement approach, which also impacts the analytical approach and the comparability of results.

The aim of this study is to offer precise operationalizations for strategic and relational coopetition attributes positively validated as contributing to coopetition success and supported by both empirical research and insights from the existing literature. Given the above, this paper adds to the current methodological discussion within coopetition (Gnyawali & Song, 2016; Rai, Gnyawali, & Bhatt, 2023; Gelei & Dobos, 2024) emphasizing the need for more comprehensive, reliable, and comparable measurement approaches. Additionally, our results are relevant for coopetition understanding as they shed new – required (Chiambaretto et al., 2022; Klimas et al., 2023a) – light on the attributes assigned to coopetition, namely the specificity of coopetition attributes (Dorn et al., 2016; Kraus et al., 2020; Klimas et al., 2023b) acknowledged as relevant for coopetition success (Christ et al., 2017; Jakobsen, 2020).

To reach the above aim, we verified eight coopetition attributes considered as either strategic or relational coopetition attributes and identified in the literature as relevant for coopetition success through focus group interviews. As coopetition is valuable for both coopetition scholars and managers, our verification study used both these groups of informants. Our primary goal was to propose a comprehensive operationalization, which is integrative and based on the existing body of work related to the measurement of attributes, supplemented where necessary by newly identified issues deemed important by either practitioners or theorists. We assumed that both groups possess relevant experience with coopetition and, consequently, knowledge of its key attributes. Therefore, we first ran three virtual focus group interviews (VFGI) with scholars experienced in research on coopetition, and then two focus group interviews (FGI) with managers exploiting coopetition in business practice. Next, for the attributes positively verified as relevant for coopetition success, we searched for operationalizations in past coopetition research and in past research on inter-organizational relationships (IOR; if there were no scales in coopetition literature). It should be noted, however, that the identified operationalizations have been confronted with and supplemented by the findings from our focus group interviews. The adopted approach allowed us to create an integrative conceptualization and measurement frameworks for two strategic (i.e., dynamics and paradoxicality) and six relational (i.e., asymmetry, complexity, intensity, mutual dependence, strength, and tensions) coopetition attributes, which we recommend for use in future quantitative research.

The main contributions of our study to coopetition literature are the following. First, the empirical verification and finetuning of our understanding of strategic and relational coopetition attributes, which brings us closer to optimization of coopetition strategies (Osarenkhoe, 2010; Dahl, Kock, & Lundgren-Henriksson, 2016; Tidström & Rajala, 2016; Klimas & Radomska, 2022) and coopetitive relationships (Tidström, 2014; Le Roy, Fernandez, & Chiambaretto, 2018; Jakobsen, 2020) characterized by those attributes. Second, the very first empirical verification of the relevance of those attributes for coopetition success which broadens the list of success factors successively developed based on current field research (Chin et al., 2008; Thomason et al., 2013; Bouncken et al., 2015; Lindström & Polsa, 2016, Resende et al., 2018; Kumar et al., 2021). Third and foremost, the development of consistent and empirically reasoned operationalization for considered coopetition attributes claimed as relevant to the harmony of the research methodology in the field of coopetition (Gnawali & Song, 2016; Rai et al., 2022) but also is claimed to be relevant for managers (Gelei & Dobos, 2024) who should be able to monitor and intentionally shape them. Considering the pragmatic and managerial standpoint, we believe that the operationalization of coopetition attributes will improve the clarity and comprehension of attributes, thus making it easier to recognize, monitor and shape them in managerial practice, which will lead to improvements in the execution of coopetition strategies and exploitation of coopetitive relationships. This is particularly pertinent since the attributes are acknowledged as determining coopetition success (Christ et al., 2017; Jakobsen, 2020), while the results of coopetition exploitation are not always positive (Bouncken et al., 2018; Crick, 2019). Moreover, in the context of coopetition success, our study reveals the most relevant strategic (i.e., paradoxicality) and relational (i.e., mutual dependence) coopetition attributes which should be in particular interest of managers focused on successful coopetition.

The rest of the paper is structured as follows. First, we provide a brief overview of the key shortcomings and unexplored research areas related to coopetition attributes and explain our focus on two groups of those attributes: strategic and relational. We also provide detailed descriptions of all the attributes deemed relevant for achieving success in coopetition. Then, we present our methodological approach for verifying the identified attributes. Afterward, we present our findings and discuss the understanding and relevance of these attributes for both coopetition scholars and managers. Additionally, we present operationalizations for the positively verified coopetition attributes developed by synthesizing primary (i.e., conducted interviews) and secondary (i.e., existing research) data sources. In the final section, we highlight the main contributions, managerial implications, limitations, and future research directions.

LITERATURE REVIEW

One area in which there are cognitive gaps in coopetition literature are the features that may be assigned to coopetition (Dorn et al., 2016). Indeed, as claimed in previous systematic literature reviews (Bouncken et al., 2015; Dorn et al., 2016; Devece et al., 2019; Gernsheimer et al., 2021; Meena et al., 2023), although some attributes are identifiable in coopetition literature (e.g., strength – Bengtsson, Kock, Lundgren-Henriksson, & Näsholm, 2016; mutual dependency – Petter et al., 2014; Jacobsen, 2020; asymmetry – Pellegrin-Boucher et al., 2013; dynamics – Czakon et al., 2014; paradoxicality – Bengtsson & Raza-Ullah, 2022), they are usually discussed at most as a side issue and remain without sharp conceptualization and operationalization (Klimas et al., 2023b). The justification for investigating coopetition attributes can be articulated twofold - Table 1.

Table 1. Knowledge gaps and future research directions linked with coopetition attributes identified in prior coopetition literature

Claimed knowledge gaps	Recommended future research directions
The **characteristics** of coopetition and their changes over time (Bengtsson & Raza-Ullah, 2016).	Do certain stages of coopetition belong to certain types of relationships or their **features** (Tidström & Ahman, 2006)? The **stability** issue (Pellegrin-Boucher et al., 2013; Czakon et al., 2014).
The **nature** of the (ref. coopetitive) relationship (Dorn et al., 2016).	What is the glue that holds opposed or **unbalanced** competition and collaboration together (Czakon et al., 2014)? A detailed examination is needed of the **internal balance** and **dynamics** within coopetition (Czakon et al., 2014).
Knowledge on the **feature** of coopetition is fragmentary and dispersed (Dorn et al., 2016; Kraus et al., 2020; Klimas et al., 2023b).	We need to better understand coopetition **dynamics** (Czakon et al., 2020). What happens during coopetition in terms of **changes in the relationship** (Bengtsson & Raza-Ullah, 2016)?
Lack of search on the comprehensive set of **attributes** of coopetitive relationships (e.g. those categorized under constitutive, first-order, and second-order attributes) (Klimas et al., 2023b).	To study the optimal form of coopetition, including bargaining **power** or **information asymmetry** (Liu et al., 2015). How coopetition **develops over time in terms of its relational characteristics**, and how to handle the possible tensions in relationships between several partners (Jakobsen, 2020)? How can we **measure attributes** of coopetitive relationships in a rigorous way (Klimas et al., 2023b)?

Firstly, the literature reveals directly identifiable knowledge gaps in the field of attributes of coopetition (e.g., Bengtsson & Raza-Ullah, 2016; Dorn et al., 2016; Kraus et al., 2020; Klimas et al., 2023b). Secondly, recognizing that the mere existence of knowledge gaps may not be a sufficient argument, it is noteworthy that coopetition researchers explicitly recommend empirical research on coopetition attributes (e.g., Tidström & Ahman, 2006; Czakon et al., 2014; Liu et al., 2015; Jakobsen, 2020).

Furthermore, it should be noted that the effects of coopetition on coopeting firms remain one of the most critical areas of investigation among coopetition scholars (Köseoğlu et al., 2019). As claimed by the literature, these effects, including the success of coopetition and the superior performance of coopetitors, may be achieved if the attributes assigned to coopetition are ensured (Christ et al., 2017; Jakobsen, 2020; Kostis & Näsholm 2020). Such an interconnection strengthens the argument for taking a closer look at them. Hence, building upon existing conceptualizations of such attributes (Klimas et al., 2023b), our aim is to take an additional step forward by introducing reference operationalizations.

The facets of coopetition attributes

The results of a meta-systematic review of systematic literature review (SLR) on coopetition attributes (Klimas et al., 2023b) show that it is possible to distinguish 24 attributes considered relevant for coopetition success. Following the above SLR, these attributes may be systematized into three categories: (1) two constitutive features, understood as the integral parts of every single coopetitive relationship, (2) six first-order features, understood as resulting mainly from the specificity of a given coopetitive relationship and the circumstances under which coopetition is exploited, and (3) sixteen second-order features, understood as determined mainly by the behaviors and roles undertaken by coopetitors in a coopetitive relationship. Importantly, in our perspective, it is crucial to draw attention to significant differences in the subject matter addressed by those three types of coopetition attributes, a subject that serves as an additional differentiating criterion.

In this paper, we place our focus on coopetition attributes categorized within the first two groups – strategic ones referring to coopetition strategies and relational ones referring to coopetitive relationships. This choice is based on their demonstrated effect on coopetition performance, understood through the proxy of coopetition success (Raza-Ullah, 2020; Raza-Ullah & Kostis, 2020). Furthermore, from a cognitive standpoint, we perceive these attributes as considered at the inter-organizational level and more linked with the understanding of the coopetition phenomenon, while the second-order features, considered at the organizational level and adopting a behavioral perspective, are more focused on coopetitors than on coopetition per se. Therefore, the features under investigation are (in alphabetical order): asymmetry, complexity, intensity, dynamics, mutual dependence, paradoxicality, strength and tensions – Table 2.

Firstly, the strategic attributes of coopetition are regarded as inherent and fundamental aspects of all coopetition strategies, regardless of the type of coopetition strategy they pertain to (emergent or intentional coopetition – Mariani, 2007; Czakon et al., 2014; Dahl et al., 2016). The two strategic attributes under consideration are dynamics and paradoxicality. Dynamics refers to the level of changeability and variation in the intensity of competition and cooperation between coopetitors (Akpinar & Vincze, 2016; Cozzolino & Rothaermel, 2018; Chen et al., 2019). This results from the evolutionary nature of coopetition (Czakon et al., 2014). Paradoxicality, meanwhile, is characterized by the intensity and scope of competition and cooperation simultaneously linking coopetitors (Chiambaretto & Fernandez, 2016; Bouncken et al., 2018; Crick & Crick, 2019).

Table 2. Strategic and relational attributes identified in a systematic review of the literature

Attribute		Understanding resulting from systematic literature review (Klimas et al., 2023b)	Supporting references	Essence
Relational	Asymmetry	Asymmetry understood as resource asymmetry, i.e., complementarity of coopetitors in terms of resources.	Osarenkhoe, 2010; Monticelli et al., 2018; Kwon, Kang, Kim, & Choi, 2020; Meena et al., 2023; Yoo, Roh, Cho, & Yang, 2022	Scope of inequalities between coopetitors in terms of resources possessed and controlled, benefits, power, size.
		Asymmetry in terms of unbalanced importance of coopetition; "asymmetry exists when the exchange is not equally important for both firms" (Jakobsen, 2020, p. 254).	Kim, Kim, Pae, & Yip, 2013; Pellegrin-Boucher et al., 2013; Monticelli et al., 2018; Jakobsen, 2020	
		Asymmetry in terms of power - "strongly unequal dependence, even an overdependence, of one party on the other" (Lechner, Soppe, & Dowling, 2016, p. 72).	Raza-Ullah, Bengtsson, & Kock, 2014; Lechner et al., 2016; Munten, Vanhamme, Maon, Swaen, & Lindgreen , 2021	
		Asymmetry in coopetitors' size.	Baglieri, Carfì, & Dagnino, 2016; Lechner et al., 2016; Jakobsen, 2020; Yoo, Gu, & Rabinovich, 2019; Yoo et al., 2022	
		Asymmetry in engagement and mutual investments	Das & Rahman, 2010	
		(non)Equal strength or intensity of cooperation and competition.	Czakon et al., 2014; Dorn et al., 2016	

Attribute		Understanding resulting from systematic literature review (Klimas et al., 2023b)	Supporting references	Essence
Relational	Complexity	Can be reflected in coopetition dimensionality (numerous bonds and ties; different areas of proximity) and a multilevel character.	Czakon et al., 2014; Akpinar & Vincze, 2016; Bouncken et al., 2018; Crick & Crick, 2019; Garri, 2021; Seepana, Huq, & Paulraj, 2021; Crick & Crick, 2021a, 2021b; Estrada & Dong, 2020; Geurts, Broekhuizen, Dolfsma, & Cepa, 2022	Level of comprehensiveness in terms of using varied bonds at different levels (i.e., scope of proximities)
Strategic	Dynamics	Continuous changes between cooperation and competition.	Czakon et al., 2014; Liu et al., 2015; Chiambaretto & Fernandez, 2016; Gnyawali & Song, 2016; Dorn et al., 2016; Akpinar & Vincze, 2016; Cozzolino & Rothaermel, 2018; Bouncken et al., 2018; Monticelli et al., 2018; Peng, Yen, & Bourne, 2018; Chen et al., 2019; Crick & Crick, 2019; Kwon et al., 2020; Jakobsen, 2020; Park & Kim, 2021; Amata, Dagnino, Minà, & Picone, 2022	Level of changeability and variation in the intensity of competition and cooperation between coopetitors.
Relational	Intensity	Scope, high significance and number of coopetitive ties aimed at reaching both competing and joint targets on the market.	Luo, 2007; Park, Srivastava, & Gnyawali, 2014; Akpinar & Vincze, 2016; Lechner et al., 2016; Zrahia, 2018; Chen et al., 2019; Bouncken et al., 2018, 2020; Chen, Yao, Zan, & Carayannis, 2021; Raza-Ullah & Kostis, 2020; Mariani & Belitski, 2022	Level of intensity of coopetition resulting from its scope, importance, number of areas, etc.
Relational	Mutual dependence	Degree to which the coopetition outcomes of one coopetitor depend on the behaviour and actions undertaken by the other coopetitor(s). Note: so far, two dimensions have been recognized (Jakobsen, 2020): structural dependence and psychological dependence.	Petter et al., 2014; Monticelli et al., 2018; Jakobsen, 2020; Garri, 2021; Muthusamy & Dass, 2021	The level of interdependence of coopetitors' effects.
Strategic	Paradoxicality	The coopetitive relationship includes both (contradictory) cooperation and competition. "Paradoxical nature of coopetition becomes visible in the way in which this positive potential also creates possible threats and risks" (Bouncken et al., 2018, p. 393).	Pellegrin-Boucher et al., 2013; Chiambaretto & Fernandez, 2016; Bouncken et al., 2018; Chen et al., 2019; Crick & Crick, 2019; Raza-Ullah, 2020; Ricciardi, Zardini, Czakon, Rossignoli, & Kraus, 2022; Rai et al., 2022	Level of intensity and scope of both competition and cooperation.
Relational	Strength	Manifests itself in the difficulty of breaking off the coopetitive relationship or even modifying it.	Dorn et al., 2016; Klimas et al., 2023	The level of difficulty of breaking off coopetitive relationships (i.e. ending them or making them dormant).
Relational	Tensions	Differences between coopetitors' needs regarding sharing and hiding information, their willingness to co-create and appropriate value. Note: in contrast to paradoxicality, tensions cover both positive and negative emotions.	Pellegrin-Boucher et al., 2013; Petter et al., 2014; Raza-Ullah et al., 2014; Gnyawali & Song, 2016; Jakobsen, 2020; Lascaux, 2020; Liu et al., 2021; Bouncken et al., 2017; Bouncken et al., 2018; Chou & Zolkiewski, 2018	The level of being torn between creation and appropriation of value under coopetition.

Source: Based on Klimas et al. (2023b).

Secondly, relational attributes (i.e., first-order in terms of Klimas et al., 2023b) are considered to be higher-order constructs (Holm, Eriksson, & Johanson, 1999) built from a set of specific lower-order constructs indirectly linked (mainly) with the behaviors of the actors engaged in the relationship (Palmatier, Houston, Dant, & Grewal, 2013), and directly resulting from the type of coopetitive relationship (Klimas et al., 2023b). The following six relational attributes may be assigned to coopetitive relationships. The first is asymmetry in coopetitive relationships, which refers to the scope of inequalities between coopetitors in terms of the resources possessed and controlled (Kwon et al., 2020), benefits, and power (Lechner et al., 2016), but also their sizes (Quintana-Garcia & Benavides-Velasco, 2004) and the importance of coopetition for their activity (Chen et al., 2019; Jakobsen, 2020). The second is complexity, understood as the level of comprehensiveness in terms of using varying bonds at different levels (Czakon et al., 2014; Crick & Crick, 2019), which may lead to the blurring of coopetition boundaries (Akpinar & Vincze, 2016) and may explain the contradictory results in different cases (Bouncken et al., 2018). The third is intensity, which refers to the level of intensity within coopetition (both competition and cooperation simultaneously) resulting from its scope (Klimas, 2014), importance (Bouncken et al., 2018; Zrahia, 2018), and the number of areas (Bouncken et al. 2018) shaping the interdependencies between coopetitors (Lechner et al., 2016). The fourth is the mutual dependence among coopetitors, defined as the degree of interdependence of effects generated by coopetitors (Bengtsson & Kock, 1999; Czakon et al., 2014) that are crucial for coopetition longevity (Jakobsen, 2020). The fifth is the strength of coopetitive relationships, seen as the level of the difficulties of breaking off coopetitive relationships (i.e. ending or making a relationship dormant) depending on the adopted protection mechanisms (Ritala & Hurmelinna-Laukkanen, 2013). Finally, the sixth are the tensions experienced in coopetitive relationships shaped by the level of being psychologically torn (Gnyawali & Song, 2016; Bahar Nenonen, & Starr Jr, 2022) between focusing on creation and/or appropriation of value under coopetition (Jakobsen, 2020).

It should be noted that in our study, the focus is placed on the understanding, relevance, and operationalization of the eight above-mentioned attributes, not on their categorization, thus, the distinction between strategic and relational attributes is not used in the further part of our paper.

METHODOLOGY

To operationalize the coopetition-related attributes and facilitate the development of appropriate measurement scales, we conducted an explorative field study using FGI. The focus group technique was used as it is claimed to be appropriate if the final aim is to develop a comprehensive and valid survey questionnaire once the literature review has been completed and verification is needed (Powell, Single, & Lloyd, 1996; Smithson, 2000).

As a starting point we used the list of eight coopetition attributes considered at the inter-organizational level (i.e., two constitutive/strategic and six first-order/relational) as well as their general conceptualizations (see Table 2) developed by Klimas et al., (2023b) as a result of their systematic literature review.

During the interviews, the relevance of the set of considered attributes for coopetition success was verified using two techniques of focus group interviews (Nyumba, Wilson, Derrick, & Mukherjee, 2018; Halliday, Mill, Johnson, & Lee, 2021) – namely traditional face-to-face FGI and online VFGI. In total, five interviews were conducted, including three VFGIs and two FGIs. Our sample was appropriate as three FGIs are said to be the minimum number of group interviews required to reach a satisfactory saturation level (Sweet, 2001).

Acknowledging that interviewees must have relevant knowledge and represent the community interested in the investigated area (Lokot, 2021), we saw it reasoned to diversify our key informants (Kumar, Stern, & Anderson, 1993) and run the interviews with coopetition researchers and managers experienced in coopetition. Notably, as we aimed to develop methodologically valid operationalization, it was essential to ensure construct and face validities (Hinkin, 1995; Czakon et al., 2020). On the one hand, to ensure construct validity, it was reasoned to talk (primarily) with scholars experienced in research on coopetition and, therefore, are capable of assessing and developing initial conceptualizations but also providing sound methodological insights for the operationalizations of coopetition attributes. On the other hand, coopetition represents a managerial phenomenon, serving as a strategy or, at the very least, a strategizing practice (Tidström & Rajala, 2016; Le Roy et al., 2018). Thus, for practical applicability, ensuring face validity of the developed conceptualizations and operationalizations is crucial when targeting practitioners. Consequently, we deemed incorporating a managerial perspective in our approach essential. Therefore, online VFGIs were organized with coopetition scholars, while on-site FGIs were organized with managers.

The data collection process was narrowed to Poland. We are aware that the national context of field investigation limits generalizability, however, in coopetition literature, nationally focused research dominates (Dorn et al., 2016; Meena et al., 2023) as coopetition is acknowledged by a highly contextual phenomenon in terms of national formal institutions (Czakon et al., 2014) and national culture (Klimas, 2016). Moreover, when our research process was designed, we assumed that the proposition of operationalizations would build on data triangulation, namely scales, measurements, and indicators already available and in the literature finding support in data collected in field research, to limit the bias resulting from the national contextuality of gathered primary data.

VFGIs were carried out by the principal investigator in April 2022 and lasted, on average, 81 minutes. All VFGIs were organized via MS Teams and video-recorded with the participants' consent. The first batch of interviews were conducted with scholars with extensive experience in coopetition research, namely those who published two or more articles on coopetition in journals indexed by JCR (IF > 1; data source: Web of Science) or published 1 such article and defended the doctoral dissertation on coopetition (data sources: Web of Science and Nauka Polska). In total, twelve coopetition researchers have been identified. However, one refused to participate in the study, while three were excluded as they were engaged in the research process. Finally, eight scholars were interviewed, including three assistant professors (coded here as DR), three associate professors (coded here as HAB), and two full professors (coded here as PROF). Given the heterogeneity/diversification rules in qualitative studies (Daly & Lumley), the VFGIs were diversified in terms of participants' tenure and experience in coopetition research, but also in terms of the specific area of interest in the field of coopetition (e.g., firm coopetition vs coopetition of public institutions; coopetition of high-tech firms vs low-tech firms vs firms from the creative industries; exploitation of qualitative research vs quantitative research vs mixed research).

FGIs were conducted by a research company in June 2022 and lasted 120 minutes. In each, the participants were 6 randomly selected top and medium-level managers experienced in, responsible for, or having knowledge of their firm's cooperation with business rivals. Both FGIs were voice-recorded with the consent of the participants. Given that coopetition is industry-sensitive (Czakon et al., 2014) and research has proven the differences between coopetition in high-tech and low-tech industries (Lansink, 2016; Hameed & Naveed, 2019), we decided to run one FGI with managers from high-tech firms (the FGI in Katowice, Poland; coded here as HT) and one with low-tech companies (the FGI in Wroclaw, Poland; coded here as LT). FGIs were observed by the research team.

During the interviews, we used an interview guide developed directly based on the coopetition attributes (i.e., understanding and categorization) identified as a result of SLR (Klimas et al., 2023b). We believe that utilizing results from a comprehensive literature review ensured the construct validity, while to ensure face validity, the tool underwent a two-pronged consultation process. However, to ensure that the discussion with the interlocutors genuinely focused on attributes relevant to the success of coopetition, the last part of our interview guide and, respectively, the last part of FGIs were dedicated to evaluating the importance of the discussed attributes for successful coopetition. Regarding the quality of our interview guide, on one hand, the tool was discussed with two managers to ensure that all components were understandable to them and equally understandable to the research team. Additionally, we were able to estimate the approximate interview duration. On the other hand, the tool was reviewed by an experienced researcher with a rich background in conducting qualitative research, including facilitating focus group interviews.

Figure 1. Miro board presenting the understanding and categorization of strategic and relational coopetition attributes used in focus group interviews

Source: Visualisation made using the virtual Miro board via https://miro.com/

Our scenario guide addressed several issues. First, we outlined the general assumptions about coopetition attributes and their categorizations. Graphical representations were used to assist in presenting the identified features. In the case of VFGI, we used a colorful Miro board (Figure 1; prepared on www.miro.com), which showed our assumptions about the general meaning and categorization of coopetition attributes. For the FGIs we used a small sheet of paper with a particular attribute, which was placed on the table in the focus room using the adopted categorization.

Then, we asked the interviewees to provide feedback on the accuracy of the developed categorizations and initial conceptualizations. We specifically inquired whether they agreed with conceptualization and if the list of attributes was complete or not, whether some attributes were missing, or if some were not of use. We then asked the interviewees to focus on particular attributes. This part involved detailed clarification of the understanding of particular attributes and exploring possibilities and methods for their measurement in business practice. Finally, we concentrated on the interviewees' evaluation of the coopetition attributes regarding their relevance for coopetition success in both long- and short-term perspectives. Interestingly, in the last part of the research, we obtained additional information indicating that managers perceive the importance of certain attributes differently than scholars, which was an additional effect of our VFGIs and FGIs. Although these differences were not the core of our research, we see it as an insightful side issue worth presenting.

We conducted a thematic analysis of all interview transcriptions. All the most relevant quotations are presented in italics below, while the researchers' remarks, comments, and explanations are given in plain font. Our book of codes covered a list of 8 initially adopted coopetition attributes, namely asymmetry, complexity, dynamics, intensity, mutual dependence, paradoxicality, strength, and tensions.

RESULTS

The following sections target the limited understanding and poor recognition of the relevance of strategic and relational coopetition attributes claimed to be important for coopetition success. Notably, in the conducted interviews, in the case of both types of our key informants, the initial list of eight coopetition attributes, covering two strategic and six relational attributes, has been adopted below as the final one. Nonetheless, it should be noted that regarding relational attributes, managers in FGIs suggested adding trust and commitment, while scholars in VFGIs suggested adding also power to the initial list. However, although those coopetition attributes are considered as behavioral attributes (Klimas, Sachpazidu, Stańczyk, Kawa, & Nadolny, 2024) determined by coopetitors' actions and behaviors (Czakon & Czernek, 2016; Chim-Miki & Batista-Canino, 2017; 2018; Crick, 2021; Crick & Crick, 2021a), they were out of the scope of this investigation, and thus have not been included to further investigation.

In the following parts, the considered coopetition attributes are addressed alphabetically, with a division into the perceptions of coopetition scholars (first section below) and coopetition practitioners (second section below). In general, both theoretical and practical perspectives support the existing understanding of the considered attributes. However, due to the fact that the filtering stage of the FGIs, which was focused on ensuring that the discussion revolved around attributes relevant to the success of coopetition, revealed certain discrepancies between our two types of key informants, the third section presents the relevance of the attributes in terms of the weight assigned to them by scholars and managers. In the last part (fourth section below), we propose operationalizations for all eight attributes positively validated as relevant to coopetition success in our field investigation. These operationalizations are constructed utilizing existing and accessible scales, primarily sourced from coopetition literature and secondarily from IOR literature. Importantly, we ensured that these proposed measures align with the adopted conceptualizations (Table 2) and the insights gathered from our interviews.

Understanding of coopetition attributes by scholars

Asymmetry was only brought up and discussed in one VFGI conducted with the most experienced researchers holding the title of full professor (PROF). One participant [PROF_1] pointed out that asymmetry is a matter of scale. More precisely, we can "*have different resources, but in the same amount. And then there is no asymmetry*", so asymmetry appears when "*I have a lot of them (resources), and you have very little*," which is consistent with the approach presented by many authors (Osarenkhoe, 2010; Monticelli et al., 2018; Kwon et al., 2020; Meena et al., 2022; Yoo et al., 2022). Another participant [PROF_2] highlighted that the concept of asymmetry encompasses not only physical resources but also knowledge or disparities in the scale or range of activity. The fact is that asymmetry can also be considered through the lens of power

(Raza-Ullah et al., 2014; Lechner et al., 2016; Munten et al., 2021), exchange (Pellegrin-Boucher et al., 2013; Monticelli et al., 2018), or intensity of coopetitive activities (Czakon et al., 2014; Dorn et al., 2016).

Another attribute is complexity, which indeed aroused quite intense emotions and a deep discussion among the interviewed scholars. Generally, it was seen as diversity in terms of the actors, their roles, and the activities undertaken under a coopetition agreement, similar to what Geurts et al. (2022) state. It was frequently shown as a relational attribute associated with other coopetition attributes, which confirms that it should be seen as a first-order feature (Holm, 1999). One of the participants emphasized that complexity could help to find "*something specific that the (parties) need. So, something complementary*" [DR_3]. Others pointed out that this attribute can relate to the "*multidimensionality of concepts and relationships*" [HAB_1] and "*varying resources and other diversity*" [PROF_1]. Hence, we decided to include the multidimensionality of actions and links between coopetitors as complexity's items.

The scholars had varying perspectives on the dynamics of coopetition, which "*is a feature that de facto constitutes coopetition*" [HAB_1]. According to some respondents, the dynamics of coopetition change over time as a coopetition "*relationship is always changing over time, it is never the same (...) the relationship, it is something alive (...). These dynamics are emphasized very strongly all the time*" [HAB_1]. As changes in the coopetition relationship over time can be considered in the context of its meaning and scope (Klimas et al., 2023) as well as the amount of cooperation or competition (Osarenkhoe, 2010; Czakon et al., 2014; Bouncken et al., 2018), we included it among the measures of dynamics. Additionally, one of the scholars stated that "*it doesn't have to be dynamic coopetition at all .... It can be non-dynamic*" [PROF_1], which confirms the claim of Deniz and Young (2007) that changes in relationships may be more regular than irregular.

Accordingly, the researchers discussed intensity by referring to attributes such as competition intensity and cooperation intensity. They pointed out that "*with this intensity, we define the dynamics* (ref. of the relationship) *in terms of competition and cooperation*" [DR_3]. What is more, they noted that "*the intensity of one relationship may be greater than another (...), and both may be equally low in intensity*" [HAB_2]. What is crucial in terms of intensity is the degree of both competition and cooperation [PROF_2]. One of the participants commented on intense coopetition: "*One may be interested in intense cooperation only when there is fierce competition*" [PROF_1]. These comments align with Raza-Ullah and Kostis (2020), who claimed that the intensity of coopetition consists of the intensity of cooperation and competition.

Mutual dependence was the attribute that aroused great interest among the researchers, as in their opinion, coopetition is "*supposed to generate value for both parties, that is mutual benefit*" [HAB_2], and to do so among coopetition partners, "*there must be something specific that they need*" [DR_3]. Mutual dependence is linked directly "*with a competitor who is, for example, a stronger player, more familiar and so on, brings us a certain prestige, but also such internal strength that we strengthen ourselves and thus build our competitiveness*" [DR_2]. Searching for confirmation of mutual dependence in the literature, we find that it is analyzed in two aspects important for successful coopetition: structural and psychological (Jakobsen, 2020).

In the opinion of scholars, coopetition "*is a paradoxical relationship*" [PROF_2] and "*this is the thing that we always mention first, and is... well, this is actually the essence of coopetition*" [HAB_1] where there are "*certain convergent cooperative goals and this divergence of goals into various competing ones (...)is something that comes from this sense of coopetition in general*" [DR_2]. In the scholars' view "*not everyone feels it, as a paradox. There are people (...) who are generally not affected by the fact that there is a paradox. There is a paradox with regard to themselves, but it is not a paradox for them. Or at least there are no negative consequences. So for me, paradoxicality is not at all an intrinsic characteristic*" [PROF_1] and "*more often, in fact, this lack of awareness is much more frequent because of this paradox, not that we have a combination of one and the other, and it is probably for this reason that this apparent lack of awareness is much more frequent*" [HAB_1]. The coopetition paradoxicality in this approach comes down to feeling both positive and negative emotions of coopetitors (Raza-Ullah, 2020), which, however, allows the implementation of strategy through a coopetition-level plan (Ricciardi et al., 2022).

According to the scholars, "*strength is actually the intensity or frequency of contact*" [PROF_1]. They connected strength with "*these strong ties for which there is the problem of not breaking them by such loyalty to the partner*" [HAB_1]. They also agreed that the strength of the relationship among partners does not have to be different in a single relationship – "*This strength will perhaps manifest itself somewhere in the multidimensionality of the relationship (...) this intensity may be of one type for one relationship, and of a different type for another*" [HAB_2] and "*here, this cooperation firstly does not have to be based on strong ties, secondly it can be very superficial, or ad hoc just becoming every now and then somewhat more intensified and... and generally at a low level of intensity*" [HAB_1]. All in all, opinions came down to perceiving the strength of coopetition as strong bonds, attachment to the coopetitor and lack of willingness to break these bonds, as Shi, Shi, Chan, & Wang, 2009 claim.

The next coopetition attribute regards "*tensions that combine with conflicts*" [HAB_2], where "*this tension (...) can be the result simply of conflict. That is, first there is conflict...and as a result of that conflict, there is tension*" [HAB_1] and "*conflict is a type of thing that has a course (...) it will erupt only under certain conditions (...) (and) prevents coopetition as long as there is not at least partial compliance, but if you have partial compliance, well you have a residual difference*" [PROF_1]. A valuable comment was the statement regarding the differences between tensions and paradoxicality: "*(…) tension is measurable, and the paradox is not. The tension may be low, it may be high, it may be above the control threshold or below the control threshold*" [PROF_1]. This comment highlighted the need for finding a precise and adequate measurement of paradoxicality (Bengtsson et al., 2016).

Understanding of coopetition attributes by managers

As in our VFGIs conducted with the scholars, in the group composed of managers from high-tech and low-tech firms, asymmetry was discussed in the context of resource imbalance and the differences in company size. One of the participants [HT_5] stated that different levels of resources could cause a small firm not to see a large one as a threat. However, the relationship in such cases ("*relationship initialization*" [LT_6]) will be slow. There emerges an important issue overlooked by scholars, namely related to the perception of asymmetry in terms of size, which is discussed, among others, by Baglieri et al. (2016), Lechner et al. (2016), Jakobsen (2020), and Yoo et al. (2019; 2022).

The participants quite clearly approached complexity as being a significant attribute of coopetition as "*expanding possibilities*" [LT_2] generated under coopetition and including "*different ways of approaching work*" [LT_6] covered by a coopetitive agreement, which prompted us to consider in the operationalization of this attribute the item focused on the heterogeneity and diversity of actions.

In the opinion of managers, the dynamics of coopetition " *fluctuate a lot depending on the scale and on the type of business*" [HT_6]. On the one hand, under the coopetition strategy, respondents admitted that "*we are in regular contact, do joint planning, we are close to each other all the time and we are developing all the time, so .... we are very committed*" [LT_6]. On the other hand, depending on the type of coopetition strategy adopted "*the dynamics can be different, and even stagnant dynamics can also be as a factor that (...) in the back of my mind is coopetition, once a year I use it and it's enough for me, it's enough for him too*" [LT_5]. Such opinions indicate that competition dynamics may be regular and change infrequently (Denize and Young, 2007). All of the above place dynamics as highly linked with changes, however, not in terms of changes in the interplay between cooperative and competitive links as in the case of intensity, but in terms of adjusting coopetition strategy to a changing business context.

Moving on to the next attribute, intensity, managers focused mainly on the fact that constant changes between cooperation and competition are essential for the coopetitive relationship [HT_1], especially since "*if we don't cooperate, what's the harm in competing?*" [LT_3]. Once again, this shows that coopetition intensity depends directly on the intensity of both cooperation and competition (Raza-Ullah & Kostis, 2020).

Mutual dependence, the next coopetition attributes, was discussed as the "*interdependence, that is, the effects of one depend on the effects of the other – so it is critical*" [HT_2]. Also, a very important aspect of mutual dependence is that it works for all the partners (both small and large firms) "*there is a sense of a lack of insecurity (...) I pose no threat to them (coopetitor) ... they have no interest in being afraid, and I have no interest either because they are strong enough that I can only benefit from it. This relationality is precisely what's cool because everyone knows where their place is*" [HT_6]. Managers pointed out that the size of a firm is important as "*small firms, however, are afraid of cooperation with such large ones because it has resources and people - this is a risk, very large ... large companies prefer to cooperate with a smaller company where they are the dominant party ... but with an equal partner, where they have the same knowledge and resources, the negotiations will be much more difficult*" [HT_6] and "*you can always push the small one a little bit*" [HT_3]. Managers' opinions represent the proper attitude of coopetitors, when each has an equal right to say in the business and an equal influence on the other (Muthusamy & Dass, 2021). Additionally, we noticed that managers pay great attention to the fact that the result of mutual dependence depends on the mutual actions of the coopetitors, which we consider an essential aspect of this attribute of coopetition.

The paradoxicality of coopetition is something natural for managers as "*this is the natural state of things, there is no rift here, every company cares about its development, so it is automatic to select any path that leads to this development and make use of resources of people who are theoretically our opponents ....*" [LT_6]. This confirms constitutive nature of paradoxicality of coopetition strategies claimed in the conceptual works (Bengtsson et al., 2016; Klimas et al., 2023b). Also, practitioners pointed out that "*it's a bit like the situation in marriage - on the one hand we want to be with each other* *so that someone can bring us tea in our old age, and on the other hand there is a risk that we may divorce. So, we do not know what will happen or when it will happen....* "[HT_4]. Respondents also presented a more positive attitude towards paradoxicality, as for them it is "*healthy competition as it's striving for the same goal, whoever is first is better, but competition implies that we disturb each other. Whoever is faster will reach the goal (…) of course, we can get angry, but the next race will come, and we keep running*" [LT_6].

When asked about strength, managers pointed to the link with experience where "*the most important thing in all this is ... these past experiences - because once I get disappointed once, I think twice the second time; when I get disappointed a second time, then I think ten times*" [LT_5]. In a situation of non-exhaustive opinions, we assume that if there are no negative experiences, coopetition gains strength; otherwise, coopetition is finished.

In the opinion of managers, tension "*includes both positive and negative emotions*" [HT_6], which strictly corresponds with what Raza-Ullah (2020) describes as paradoxical tension underplayed by an emotional approach and continuous willingness to co-create an appropriate value (Bouncken et al., 2017; Bouncken et al., 2018). Also, it can be a "*conflict of interests and roles (...) and that is extremely important*" [LT_1] and "*when people cooperate, then when it's good, it's good. When it's bad, it's bad – then people behave differently, companies behave differently and react in different ways to a bad situation*" [LT_2].

Heterogenous relevance of coopetition attributes – a side but inspirational outcome of the study

In order to guarantee that the discussion with participants remained focused on attributes relevant to the success of coopetition and thus our further works on their operationalization will refer to the relevant attributes only, all respondents were requested to assign the coopetition attributes into one of four categories referring to the role of a particular attribute in achieving the goals of coopetition and thus making the coopetitive relationship successful. The following categories were used: 3 – key/critically relevant; 2 – very relevant; 1 – relevant; and 0 – not relevant. The ranking of these categories indicated the degree of relevance of each attribute, differentiating between those that are and are not relevant (Table 3).

Table 3. Hierarchy of the relevance of strategic and relational coopetition attributes for coopetition success

VFGI DR	**VFGI HAB**	**VFGI PROF**	**FGI High-Tech**	**FGI Low-Tech**
3 - key/critically relevant attributes for coopetition success (i.e., achievement of shared goals)				
Asymmetry^r Paradoxicality^s Strength^r	Asymmetry^r Mutual dependence^r Paradoxicality^s Strength^r	Asymmetry^r Paradoxicality^s Strength^r Tensions^r	Mutual dependence^r	Mutual dependence^r
2 - highly relevant attributes for coopetition success (i.e. achievement of shared goals)				
Complexity^r Intensity^r Mutual dependence^r Tensions^r	Complexity^r Intensity^r Tensions^r	Complexity^r Intensity^r Mutual dependence^r	Intensity^r Paradoxicality^s Complexity^r Tension^r	Intensity^r Paradoxicality^s
1 – relevant attributes for coopetition success (i.e., achievement of shared goals)				
Dynamics^s	Dynamics^s	Dynamics^s	Asymmetry^r Strength^r Dynamics^s	Asymmetry^r Strength^r Tensions^r Dynamics^s

Note: ^{s} – strategic coopetition attributes, ^{r} – relational coopetition attributes.

The first and general conclusion is that, indeed, all of the considered attributes are considered relevant for coopetition success, however, this relevance varies among the attributes. The second conclusion is that this relevance slightly varies also among the two types of key informants, although the respondents showed relatively high consistency in the opinions they expressed.

On the one hand, nobody identified any of the attributes under consideration as irrelevant. This strengthens our claim on the need for their operationalization and the development of measurement frameworks as the attributes are confirmed to be relevant for coopetition success. On the other hand, the relevance assigned to the considered attributes, even though the group consisted of quite homogenous interlocutors, was found to be slightly different between scholars and managers.

The most significant difference between the representatives of theoretical and practical experience in coopetition refers to asymmetry and strength, which are key for scholars but were assessed as "just" relevant by managers. Respondents from the "scientific" FGI jointly identified the following as critical, key attributes (3): asymmetry, paradoxicality, and strength. Meanwhile, respondents from the "practitioners" group pointed to mutual dependence as a critically relevant attribute both in the high- and low-tech sector. Interestingly, they identified only one attribute as being critical. In categories 1 and 2, the respondents indicated minor differences in the relevance of similar attributes, wherein the "scientific" FGI identified mutual dependence, while the "practitioners" selected intensity and paradoxicality as very relevant attributes for achieving coopetition goals and making coopetitive relationships successful (2). The main difference between the "practitioners" group and the "scientific" respondents was the identification of asymmetry, strength and tension as relevant attributes (1). The output categorization (Table 3) indicates that all of the 8 attributes classified under these three categories (3, 2, 1) are relevant for achieving goals of utilized coopetitive relationships, which remains in line with prior claims that attributes matter for coopetition success (e.g., Jakobsen, 2020). The particular importance of our findings relates to the first category (i.e., 3 – key/crucial relevance) as it supports prior arguments (Klimas et al., 2023b) that in the case of coopetition, there are more than two categories of attributes than are usually considered in other types of inter-organizational relationships (Holm, 1999).

Operationalization of coopetition attributes

Extant coopetition literature claims, that coopetition may be characterized by a wide scope of attributes, and our qualitative investigation supports this claim. The attributes involved are as follows: asymmetry, complexity, dynamics, intensity, mutual dependence, paradoxicality, strength, and tensions – as shown in Table 2. As these attributes are relevant in terms of achieving coopetition goals and making coopetition successful, we would like to offer their operationalization to make it possible to measure them, and thus make it possible to monitor them or even intentionally shape them.

To do so, following the multi-item approach recommended for complex phenomena considered in strategic management (Deng & Dart, 1994) and recommendations for replication of measurement approaches already available in the literature (Bettis et al., 2016), we looked for potential, however coherent with the adopted understandings and conducted interviews, indicators applicable to operationalize particular coopetition attributes. Firstly, we searched in coopetition literature. Secondly, if the measures were not found, we searched in the broader literature focusing on inter-organizational relationships. Basically, in two cases (i.e., dynamics and strength), we could not identify measurement scales and indicators in coopetition literature. Notably, the final proposition of scales or individual proxies measuring particular coopetition attributes found in the literature has been confronted with the data collected during our focus group interviews. The integrated results of our exploration are presented in Table 4.

Table 4. Operationalizations proposed for positively verified strategic and relational coopetition attributes

Attribute	A multi-item approach	Consistency with reference literature	Consistency with interviews	
			VFGIs	FGIs
Strategic coopetition attributes				
Paradoxicality	The agreements between us and our coopetitor provide clear and easily applicable penalties for any incorrect behavior by a participating firm.	Ricciardi et al., 2022 (Fairness-Opportunism)		LT HT
	There is the right level of trust between us and the coopetitor.			LT HT
	There is a robust sharing of common values between us and the coopetitor.	Ricciardi et al., 2022 (Resource Sharing-Resource Control)		LT HT
	Thanks to the coopetition, the partners share human resources and/or other essential resources.			LT HT
	The coopetition develops joint projects that our company could not undertake.	Ricciardi et al., 2022 (Engagement-Rivalry)		LT HT
	The coopetition develops a strategy through a coopetition-level plan.	Ricciardi et al., 2022	DR HAB PROF	
	In this coopetition, we feel both positive and negative emotions simultaneously.	Raza-Ullah, 2020 (Emotional ambivalence)	DR HAB PROF	

Attribute	A multi-item approach	Consistency with reference literature	Consistency with interviews VFGIs	FGIs
Dynamics	In general, this coopetition changes more infrequently than frequently.	Literature on IOR: Denize & Young, 2007 - information exchange variability; Klimas et al., 2023	PROF	LT
	In general, this coopetition is characterized more by regular than irregular exchanges.		PROF	LT
	Our coopetition with this business partner changes frequently.	Literature on IOR: Klimas et al., 2023	PROF	LT
	The meaning of cooperation with this coopetition partner changes over time.		HAB	
	The scope of cooperation with this coopetition partner changes over time.		HAB	HT
	The amount of cooperation with this competitor changes over time.	Inspired by Osarenkhoe, 2010; Czakon et al., 2014; Bouncken et al., 2018	HAB	
	The amount of competition with this competitor changes over time.		HAB	
Relational coopetition attributes				
Asymmetry	There is an asymmetry in terms of possessed and controlled resources between us and our coopetitor.	Inspired by Osarenkhoe, 2010; Monticelli et al., 2018; Kwon et al., 2020; Meena et al., 2022; Yoo et al., 2022	PROF	HT LT
	There is an asymmetry in terms of exchange between us and our coopetitor.	Inspired by: Kim et al., 2013; Pellegrin-Boucher et al., 2013; Monticelli et al., 2018; Jakobsen, 2020	PROF	
	There is an asymmetry in terms of power held by us and our coopetitor.	Inspired by: Raza-Ullah et al., 2014; Lechner et al., 2016; Munten et al., 2021	PROF	
	There is a difference between us and our coopetitor in terms of size.	Inspired by: Baglieri et al., 2016; Lechner et al., 2016; Jakobsen, 2020; Yoo et al., 2019; Yoo et al., 2022		HT LT
	There is an asymmetry in terms of mutual engagement and investments made by us and our coopetitor.	Pellegrin-Boucher et al., 2013; Monticelli et al., 2018	PROF	
	In our coopetition, the strength/intensity of cooperation and competition are not the same.	Inspired by: Czakon et al., 2014; Dorn et al., 2016	PROF	
Complexity	In this coopetition high number and variety of individual actors engaged.	Geurts et al., 2022	DR HAB PROF	
	It is high number and variety of issues covered by coopetition.	Inspired by: Geurts et al., 2022	DR HAB PROF	
	Heterogeneity and diversity of actions undertaken are intense in this coopetition.	Interviews		LT
	Multidimensionality of actions undertaken (e.g., on such levels as individual, operational, strategic, inter-organizational) is intense.		HAB PROF	
	Multidimensionality of links between us and our partner, e.g. cognitive, technological, social, organizational, institutional, geographical, etc. is intense.		HAB PROF	
Intensity	We operationalize coopetition intensity as a multiplicative index of (a) cooperation intensity (i.e., we and the other firm cooperate intensely in some activities) and (b) competition intensity (i.e., we and the other firm compete intensely in some areas) – thus a specific scale is not needed as the measurement should be done using the scales for cooperation intensity and competition intensity.	Raza-Ullah & Kostis, 2020	DR HAB PROF	HT LT
Mutual dependence	We and the coopetitor have an equal say in all business dealings in the alliance.	Muthusamy & Dass, 2021 (Mutual influence)		HT
	We and the coopetitor have an equal influence on each other in all alliance-related decisions.			HT
	Our outcomes from coopetition depends on our coopetitor's behavior and actions.	Interviews		HT
	We and our coopetitor are mutually dependent in a structural manner due to common challenges, financial interlinks and actions undertaken jointly	Inspired by the qualitative findings of: Jakobsen, 2020	DR HAB	
	We and our coopetitor are mutually dependent in a psychological manner due to the existing trust, generosity and emotions between us.		DR HAB	

Attribute	A multi-item approach	Consistency with reference literature	Consistency with interviews VFGIs	FGIs
Strength	We are not looking for alternatives to replace our current coopetitor.	Literature on IOR: Shi et al., 2009 (Cognative strength)	HAB	
	Even if we find a better coopetitor, we will definitely not leave the current one.			
	We do not want to change our coopetitor right away.		HAB	
	We have good informal relationships with this coopetitor.	Literature on IOR: Shi et al., 2009 (Affective strength)		
	We like the interaction with this coopetitor.			
	We defend this coopetitor when other firms criticize or attack them.			
	We care about our coopetitor's long-term success.			
	We have close relationship with our coopetitor.		HAB	
Tensions	In this coopetition, it is difficult to both cooperate in some areas and compete in others.	Raza-Ullah, 2020 (Paradoxical tension)	HAB PROF	LT HT
	In this coopetition, building a close relationship and keeping a certain distance is difficult.			
	In this coopetition, it is difficult to both share knowledge and protect important knowledge.			
	In this coopetition, learning from each other and winning the learning race is difficult.			
	In this coopetition, there is a continuous willingness to both co-create and appropriate value.	Inspired by: Bouncken et al., 2017; Bouncken et al., 2018		LT HT

Note: The literature in italics references works focusing on particular features of IOR, as works in coopetition literature offering measurement were not identified. Therefore, the proposals for the items were made based on the measurement scales available in the literature on IOR.

Given that coopetition is a complex theoretical construct (Czakon et al., 2014; Dorn et al., 2016; Bengtsson & Raza-Ullah, 2016; Devece et al., 2019; Crick, 2019; Xie, Gao, Xia, Zhang, & Tao, 2023), it is recommended to use the subjective measurement approach. This approach seems to be reasoned as coopetition is considered an abstract phenomenon (Crick & Crick, 2019) depending on managers' individual perceptions and cognitions (Czakon et al., 2020). Finally, as Likert-type scales dominate in research on coopetition, they are also recommended when measuring coopetition attributes. To sum up, following the above-mentioned methodological recommendations and the results of our study, we recommend measuring the considered coopetition attributes – i.e., asymmetry, complexity, dynamics, intensity, mutual dependence, paradoxicality, strength and tensions – using the set of specific statements provided in Table 4, and assessing their correspondence to real-life examples of coopetitive relationship using a subjective approach based on Likert-type scale.

DISCUSSION AND CONCLUSION

The aim of this paper was to provide a comprehensive and integrative operational understanding of strategic and relational coopetition attributes, which have been empirically validated as factors contributing to coopetition success and are supported by insights from existing literature. As a result, we propose measurement approaches for 8 specific features of coopetitive relationships (Table 4). We see our operationalization as comprehensive as it builds on solid literature review and verification qualitative investigation integrating two quite different perspectives, namely researchers more focused on theory, definitions, and sound conceptualization and managers more focused on practical application and operational utilization. As an additional but insightful result of our investigation, we provide evidence for the difference in terms of the relevance of considered attributes for coopetition success (Table 3).

The main contribution is methodological, as the results of our investigation provide operationalizations for eight relevant coopetition attributes (Table 4), making it possible to test them quantitatively, including testing a potentially hierarchical model for them. On the one hand, operationalizing a set of coopetition attributes addresses, as shown in Table 1, the knowledge gaps and recommended directions for research within coopetition phenomenon. It also adds to existing knowledge on selectively and fragmentarily investigated coopetition attributes (e.g., asymmetry – Osarenkhoe, 2010; Monticelli et al., 2018; Jakobsen, 2020; complexity – Akpinar & Vincze, 2016; Bouncken et al., 2018; mutual dependency – Hameed & Naveed, 2019; strength – Ritala & Hurmelinna-Laukkanen, 2013; Zrahia, 2018; paradoxicality – Raza-Ullah, 2020; Crick & Crick, 2021a; Liu et al., 2021; tensions – Munten et al., 2021; Geurts et al., 2022; trust – Kostis & Näsholm, 2020; Raza-Ullah, 2021). On the other hand, the development of comprehensive and integrative (i.e., built up using the scales already available in the literature, hence appropriate in the context of gathered qualitative data from both managers and scholars) operationalizations addresses methodological calls for greater precision and reliability in measuring coopetition-related constructs (Gnyawali & Song, 2016; Czakon et al., 2020; Rai et al., 2023; Gelei & Dobos, 2024). In a broader context, the offered operationalizations, as resulting from integrating existing measurement approaches for the considered attributes, supplemented and validated through FGIs, demonstrate to both researchers and managers how to accurately measure the attributes of coopetition strategies and coopetitive relationships that interest them. Adopting an integrative approach to knowledge development (i.e., the focus on guiding future investigations based on the synthesis of existing knowledge - Sauer & Seuring, 2023) can be seen as a significant contribution to the advancement of coopetition research.

Moreover, this study contributes to coopetition literature as it provides empirical evidence for the relevance of coopetition attributes for coopetition success as suggested in existing literature (Christ et al., 2017; Jakobsen, 2020). In the same vein, one would note that it directly addresses the research question posed by Meena et al. (2023), considered as worth addressing so as to push knowledge on coopetition further: "*What are the factors of coopetition leading to a successful alliance?* " (Meena et al., 2023, p. 131). As shown in Table 3, no attribute has been marked by our interlocutors as irrelevant for the achievement of coopetition goals, however, the relevance of particular attributes for coopetition success seems to vary. We believe that those findings add to the current knowledge about success factors of coopetition (Chin et al., 2008; Thomason et al., 2013; Bouncken et al., 2015; Lindström & Polsa, 2016; Resende et al., 2018; Kumar et al., 2021), which so far has not covered strategic and relational coopetition attributes. Regarding the relevance of coopetition attributes, or criticality of attributive success factors of coopetition, it should be noted that in a slightly contrasting view, our empirical verification study corresponds to the conclusions made by Klimas et al. (2023b), who categorized only two features – i.e., dynamics and paradoxicality – as critical ones. Based on our interviews, we cannot definitively confirm or reject this categorization as paradoxicality (but also mutual dependence) has been found to be a critical success factor while dynamics to be "just" relevant for coopetition success. Considering those inconsistencies, we call for further, in-depth, quantitative investigation and verification of the relevance of coopetition attributes. This is even more reasoned as although we found the differences among the features in terms of their relevance, the opinions of our interviewees were highly divergent (for example, between complexity, asymmetry, and strength). We believe that further quantitative research will indicate if - in the context of the impact on coopetition success - there is a hierarchy of coopetition attributes or not, and what this hierarchy is like. Moreover, considering the relatively greater cognitive value of studies employing a multi-informant approach and differentiating key informants (Homburg, Klarmann, Reimann, & Schilke, 2012; Taylor & Blake, 2015), alongside the lack of such studies in the field of coopetition (as multi-informant research is notably absent in various SLRs summarizing the existing literature on coopetition – (e.g., Corbo et al., 2023; Meena et al., 2023), and taking into account our findings that suggest practitioners' and scholars' perspectives may differ and even complement each other (supportively for findings on family issues in which mothers and daughters were used as key, complementary informants – Sands & Roer-Strier, 2006), it seems reasonable to pursue research involving diverse informants in the coopetition context. Specifically, these studies could focus on the most commonly explored areas, such as the antecedents of coopetition and its outcomes, particularly those related to innovation.

In addition to contributing to the theory and research on coopetition, our study offers practical value in two dimensions. Firstly, it verifies attributes as factors contributing to coopetition success (Table 3). Secondly, it presents operationalizations for these factors (Table 4). In managerial practice, coopetition is used to leverage firm performance. Nonetheless, the success rate of coopetition is far from 100%, as coopetition brings both positive and negative effects (Bouncken et al., 2018) and usually ends up as a strategic failure (Bengtsson & Raza-Ullah, 2016; Crick, 2020). This explains the great interest of practitioners and scholars in the identification of (key/critical) success factors of coopetition (Chin et al., 2008; Ritala, 2012; Thomason et al., 2013; Bouncken et al., 2015; Klimas, 2016; Lindström & Polsa, 2016; Resende et al., 2018; Kumar et al., 2021; Raza-Ullah, 2021). Therefore, as a main managerial implication of our study, we see the extension of the list of success factors of coopetition by eight coopetition attributes. Our study shows managers of firms adopting coopetition strategies that asymmetry, complexity, dynamics, intensity, mutual dependence, paradoxicality, strength and tensions should be considered and monitored, as they may impact the success of coopetition.

In the case of strategic coopetition attributes covering paradoxicality and dynamics, our study shows that much higher relevance for coopetition success is assigned to paradoxicality (Table 3) than to dynamics. For the managers, it means that the implementation of a successful coopetition strategy needs more significant focus on handling coopetitive paradoxes (Raza-Ullah et al., 2014; Raza-Ullah, 2020; Crick & Crick, 2021a) and strategic coopetitive dilemmas (Klimas & Radomska, 2022) than on the changes in the levels of competition and cooperation. This not only indicates that changes in the intensity of competition and cooperation are less significant than managing paradoxes but also suggests that periodic imbalances in the intensity of competition and cooperation, meaning occasional lack of balance between them, do not necessarily require immediate remedial or corrective actions from the perspective of ensuring the success of coopetition.

Concerning relational coopetition attributes, the utmost significance for coopetition success has been ascribed to mutual dependence, and to a slightly lesser extent, intensity and tensions. These relational attributes necessitate heightened managerial attention in managing coopetitive relationships (Tidström, 2014; Le Roy et al., 2018; Jakobsen, 2020). Continuous monitoring is particularly crucial, given that coopetitive relationships, along with their attributes, undergo temporal changes (Bengtsson & Raza-Ullah, 2016).

Moreover, besides broadening the managerial awareness of the relevant drivers of coopetition success (Table 3), we show managers how to measure the attributive success factors (Table 4). The developed operationalizations can be applied to assess and enhance coopetition strategies and coopetitive relationships, potentially leading to improved performance and success in cooperative endeavors, which in turn may lead to an increase in firm performance (Crick, 2019). Therefore, as argued by Gelei and Dobos (2024), as our study offers clear operationalizations, it holds practical meaning for managers by elucidating the complex nature of coopetition attributes by offering valuable insights for better navigation and more successful adoption of coopetition.

Given the methodological perspective, our research should also be interpreted in light of several limitations. Firstly, there are always some limitations in this type of research, such as the possibility of obtaining data suggested by a moderator or dominant participant, or subjectivity in interpreting empirical material (Smithson, 2000). We tried to avoid such errors by using two types of key informants, by relying on the moderator's professionalism and expertise in the field of coopetition research, and by a team of three researchers observing the FGI from behind a two-way mirror. Moreover, the diversity of the sample, which included scholars experienced in coopetition research and senior managers from firms exploiting coopetitive relationships, meant more variety in discussions and a richer insight into how the topic relates to practice, instead of focusing solely on the scientific field. The two perspectives gave us a broader view of the meaning, role, and hierarchy of features of coopetition. We believe that this is an essential direction for focus group research. Nonetheless, our virtual FGIs with coopetition scholars were conducted by a facilitator who was well-known to the participants, which may have affected the findings. Secondly, since the focus groups were conducted in Poland, we realize that the verification of coopetition features may be burdened with an assessment error resulting from cultural and national values. Nonetheless, as coopetition is claimed to be a highly contextual phenomenon (Czakon et al., 2014), the national scope of our study seems to be reasoned. However, given the above, it would be valuable to include international focus groups in the future or at least to test the developed operationalization in different national contexts.

Finally, it should be noticed that, to the best of our knowledge, neither in our explorative study nor in other research, none of the considered coopetition attributes has undergone the multi-stage validation process as defined by Gerbing and Anderson, 1988; Hinkin, 1995 or Hair, Black, Babin, and Anderson, 2019. Therefore, the proposed measurement items (Table 4), employing the measurement recommendations outlined in the last subsection of "Findings", should be subjected to a quantitative validation process to test our propositions for unidimensionality, reliability, convergent validity, discriminant validity, and predictive (nomological) validity as it has been done for instance for behavioral antecedents of coopetition (Czakon et al., 2020) or coopetition capability (Rai et al., 2023).

While our findings directly point to the need to undertake quantitative research on the coopetition attributes, the other research avenues may also be outlined. On the one hand, given the identified but relatively chaotic diversification of the relevance of particular relational coopetition attributes, but also considering the side comments made by some of our interlocutors and the literature on inter-organizational relationships (e.g., Jap & Ganesan, 2000), it might be that the attributes and their meaning depend on the maturity of a relationship and its specific phase in the life cycle. This remains in line with research on coopetition in which the phase of the coopetition life cycle has been used as a control variable (Bouncken et al., 2020; Xu, Yang, Zhang, & Guo, 2021). On the other hand, as our research confirms that the strategic and relational coopetition attributes are relevant for coopetition success, we suggest undertaking quantitative research focused on testing the relationship between the attributes and coopetition success (to measure the success of coopetition the scale developed by Raza-Ullah (2020) may be used). Moreover, as coopetition success is claimed to lead to coopetition performance and firm performance (Crick, 2019), we see it interesting to test the relationships (direct and indirect with mediation effects) between coopetition attributes and those two types of coopetition outcomes (to measure coopetition performance the scale used by Ricciardi et al. (2022) may be used, while to multidimensionally measure firm performance in the context of coopetition one may use the scale developed by Crick (2020)). Furthermore, as the attributes can be considered at different levels, it might be interesting to test their joint, multi-level impact on coopetition outcomes using hierarchical linear modeling (HLM). All in all, those research ideas remain in line with a recent stream of research focused on the factors impacting coopetition performance (Raza-Ullah, 2020; 2021; Raza-Ullah & Kostis, 2020; Ricciardi et al., 2022). Last, our study sheds light on the differences in the attributed meaning, role, and importance of various coopetition characteristics between coopetition researchers and practitioners. In this context, examining to what extent these differences exist and whether they will be confirmed as statistically significant in quantitative studies becomes intriguing. Furthermore, the fact that academia and practice value the attributes of coopetition differently prompts reflection on how well academic research meets the needs and understanding of the world by practitioners.

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Author contributions statement

Patrycja Klimas: Conceptualization, Data Curation, Formal Analysis, Funding Acquisition, Investigation, Methodology, Project Administration, Resources, Software, Supervision, Validation, Visualization, Writing Original Draft, Writing – Review & Editing. General Coordination of Works. **Sylwia Stańczyk**: Conceptualization, Funding Acquisition, Investigation, Resources, Visualization, And Writing – Review & Editing. **Karina Sachpazidu**: Conceptualization, Funding Acquisition, Investigation, Resources, Visualization, and Writing – Review.

Conflicts of interest

The authors have no conflict of interest to declare.

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Guiding incumbent companies in navigating digital transformations: A qualitative study on structural ambidexterity and strategic leadership

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Abstract

PURPOSE: *Despite digital transformation being a focus topic for incumbent companies, organizational structures are a significant barrier to their success. Referring to the positive correlation between ambidexterity and digital innovation, our research provides guidance on structural ambidexterity for incumbent companies. Previous research has barely differentiated between exploration and exploitation in digital transformation. In the present paper, we fill part of this research gap by focusing on structural ambidexterity in digital transformations and providing guidance on how incumbent companies can overcome organizational challenges.* ***METHODOLOGY****: Our research is based on an explorative research design with 33 semi-structured interviews that allow in-depth information. The interview partners were selected using purposive sampling and represented different industry and hierarchy levels. All of them have been in a position related to digital transformation in an incumbent company for the last two years. We ensure scholarly rigor using thematic analysis to analyze our data.* ***FINDINGS:*** *Our decision tree guides separation or integration based on the closeness of digital activities to the core business and the association of the activities to exploration or exploitation. Additionally, we recommend considering the digital maturity grade in the decision-making. Developing a cross-functional digital transformation strategy and pursuing a balanced portfolio fosters ambidexterity in digital transformation. Clear responsibilities, collaborative decision-making, candidate selection, and collaboration with IT are essential leadership activities.* ***IMPLICATIONS*** *for theory and practice: Our research expands the existing research on digital transformations of incumbent companies. We specifically contribute to the limited details on how to separate digital activities considering an exploration/exploitation perspective. Our study guides practitioners to address one of their major challenges in digital transformations with the help of our decision tree.* ***ORIGINALITY AND VALUE****: Based on the positive correlation between ambidexterity and digital innovation, our study contributes to the existing research by providing in-depth knowledge of structural ambidexterity in digital transformations. This detailed information is essential to provide knowledge on enabling the positive correlation between ambidexterity and innovation in the context of structural ambidexterity.*

Keywords: *digital transformation, digitalization, organizational structures, structural ambidexterity, temporal ambidexterity, incumbent companies, guidelines*

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INTRODUCTION

Digital transformation has become a primary concern for many incumbent companies (Hess et al., 2016; Kane et al., 2015). Incumbent companies no longer question the decision to digitally transform as this is no longer an option to stay competitive (Brunetti et al., 2020; Mirković et al., 2019; Paulino, 2022; Verhoef et al., 2021). Facing market disruptions enabled by digital technologies and new market entrants, companies need to derive a strategy to embrace digital transformation (Hess et al., 2016). Incumbent companies require answers on leveraging opportunities supported by digital technologies (Westerman et al., 2014). Despite the growing interest, the research on incumbent's digital transformation is still quite narrow (Gregory et al., 2015; Oberländer et al., 2021). The availability of new technologies provides companies across multiple industries (Soto Setzke et al., 2023) with new opportunities (Göbeler et al., 2020) to change their value propositions (Soto Setzke et al., 2023). Nevertheless, incumbent companies also face challenges in that process (Klos et al., 2021; Mirković et al., 2019; Zhang et al., 2023). Often, companies fall behind on the expected financial improvements despite investments in digital offerings (Gebauer et al., 2020; Klos et al., 2021). Even if the majority of the existing literature addresses the impact of technologies on digital transformation (Coreynen et al., 2020; Mirković et al., 2019; Soluk & Kammerlander, 2021), technological know-how is not identified as a significant barrier to digital transformation (Mirković et al., 2019). Studies show that planning, developing, and implementing the technological aspects of digital transformations is most evident, but technological know-how alone is insufficient for success. Instead, the required organizational changes confront incumbent companies with additional tasks (Bjoerkdahl, 2020; Mirković et al., 2019). Developing new digital value propositions, such as digital services, requires incumbent companies to adjust processes, working models, and organizational structures (Soto Setzke et al., 2023). Therefore, aside from technological aspects, the managerial aspect of digital transformation might have substantial implications (Soluk & Kammerlander, 2021). The definition of digital transformation shows that it includes improving the existing by raising efficiencies of existing processes and enhancing products and services by integrating digital technologies. It also contains aspects with a higher level of change impact, such as rethinking business models in a radically new way (Alghamdi, 2018; Hess et al., 2016; Schiffer, 2021; Vesna Bosilj Vukšić et al., 2018; Wu et al., 2021). Also, Soto Setzke et al. (2023) point out the fundamental change character of digital transformation and the differentiation to prior technology changes.

Therefore, digital transformation comprises incremental and radical innovation activities (Hoessler & Carbon, 2022; Ismail et al., 2017) and can be linked to the concept of ambidexterity (Duncan, 1976; March, 1991). Ambidexterity is about being able to address current business needs but also addressing future developments. Ambidextrous companies can balance conflicting demands (Duncan, 1976; Gibson & Birkinshaw, 2004; Michael. Tushman & O'Reilly III, 1996). Whereas there is individual research on digital transformation or ambidexterity, research has not focused too much on ambidexterity (Brauer et al., 2021; Wu et al., 2021). Suppose ambidexterity is connected with digital transformation; in that case, the focus is often on individual aspects such as performance impact (Del Giudice et al., 2021), technical aspects (Shao et al., 2021; Wu et al., 2021), or IT structures (Iho & Missonier, 2020; Jöhnk et al., 2020; Montealegre et al., 2019). Nevertheless, research shows a positive correlation between ambidexterity and digital innovation (Del Giudice et al., 2021). One differentiating factor of the different concepts of ambidexterity is separation and integration via organizational structures, and digital transformation efforts often require structural changes (Hess et al., 2016; Soto Setzke et al., 2023). Multiple researchers explain that digital transformation influences organizational structures (Holotiuk, 2020; Schiffer, 2021), and it has been identified as a challenge for incumbent companies (Bjoerkdahl, 2020; Mirković et al., 2019). Nevertheless, this has received little research attention so far, especially not providing in-depth details. Also, a recent study highlights the need for more research on the centralizing and decentralizing dynamics in digital transformation (Plekhanov et al., 2023).

We aim to address this research gap. To guide how to manage one of the major challenges in digitally transforming incumbent companies, we focus on structural ambidexterity in digital transformations. With this, we address the research gap on how incumbent companies can overcome organizational challenges (Smith & Beretta, 2021). Addressing the lack of details on how to separate, we investigate exploration/exploitation separation, its driving factors, and how to separate or integrate digital / core business. As leadership is required to create or reinforce ambidextrous behavior (Alghamdi, 2018; Bell & Hofmeyr, 2021; Jansen et al., 2008; Keller & Weibler, 2015; Lin & McDonough III, 2011; Mueller et al., 2020; Probst et al., 2011), we add needed strategic leadership activities to frame our research objective. Our study aims, therefore, to answer the following research questions (RQs):

RQ1) How can incumbent companies apply the concept of structural ambidexterity to navigate digital transformation?
RQ2) What elements of strategic leadership do leaders in incumbent companies need to implement when navigating digital transformation considering structural ambidexterity?

We first develop the theoretical background, make our methodology transparent, and illustrate our results, and will then discuss the results in the face of already existing findings to draw practical conclusions for entrepreneurship, management, and innovation leadership (Hoessler & Carbon, 2022; Ismail et al., 2017).

LITERATURE REVIEW

Digital transformation

Digital transformation has gained increasing interest from researchers and practitioners (Klonek et al., 2020; Vesna Bosilj Vukšić et al., 2018; Westerman et al., 2014). Lacking one unified definition (El Sawy et al., 2020; Haffke et al., 2016), existing understandings have similarities, which we use for our combined definition in this paper. Digital transformation goes beyond technologies (Eberl & Drews; El Sawy et al., 2020). It is a leadership challenge to enable the necessary change to transform the business successfully (Hensellek, 2020). Compared to new digital start-ups, incumbent companies have already established external relationships, defined internal processes (Zhang et al., 2023), and preserved core competencies (Klos et al., 2021). Therefore, their reaction to digital transformation is different. In our study, we focus on incumbent companies to address this distinction. Digital transformation aims to create radically new ways of doing business (Berghaus & Back, 2016; Holotiuk; Nambisan et al., 2019). A fundamental change in value proposition through, for example, new business models is characteristic of digital transformation (Zhang et al., 2023). The existing way of doing business is either substituted, extended, or transformed with the help of digital technologies and leadership (Pihir et al., 2018). Especially recent developments in three-dimensional printing (Klos et al., 2021) and artificial intelligence are seen as enablers for transforming decision-making processes or business models (Klos et al., 2021; Zhang et al., 2023). Digital transformation can be seen as the most advanced stadium of a three-phase process (Hoessler & Carbon, 2022; Verhoef et al., 2021). This is a long path achieved by combining incremental and radical innovations shown in different maturity phases (Goerzig & Bauernhansl, 2018; Porfírio et al., 2021). This transformation process needs to be guided by a strategic setting (Klos et al., 2021). The first phase of digital transformation is digitization (Tekic & Koroteev, 2019). This phase is limited to technology (Yoo et al., 2010). The second phase is an intermediate stage between the initial digitization and the final target of a digitally transformed business. Words like digitalization, digital innovation, and digital business model change describe phase two. Automated, extended, or substituted business processes with higher efficiency or higher value added for the customer is the outcome (Cavalcante et al., 2011; Florek-Paszkowska et al., 2021; Li, 2020; Sousa & Rocha, 2019). Whereas there is no clear key performance indicator, when the next phase is achieved, it is more about clustering different activities on the path to digital transformation. Therefore, Saarikko et al. (2020) describe the three clusters as domains instead of stages. In this paper, we use the term "phase," as we can see them as consecutive but not as clearly moving upwards as the term "stage" would imply. Those phases can be connected to digital maturity grades (Ifenthaler & Egloffstein, 2020). Nevertheless, digital transformation is not a final stage. Instead, it is a path that includes multiple choices with potentially different outcomes (Furr et al., 2022). With the given definition, we identify that digital transformation is a process that includes incremental and radical innovations and, therefore, can be linked to the concept of ambidexterity. In the following section, we will first generate a general understanding of ambidexterity, its concepts, and how to achieve it independently of the digital context. This is followed by an analysis of the literature on ambidexterity in digital transformation.

Ambidexterity in general

Companies that balance exploration and exploitation are ambidextrous organizations (Duncan, 1976; Michael. Tushman & O'Reilly III, 1996). Exploration is characterized by experimenting and investigating radically new topics (March, 1991) and is associated with radical innovations (Beckman, 2006; Benner & Tushman, 2003). A higher level of risk is associated with exploration due to the unknown (March, 1991). Exploitation can be described as improving the existing, focusing on efficiency and productivity gains. Exploitation is closely connected to established processes or products, so the results are more obvious and risk-averse (March, 1991). Achieving balance should be the target as too much exploration can result in high costs with no results, but too much exploitation is unfavorable as it leads to stagnation (March, 1991). Existent research proves the positive relationship between ambidexterity and a company's long-term performance (Brix, 2019). Especially in a fast-changing environment, one characteristic of digital technologies is that a long-term balance of exploration and exploitation is essential (O'Reilly III & Tushman, 2013; Yoo et al., 2012). As those activities are paradoxical, managing them is highly challenging for companies—they often have problems achieving ambidexterity. For example, companies find it difficult to find an applicable balance (Chen & Katila, 2008), not prioritizing one of the activities, especially exploitation (Chen & Katila, 2008), responding to changing environments (Halevi et al., 2015), achieving ambidexterity in superior management (Keller & Weibler, 2015) and establishing new mindsets and skills (Michael Tushman & Euchner, 2015). There is no unique definition of ambidexterity, mainly resulting from different understandings if exploration and exploitation are complementary or fundamentally incompatible and in competition. In addition, scholars represent different opinions if ambidexterity means achieving a simultaneous balance of exploration and exploitation (balanced ambidexterity) (Cao et al., 2009; Gupta et al., 2006; Levinthal & March, 1993) or if it also can be switching between them over time (combined ambidexterity) (Cao et al., 2009). Based on those various definitions, multiple concepts of ambidexterity have evolved (Cao et al., 2009). In the original literature on ambidexterity, the main concepts are *structural ambidexterity* (Benner & Tushman, 2003; Duncan, 1976; Gibson & Birkinshaw, 2004; O'Reilly III & Tushman, 2013), *sequential ambidexterity/punctuated* equilibrium (Boumgarden et al., 2012; Cao et al., 2009; Gupta et al., 2006; Simsek, 2009) *and contextual ambidexterity* (Gibson & Birkinshaw, 2004). Reasoned by the interdisciplinary characteristics of digital innovation and the fast-changing character of digital technologies, Holotiuk and Beimborn (2019) introduced a new form of ambidexterity called *temporal ambidexterity.* The different concepts of ambidexterity are not mutually exclusive but can be combined (Brauer et al., 2021; Jöhnk et al., 2020). If structural separation occurs and employees are guided to pursue exploration and exploitation activities (contextual), companies combine structural and contextual ambidexterity. This concept of ambidexterity is called *hybrid ambidexterity* (Jöhnk et al., 2020; Ossenbrink et al., 2019). We do not list this concept separately as it involves the combination of structural and contextual ambidexterity, which would duplicate the individual aspects.

Ambidexterity is often connected to dynamic capabilities, and especially in the digital context, this connection is justified. Dynamic capabilities help to address changing environments and gain competitive advantage (Teece et al., 1997). Dynamic capabilities are split into three primary activities: 1) Sensing, 2) Seizing, and 3) Transforming (Teece, 2007). On the one hand, sensing can be connected to exploration as it is about identifying new things (Birkinshaw et al., 2016; Teece, 2007). On the other hand, seizing is related to exploitation as it is about improving the existing through execution (Birkinshaw et al., 2016; Teece, 2007). Connecting dynamic capabilities with exploration, exploitation, and ambidexterity leads to the lower-level concepts of sensing (exploration) and seizing (exploitation). Those are associated with the higher-level concept of transformation, which is about splitting resources (Birkinshaw et al., 2016). Table 1 illustrates the differences between the four concepts of ambidexterity based on the main differentiating factors and dynamic capabilities perspective.

Table 1. Characterizations of concepts of ambidexterity

	Structural ambidexterity	**Sequential ambidexterity**	**Contextual ambidexterity**	**Temporal ambidexterity**
Responsibility split regarding exploration and exploitation	Separation of organizational units	Shift of focus on the firm level	Employees to split time	Employees to shift between organizational units
Way of managing trade-off between exploration and exploitation	Separation	Consecutive	Integration	Temporal separation and Alignment
Dedicated exploration or exploitation organizational unit	Either / Or	Either / Or – changes over time	Both	Both – limited time
Team structure within organizational Unit	No details available – tendency towards more fix structures	N/A as no different organizational units	N/A as no different organizational units	Flexible team structure – Employees shifting between units

	Structural ambidexterity	Sequential ambidexterity	Contextual ambidexterity	Temporal ambidexterity
Dynamic capabilities	Separated sensing/seizing units via resource-linking capability	Sensing and seizing managed via focus-shifting capability	Sensing and seizing managed via context-shaping capability	Separated sensing/seizing units via resource-linking capability, temporal focus-shifting capability

Source: Birkinshaw et al. (2016), Hoessler and Carbon (2022), and Holotiuk and Beimborn (2019).

With the help of dual structures, such as separating by setting up business units dedicated to either exploration or exploitation, the two competing activities can be balanced when following the concept of *structural ambidexterity* (Duncan, 1976; Gibson & Birkinshaw, 2004). Separated sensing/seizing units are managed via a resource-linking capability (Birkinshaw et al., 2016). When a company's focus is set to either exploration or exploitation over a more extended period and then shifted consecutively on a company level, companies pursue *sequential ambidexterity* (Gupta et al., 2006; Simsek, 2009). Sensing and seizing are managed via a focus-shifting capability (Birkinshaw et al., 2016). Companies enabling employees to split their time between exploration and exploitation choose *contextual ambidexterity* by integrating exploration and exploitation. There is no focus on exploration or exploitation (Gibson & Birkinshaw, 2004). Sensing and seizing are managed via context-shaping capability (Birkinshaw et al., 2016). *Temporal ambidexterity* combines structural, sequential, and contextual ambidexterity as selected employees shift to the digital innovation lab for a limited time and focus on exploration during this time. With this flexible team structure, employees return to their original business and concentrate again on exploitation (Holotiuk & Beimborn, 2019). Separated sensing/seizing units are managed via resource-linking and focus-shifting capability for employees shifting between units (Birkinshaw et al., 2016). Overall, there is no universal right decision. Instead, the leadership is responsible for placing the company in a suitable composition of exploration and exploitation to gain a competitive advantage (Keller & Weibler, 2015). This also highly depends on the context, such as industries and other environmental factors (Bell & Hofmeyr, 2021; Havermans et al., 2015; Wasono & Furinto, 2018). Empirical research proves a positive relation between ambidexterity and superior company performance (Brix, 2019), and leadership is required to create or reinforce ambidextrous behavior (Alghamdi, 2018; Bell & Hofmeyr, 2021; Jansen et al., 2008; Keller & Weibler, 2015; Lin & McDonough III, 2011; Mueller et al., 2020; Probst et al., 2011). Leadership in this paper implies "lead[ing] oneself and human communities […] into an innovative and creative future in open and complex situations under unclearly defined and dynamic conditions" (Faix et al., 2020, p. 61). Aside from motivating people to change, providing direction and vision and aligning people are leadership responsibilities (Kotter, 2017). This definition also considers the requirements and specifics of current times (Faix et al., 2020). According to (Samimi et al., 2020, p. 3), leadership includes "managing conflicting demands," implicating a connection to ambidexterity.

Ambidexterity in digital transformation

IT ambidexterity is a research stream covering a portion of ambidexterity in digital transformation (Park et al., 2020). It does not cover the full scope of digital transformation. Instead, it is limited to the paradoxes of IT transformations, such as IT portfolio decisions or IT architecture (Gregory et al., 2015) and infrastructure changes (Montealegre et al., 2019). In addition, IT ambidexterity applies the described concepts of structural, sequential, or contextual ambidexterity to the IT context (Park et al., 2020). Nevertheless, those concepts are limited to the technology character and purpose of IT without considering the full intent of digital transformation. For example, Park et al. (2020) refer to digitization as not covering the aspects of digital transformation. Individually, sequential ambidexterity (Smith & Beretta, 2021) and contextual ambidexterity (Hoessler & Carbon, 2022; Hron et al., 2021) are only sporadically brought into the context of digital transformation. Smaller companies, mainly, have limited resources and, therefore, pursue a path of digital transformation with different focus areas over time (Bjoerkdahl, 2020). This concept can be indirectly linked to sequential ambidexterity. Asking leaders to provide the context for employees to focus on suitable activities can be indirectly mapped to contextual ambidexterity (Göbeler et al., 2020; Hoessler & Carbon, 2022; Hron et al., 2021).

The highest popularity within the digital transformation context receives structural ambidexterity, mainly focusing on digital innovation labs (Holotiuk, 2020; Raabe et al., 2020) or separating the traditional from the new digital business (Kaiser & Stummer, 2020). Structural ambidexterity is described as a concept especially applicable to incumbent companies, allowing them to continue the existing but also step into the digital world (Schiffer, 2021). In addition, we see the closely associated concept of temporal ambidexterity due to its origin in the digital context as a focus area (Holotiuk & Beimborn, 2019). This paper focuses on structural ambidexterity as organizational structures are identified as one major challenge of digital transformations of incumbent firms (Mirković et al., 2019). We identified the literature connecting digital transformation with ambidexterity, mainly focusing on structural ambidexterity, and analyzed the existing research. We selected "Web of Science" as the scientific platform using the databases CPCI-SSH , CPCI-S , SCI-EXPANDED , SSCI for our research. "Digital AND ambidex*" is the search topic we used to identify research connecting digital transformation and ambidexterity. As digital transformation is an emerging research field that has started growing in the last 15 years (Hoessler & Carbon, 2022; Pihir et al., 2018), we limited our search to 2008-2023. Our initial search results included 193 articles. After eliminating the non-accessible ones, we reviewed 174 articles. Our exclusion criteria removed articles with no digital context, different focus areas, no or minimal ambidexterity qualitative context, limited to technologies, no business context, and not related to incumbent companies. The result was 23 articles. Details can be found in Figure 1.

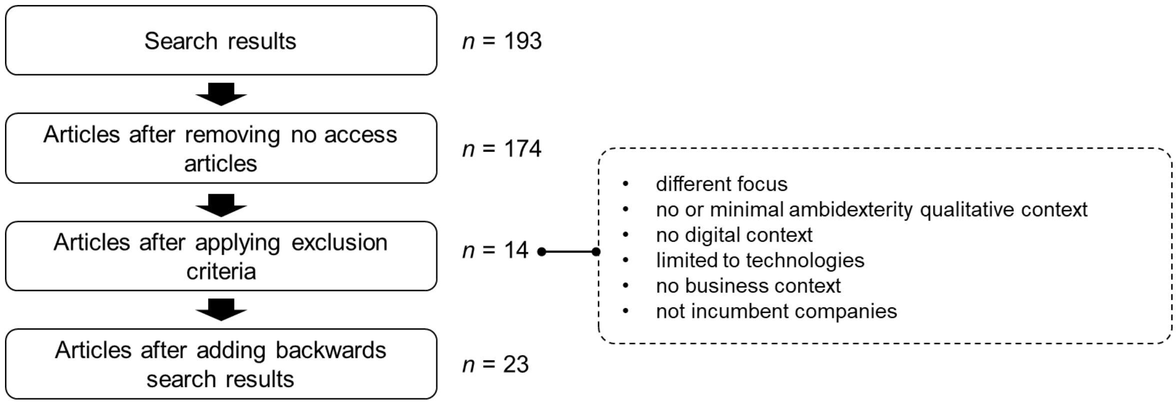

Figure 1. Process of literature review

Combining the traditional understanding of separating exploration/exploitation activities via organizational structures as structural ambidexterity, we categorized the 23 articles into four categories:

1) Not distinguished between exploration/exploitation in digital business (7).
2) Fuzzily distinguished exploration/exploitation in digital business (7).
3) Clear distinguished exploration/exploitation in digital business (4).
4) N/a; no details provided (5).

The comparison of the categories shows that most of the existing research either provides no details, neglects the differentiation of exploration/exploitation in digital business, or provides only minimal information about the separation. Only 4 out of 23 analyzed papers clearly distinguish between exploration/exploitation in digital business. Here, the authors clearly state the separation of exploration from exploitation in digital business (Brauer et al., 2021; Holotiuk & Beimborn, 2019; Hron et al., 2021). An example of providing a low level of distinguishing between exploration/exploitation in digital business is the work of Hess et al. (2016). Hess et al. (2016) recommend separating new digital products and integrating hybrid products related to the core business in the core organization. Sia et al. (2021) and van den Buuse et al. (2021) extend the scope from product to offerings and propose separating them. Nevertheless, there is no indication of how incremental or radical the new offerings are. From a process perspective, Sia et al. (2021) provide clear guidance to integrate automation activities into the core organization. This aligns with the literature review of Hoessler and Carbon (2022), who classified the automation of existing processes as exploitation. In addition, existing literature suggests considering innovation stages (Hellmich et al., 2021), focus areas (Jöhnk et al., 2020), and levels (Jaspert & Ebel, 2022). 7 out of 23 papers do not distinguish between exploration/exploitation in digital business. Even if a lot of the research does not label it structural ambidexterity (Schiffer, 2021), research is showing that companies separate new digital businesses with the help of separate business units (Sund et al., 2021) or sub-companies (Kaiser & Stummer, 2020). So-called digital units or digital innovation labs are separated to conduct digital innovations. Nevertheless, there is no distinction between exploration and exploitation within digital innovation (Åkesson et al., 2018; Göbeler et al., 2020; Holotiuk, 2020; Kaiser & Stummer, 2020; Schiffer, 2021; Smith & Beretta, 2021; Sund et al., 2021). A case study conducted by Göbeler et al. (2020) shows problems arising from separating all digital activities. In addition to the four categories mentioned above, we analyzed the literature to see if they mention details on how organizational structures can change over time. It is brought up by some authors that a digital innovation hub can be a temporary separation and dissolved over time (Åkesson et al., 2018; Göbeler et al., 2020; Hron et al., 2021; Svahn et al., 2017). Also, we identified that more than half of the existing studies focus on one industry. As digital transformation affects a wide range of industry sectors (Hess et al., 2016; Kane et al., 2015), we see this as a limitation and recommend a study not limited to one specific sector. Table 2 summarizes the results of our literature research on digital transformation and structural ambidexterity.

Table 2. Literature research on digital transformation and structural ambidexterity

	Number (%)	Details and sources
Not distinguished exploration/exploitation in digital business	7 (30%)	Everything related to digital separated (Åkesson et al., 2018; Göbeler et al., 2020; Holotiuk, 2020; Kaiser & Stummer, 2020; Schiffer, 2021; Smith & Beretta, 2021; Sund et al., 2021) but closely connected to core organization (Smith & Beretta, 2021) or integration of exploration outcome (Holotiuk, 2020) Case studies show problems arising from separating all digital activities (Göbeler et al., 2020)
Fuzzily distinguished exploration/exploitation in digital business	7 (30%)	Hybrid products related to core business integrated into the core organization and new digital products are separated (Hess et al., 2016) Automation core business (Sia et al., 2021), new digital offerings separate unit (Sia et al., 2021; van den Buuse et al., 2021) Renewal and refinement units (limited to digital platforms) (Montealegre & Iyengar, 2021) Different set-ups depending on the innovation stage (Hellmich et al., 2021), focus areas (Jöhnk et al., 2020) and levels (Jaspert & Ebel, 2022)
Clear distinguished exploration/exploitation in digital business	4 (17%)	Exploration in a separate unit (Brauer et al., 2021; Holotiuk & Beimborn, 2019; Hron et al., 2021; Raabe et al., 2020) but drift to exploitation (Hron et al., 2021)
N/a; no details provided	5 (22%)	No details overall on the responsibilities of separate unit (e.g., innovation hub) vs. core (Kronblad et al., 2023; Soto Setzke et al., 2023; Svahn et al., 2017) No separation (Gastaldi et al., 2018; Oberländer et al., 2021)
Total	*23*	
Change over time	4 (17%)	Dissolvement of innovation hub (Åkesson et al., 2018; Göbeler et al., 2020; Hron et al., 2021; Svahn et al., 2017)
No details on change over time	19 (83%)	No details on changes in separate hub (Brauer et al., 2021; Hellmich et al., 2021; Hess et al., 2016; Holotiuk, 2020; Jaspert & Ebel, 2022; Jöhnk et al., 2020; Kaiser & Stummer, 2020; Kronblad et al., 2023; Montealegre & Iyengar, 2021; Raabe et al., 2020; Schiffer, 2021; Sia et al., 2021; Smith & Beretta, 2021; Soto Setzke et al., 2023; Sund et al., 2021; van den Buuse et al., 2021)
Total	*23*	
One industry	13 (57%)	(Åkesson et al., 2018; Gastaldi et al., 2018; Göbeler et al., 2020; Hron et al., 2021; Jaspert & Ebel, 2022; Kaiser & Stummer, 2020; Kronblad et al., 2023; Schiffer, 2021; Sia et al., 2021; Smith & Beretta, 2021; Sund et al., 2021; Svahn et al., 2017; van den Buuse et al., 2021)
Multiple industries	9 (39%)	(Brauer et al., 2021; Hellmich et al., 2021; Hess et al., 2016; Holotiuk, 2020; Holotiuk & Beimborn, 2019; Jöhnk et al., 2020; Oberländer et al., 2021; Raabe et al., 2020; Soto Setzke et al., 2023)
Unclear	1 (4%)	(Montealegre & Iyengar, 2021)
Total	*23*	

METHODOLOGY AND RESEARCH METHODS

The underlying method to answer our research question is based on Mayring (2001) and enriched with guidance provided by Braun and Clarke (2006) for code development. Figure 2 displays the method used in the present paper.

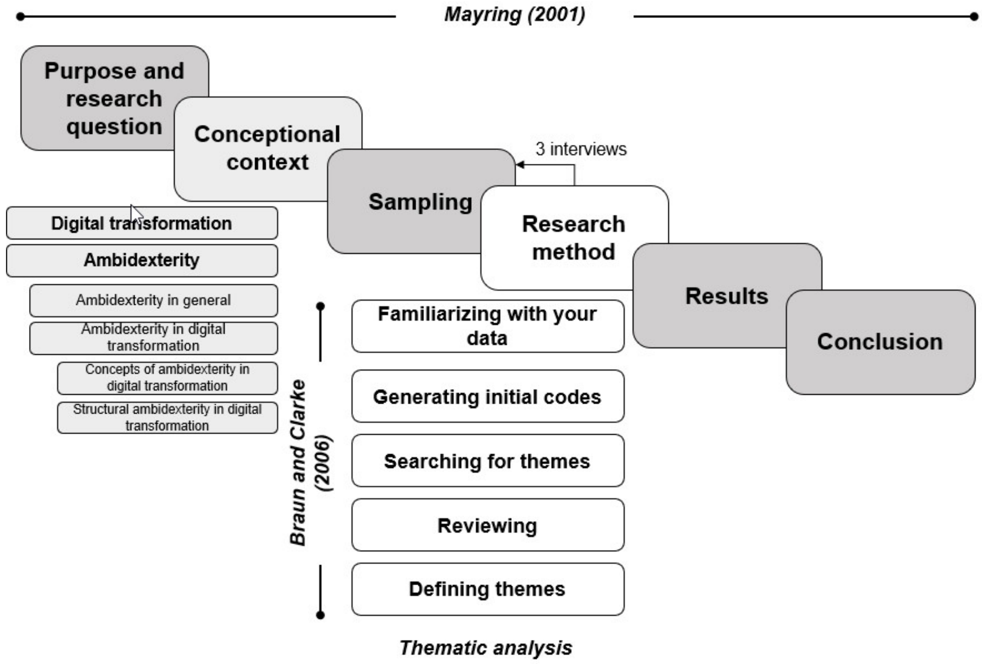

Figure 2. Research design for a qualitative study
Source: Mayring (2001) and Braun and Clarke (2006).

Our study has the *purpose* of addressing the research gap on how to overcome organizational challenges (Smith & Beretta, 2021) and master structural ambidexterity in digital transformations. Therefore, we provide guidance for incumbent companies on achieving structural ambidexterity in digital transformations. Therefore, one of our two research questions is: How can incumbent companies apply the concept of structural ambidexterity to navigate digital transformation? In our study, we investigate exploration/exploitation separation and its driving factors, as well as how to separate or integrate digital/core business. The baseline for those focus areas in our research is the literature research illustrated in Table 2. Explained by the necessity of leadership to achieve ambidexterity (Alghamdi, 2018; Bell & Hofmeyr, 2021; Jansen et al., 2008; Keller & Weibler, 2015; Lin & McDonough III, 2011; Mueller et al., 2020; Probst et al., 2011) we also consider needed strategic leadership activities in our research objective. Related to this, our second research question is: What elements of strategic leadership do leaders in incumbent companies need to implement when navigating digital transformation considering structural ambidexterity? After defining the purpose and research question, as a second step, we provide insights into the *conceptional context* by providing definitions of the affected research streams digital transformation and ambidexterity. In addition, we combine the two topics, focusing on structural ambidexterity following our research questions.

Sampling: One aspect of our purposive sampling (Etikan et al., 2016) was ensuring our 33 interview partners work in incumbent companies, not digital startups (Misoch, 2019). Another characteristic of the expertise of the selected participants is the job title. Our selection criteria of being in a position related to digital transformation in an incumbent company in the last two years ensured familiarity with the research topic. Different hierarchy levels provide a heterogeneous sample for the leadership aspects we address with our research. In addition, we identified that a perspective on multiple industries is beneficial, so we clustered our interview partners using the Global Industry Classification Standard. Interviewing study participants from different industries increases the robustness and credibility of our findings as we allow a holistic view considering multiple industries. This is especially relevant due to the wide-spread impact of digital transformation on multiple industries. In addition to industry experience, we included researchers or lecturers in our study to cover the research side. Split by the variables sector experience and hierarchy levels, Table 3 shows the composition of our interview partners.

Table 3. Study participants

Variables	Variable description	Number (%)
Sector experience	Consumer Discretionary Sector (Automobiles & Components)	5 (15%)
	Healthcare (Pharmaceuticals, Biotechnology & Life Science)	5 (15%)
	Industrials (Electrical Equipment, Machinery, Transportation, Construction and Engineering)	10 (30%)
	Materials (Chemicals, Construction Materials)	3 (9%)
	Information Technology (Technology Hardware & Equipment, Software & Service)	4 (12%)
	Consultancy	3 (9%)
	Research	3 (9%)
	Total	*33*
Hierarchy level	Senior Executive	3 (9%)
	Vice President	3 (9%)
	Director	7 (21%)
	Head of	10 (30%)
	Manager	4 (12%)
	Consultant	3 (9%)
	University Professor	3 (9%)
	Total	*33*

Research method: While research on ambidexterity and leadership often uses a quantitative research design (Baškarada et al., 2016), we decided to use a qualitative research design followed by a thematic analysis (Braun & Clarke, 2006). As we addressed the research gap in in-depth detail on structural ambidexterity in digital transformation, the explorative research design offers this possibility. In addition, as there is still limited research combining the individual research streams of digital transformation and structural ambidexterity (Holotiuk & Beimborn, 2019; Jaspert & Ebel, 2022), the explorative research design fits our study requirements. After coding each batch of three interviews, we examined whether we accomplished code saturation (Hennink et al., 2017). We reached code saturation after 11 rounds of reviewing three interviews in a batch, which resulted in 33 interviews. Driven by our sample size and as we suggest further testing our study results with a quantitative or longitudinal study, our research can be treated as a pilot study (van Teijlingen & Hundley, 2001). To increase the robustness of our study, one researcher did the initial coding of the transcripts, and the second researcher performed an inter-coder check (Mayring, 2014). The research partner acted as supervisor with unlimited access to all material related to the research. The second reviewer confirmed the suggested coding and conclusions. To ensure consistency (Misoch, 2019) we conducted semi-structured interviews as a qualitative research approach. Based on the main findings of our literature research on digital transformation and structural ambidexterity, our open-ended questions focused on separation/integration in digital transformations of incumbent companies as well as associated leadership aspects and what could trigger changes over time. The software MicrosoftTeams allowed us to interview study participants globally. Between May 2023 and July 2023, the first author conducted all interviews using Microsoft Teams©. To be able to familiarize with the data, we transcribed all interviews. MicrosoftTeams enabled the first raw transcription which we imported into MAXQDA (VERBI Software, 2021). The naturalized/ intelligent verbatim approach helped us generate easily readable transcripts from the raw transcripts (McMullin, 2023). We used timestamps to connect the transcripts with the recorded audio files from Microsoft Teams and anonymized all data. The steps described in Figure 2 following "Familiarizing with data" are described in the following section.

RESULTS

Our literature research on organizational structures, displayed in Table 2, served to set the level of abstraction. We are therefore focusing in our thematic analysis on how the separation is done (exploration/exploitation, digital/core business), driving factors behind the separation, changes over time, and aspects of temporal ambidexterity. The guidance for code development provided by Braun and Clarke (2006) is the baseline to answer our research question. Appendix (Tables 4, 5, and 6) displays the details of our process, from our initial coding to defined themes (Braun & Clarke, 2006). To enhance our research from a scholarly rigor perspective, we applied the procedure described by Gioia et al. (2013) for code clustering and illustration. As a first step, we generated initial codes, which were revised by either rewording, summarizing, or deleting. The result of this process step is 1st order concepts. Those are reviewed and combined in 2nd order themes (Gioia et al., 2013). As a final step, we aggregated all 2nd order themes into aggregated dimensions (Gioia et al., 2013). Figure 3 visualizes the summary of our results.

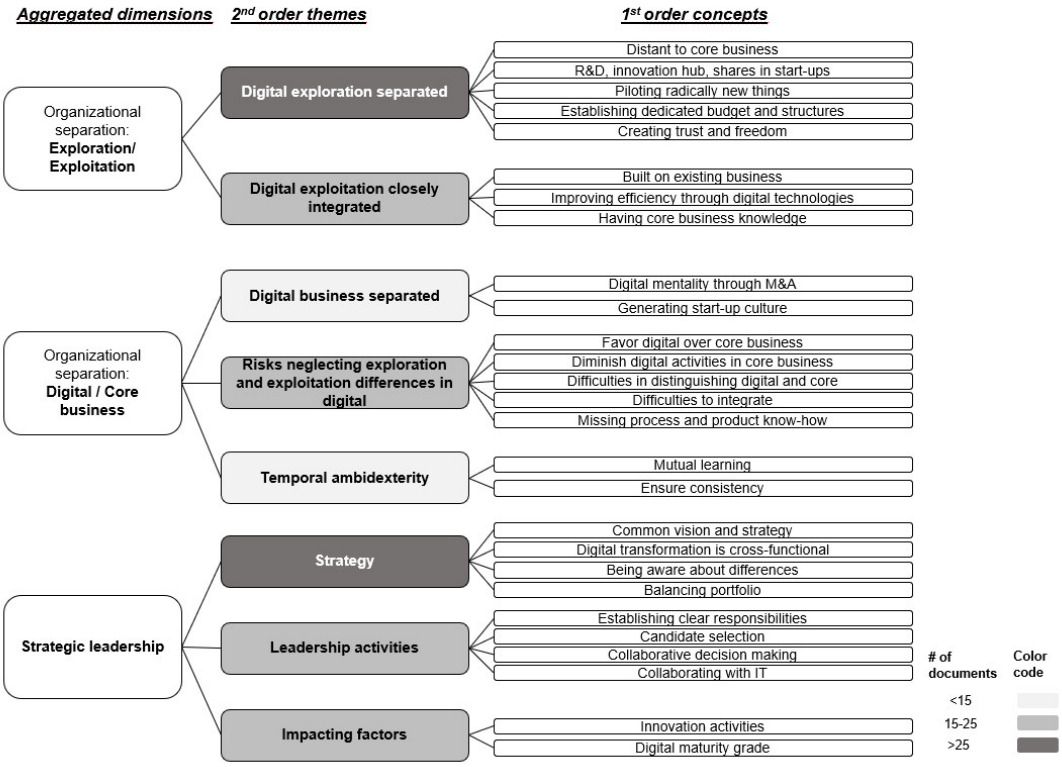

Figure 3. Structural ambidexterity in digital transformation and strategic leadership aspects

Organizational separation: Exploration/Exploitation

Following the literature on ambidexterity (March, 1991), structural separation of exploration and exploitation is one of the main concepts to become ambidextrous (Benner & Tushman, 2003; Duncan, 1976; Gibson & Birkinshaw, 2004; O'Reilly III & Tushman, 2013). Separation is also the most addressed concept in the context of digital transformation. Based on our interview results, we provide insights on when to separate and integrate digital business in terms of exploration and exploitation and the details explaining the rationale.

Digital exploration separated: Our study results show that one decision criterion to separate or integrate is how close the digital business is to the core business. Our interview partners suggest that if the digital exploration is *distant to the core business,* separate it. With these distinguishing criteria of closeness to business, we can provide further details on the differentiation made in the literature of new digital products (Hess et al., 2016) and offerings (Sia et al., 2021; van den Buuse et al., 2021). One of our interview partners states it with the following words: "Running digital initiatives, more on the exploration area, [***] do[ing] something fundamentally different, doing that through a separate group [***] or even legal entity." The recommendation is even to place the separate digital exploration unit geographically distant. Separate units can be carved out internally within a *Research and Development organization*, an *exploration (digital) innovation hub,* or a *think tank* for explorative activities. All those set-ups allow employees to focus on explorative digital activities. Aside from internal separation, externally *buying shares of startups* also enables incumbent companies to have digital exploration activities separated. The activities of a separate digital innovation unit are characterized by *piloting radical new things*. According to our interview partners, the separation allows "try[ing] something completely new" and "always keep[ing] the pipeline of ideas filled" by scouting new technologies. We also found out that the aspect of piloting by "start[ing] small and [***] try[ing] very different things" is needed to think outside the box and possibly within a separate unit.

When separating, our interview partners suggest that incumbent companies *establish dedicated budgets and structures*. Having a dedicated budget was especially important as, without a budget, improving existing topics wins over digital exploration due to short-time prioritization and quicker and more known returns. As the budget is often allocated through performance achievement measured by KPIs, digital exploration units would risk not getting the needed funding. We suggest implementing different processes and structures in a separate digital exploration unit to ensure the needed speed and flexibility. Ideas brought up are flat hierarchies or product owner structures instead of hierarchical organizations. Associated with different processes is the need to create *trust and freedom*. One of our interview partners described it with the following words: "Create the atmosphere, the room for that explorational task [***], give the freedom to the people on different levels to work on the future." It is essential not to overwhelm employees with too much guidance and control mechanisms, especially in the early stages of exploration. Instead, leaders should create a safe space to explore new solutions without fear. The separation of digital exploration enables leaders in incumbent companies to develop that trust and freedom and not get wound up in the follow-up culture of the core business.

Digital exploitation closely integrated: Following the same logic as for separation, our study results suggest not separating but instead integrating digital exploitation closely connected to the existing business. When, for example, digitizing the existing product portfolio or automating processes with the help of digital technologies, the baseline are the existing products or processes of the incumbent company. Digital exploitation is *built on the company's existing business*. Therefore, integrating digital exploitation is recommended by our interview partners. One study participant summarizes this with the following statement:" [It] would not make [***] sense to separate this from each other structurally. You need the process expertise and the digitalization expertise in this field [***] and you must bring this as closely together as possible and not separate this:" Detailed examples are integration in business units via centralized departments or even closer to the day-to-day business via support functions or directly in the business. This integration and close connection to the existing core business is essential to understanding processes to *improve efficiency through digital technologies*. Also, as digital technologies are one enabler to more efficient processes, integration can be explained by the business ownership to improve. Even if there is a high priority on improving internally incrementally, as one interview partner stated: "Make my daily work better and not do[ing] something completely radical," it is not limited to internal aspects but also addressing product improvements. The necessity of *having core business knowledge* is one major result in our study explaining the recommendation for integration. Our interview partners further distinguish in process, product, and customer knowledge. It can be described in the words of one of our study participants: "The functional experience has a more important role because [***] we focus on the current status and [***] you're discussing on a process level. You need to know how the processes are built, what are some standards [***] and what are the pain points." Also, having customer relationships and knowing how the company engages with customers is important and explains the integration.

Organizational separation: Digital/Core business

Aside from separating exploration and exploitation in digital transformations, our literature research shows that some authors refer to a separation of all digital activities (Åkesson et al., 2018; Göbeler et al., 2020; Holotiuk, 2020; Kaiser & Stummer, 2020; Schiffer, 2021; Smith & Beretta, 2021). Nevertheless, the existing research lacks details here, and our study results provide insights on occasions supporting this separation and associated risks.

Digital business separated: Our study shows that one reason for separating all digital activities from the core organization is to build up a *digital mentality through merger & acquisitions (M&A)*. One interview partner explained it in the following words: "That's why we decided to use the resources from outside, use startups [and] disruptive technologies." More specifically, startups in the digital area are often acquisition targets to bring a digital mindset into an incumbent company. Similar to building up a digital mentality through a merger, M&A is the idea of separating a unit to *generate a startup culture internally*. Benefits related to the digital context are that those startups within an incumbent company can be more flexible, agile, dynamic, and faster. All requirements are often mentioned in the context of fast-changing technologies. The separation explains how incumbent companies can focus on necessities specific to the digital context they have not been growing with.

Risks neglecting exploration and exploitation differences in digital: Building up a digital mentality through M&A and generating a startup culture are reasons we identified justifying separating all digital activities. Nevertheless, our study results show, similar to the work of Göbeler et al. (2020), that there are risks associated with this kind of separation. One risk with separating digital from the core business is that incumbent companies could *favor digital over core business*. Digital is often associated with something new, fancy, and something people want to belong to. Not educating people enough about what digital means, especially the link to the core business for digital exploitation, can lead to the fact that the digital unit is favored over the core business. Some injustice could arise as the core business feels like being alone and responsible for the company's profit, and digital is seen as the part of the company that is getting investments such as new office spaces. One of our study participants summarizes this: "How do you feel belonging to the legacy part, to the classic part? While the others are the ones getting the invest[ments] and the others are [***] asked for more EBIT to support them? [***] You can either be on the sunny side [and] spend the money, or you can [***] be on the maybe classical side." Also, Oberländer et al. (2021) describe the tensions between the core business and the digital business. As mentioned above, we identified that digital exploitation needs to be closely connected or integrated into the core business. If the separation is now based on digital/core business, we identified a risk of *diminishing digital activities in the core business* due to the separation. Without a close connection, knowledge about new technologies and mindsets cannot be transferred to the core organization, resulting in increased efficiencies. One of our interview partners condensed it by saying: "If you have a digital hub where everything digital happens, the old company will stay in the non-digital world." In addition, separating all digital activities could lead to a focus on more radical new activities, and no digitalization activities are performed for the existing business, neglecting the ambidexterity concept. We also identified that in the current stage of having a lot of digital technologies readily available, with the speed of new developments increasing and somehow already integrated into the business, we see *difficulties in distinguishing digital and core* for a separation. The non-digital and digital world continuously merges, and as one study participant said: "Nowadays, digital is a necessity. I can't imagine one workshop where you try to develop your existing portfolio where you don't think about incorporating digital." Therefore, we see a risk in drawing a clear line between digital/core business, especially the more advanced a company is in its digital transformation.

Another risk associated with *difficulties distinguishing digital from core* is that scaling up new digital ideas, such as new products or business models, does not require to be ringfenced anymore but instead requires a sales organization and more structures. Therefore, our interview partners stated the necessity of integrating digital at one point to gain efficiencies and grow the business. One study participant summarizes the thoughts of this risk: "If this is too much disconnected from the core business, tr[ying] to exploit [***] and try[ing] to make things more efficient, then you have [a] challenge." This risk becomes even more relevant for digital exploitation as the digital unit could explore technologies that are not feasible for the use cases. *Integration into the core business* is seen as a challenge if the core business needs are not addressed. This risk is closely connected to the risk of *missing process and product know-how*. If a digital unit is separated without or low interaction with the core business, there is a lack of the needed process and product know-how from experienced employees. One interview partner explained this aspect: "They might not be that good [in] being creative or experimenting with technology or building prototypes. [Instead] they are good in having a product or a service and scaling that, dealing with customers, having operational sales divisions and customer exchange. This [***] explains why in acceleration it is better to be closer to existing business again." Separating all digital activities could lead to the fact as one study participant states: "That you create something that the market is not looking for."

Temporal ambidexterity: Temporal ambidexterity is an aspect brought up less in the interviews; nevertheless, it was mentioned by multiple participants and justifies that we include it in our results. We follow the definition of temporal ambidexterity given in the Literature review section. With a flexible team structure, employees work in the digital innovation lab for a limited time, and employees return to their original business (Holotiuk & Beimborn, 2019). The study of Holotiuk and Beimborn (2019) assumes that the digital innovation lab is only responsible for exploration. Following this understanding, our interview partners see temporal ambidexterity as helpful for *mutual learning*. On the one hand, it helps mitigate the risk of difficulties integrating innovations later. The words of one of our interview partners illustrate this: "I think the success of the exploration also depends on if the ideas can be brought back to the process. If they can be brought to the exploitation. So maybe it would help to have colleagues [***] working on already existing processes that they get some time, [for example] one day a week time to work in the innovation hub." On the other hand, assuming temporal ambidexterity can also be applied to the separation of digital/core business, this can help foster mutual learning in terms of process and product knowledge for the employees in the digital lab, but also digital skills and work methods for employees located in the core business. Again, this mitigates the risks of missing process and product know-how and diminishes digital activities in the core business. Nevertheless, it was mentioned multiple times that leaders must *ensure* *consistency* in flexible structures. This is explained by having a stable core team to ensure processes are known, and it is not always a starting from scratch.

Strategic leadership

As it is a leadership challenge to enable the necessary change in digital transformations (Hensellek, 2020) and reinforce ambidextrous behavior (Alghamdi, 2018; Bell & Hofmeyr, 2021; Jansen et al., 2008; Keller & Weibler, 2015; Lin & McDonough III, 2011; Mueller et al., 2020; Probst et al., 2011), we will cover strategic leadership topics associated with structural ambidexterity.

Strategy: Our study results show that a clear *company vision* and how digital transformation is embedded is crucial. The vision makes the targeted future of the company transparent, including aspects such as where the company wants to be active and how the company wants to be seen. The strategy and road map are associated with a vision, detailing how the company intends to achieve the target picture. This also includes organizational structures and innovation activities exploration and exploitation. One interview partner states: "Have a clear vision of where they [want to] go and what they want, [for example] the different steps they need to take in the exploration and in the exploitation to get there and then keep on track [of] both" as important. Our study results emphasize that digital transformation activities need to be aligned with the corporate and digital transformation strategy covering exploration and exploitation based on the vision. Our interview partner sees the top management responsibility as the following: "C-level needs to provide some kind of strategic framing. So simply to avoid that [***] innovation [focused employees] are working on topics that are not in line with the strategic route of the company." In addition, we want to highlight that transparency and continuous communication of the vision and strategy is crucial. Aside from *having a common vision and strategy, cross-functional collaboration* is vital in digital transformation. Having diverse teams and collaborating with different functions and departments to pursue the strategy and vision was mentioned as relevant. The fast-changing character of digital technologies forces companies to not rely on individuals but instead cross-functional teams to leverage the most of it. Closely associated with ambidextrous leadership, our study results provide evidence about the necessity of *awareness about differences of exploration and exploitation* in the top management. Different leadership is required for exploration and exploitation; not everything in digital should be treated the same way. One study participant phrased it like this: "I think it's awareness and also teaching the organization that there are different things and not digital is digital." Aside from knowing the difference, keeping in mind that both activities are relevant for long-term success and, therefore, achieving a long-term balance was emphasized as an essential topic for top management. We can connect this aspect to the vision and strategy as top management should integrate both activities. This can be summarized with the words of one of our interview partners: "A leader must be conscious or must know for himself that these two tasks that he has need to be balanced." Closely associated with this is the 1st order concept *balancing portfolio*. Regarding balancing exploration and exploitation in digital transformation, our interview partners referred to balancing activities with the help of portfolio management. This means ensuring that activities in digital transformation related to exploration with a higher level of risk are more future-oriented while also exploiting the existing business with the help of digital technologies. The innovation portfolio should be composed of both. Exploitation activities ensure the current product portfolio continues to deliver a constant cash flow, which can be allocated to invest in exploration activities. A balanced portfolio is seen as crucial, as one interview partner described with the following words: "If you just exploit it and don't explore, you will die from lack of innovation. If you just explore, not exploit, you will starve." Our interview partners combined this recommendation with the product life cycle and connected the approach with the Boston Consulting matrix (BCG). One study participant explained it that way: "If you take the classical BCG matrix [***], then you [***] would consider the stars or sometimes even the cash cows to be your products which are in your portfolio really established and you still have to work on these products to improve them and to still earn money with them [***]. And [***] it's more the direction or the positioning of these question marks to be considered as the more innovative products where [***] exploration activities will happen in [***] your portfolio."

Leadership activities: Aside from creating a strategic framework, we identified further leadership activities as relevant for structural ambidexterity in digital transformations of incumbent companies. Our study results indicate that leaders need to establish *clear responsibilities*. This includes being clear about what precisely exploration and exploitation mean. Especially in cases of separation, the scope and task of the separate unit need to be clearly defined and communicated to avoid the feeling of injustice. Establishing leaders with clear job descriptions for separate entities supports this suggestion. Closely connected to responsibilities, top management must ensure they *select fitting candidates* for exploration and exploitation responsibilities in digital transformation. One study participant explains this with the words: "Leadership needs to identify what people are [***] best for and put the right people in the right [***] position [***] or organization." Different skill sets and personnel preferences are required on the individual employee level, especially when it comes to exploration and exploitation. It can be further detailed with the words of one of our interview partners: "[Who] is very innovative should be focusing on explor[ing] things and the ones that are very structured, of course, you need to be a little bit innovative [***] for exploitative things, but if you are a researcher, for example, that isn't the best choice for that." Of course, a mindset that fits the digital context should also be considered for candidate selection. Knowing that most leaders similar to employees have slight preferences for exploration or exploitation, our interview partners suggest *collaborative decision-making* as a countermeasure to foster ambidexterity. Based on the study results, we suggest having a sounding board and increasing diversity in the leadership team to support ambidexterity. One interview partner explained that "[the leader] needs to find where he is good in and needs to get the others [***] helping him to do the other thing." Connected to skill set, candidate selection, and cross-functional projects, we identified the importance of *collaborating with IT*. Due to the nature of digital transformation in digital technologies, some digital literacy is crucial and involves experts from the IT department.

Impacting factors: We identified in the Literature review section that only a view paper focus on changes over time in terms of separation and integration (Åkesson et al., 2018; Göbeler et al., 2020; Hron et al., 2021; Svahn et al., 2017). We have been focusing on this aspect in our research to gain more insights. Our interview partners argued that exploration and exploitation should not be isolated in the sense of incremental and radical innovations. Instead, an innovation can be looked at as having different *innovation phases*. The innovation can start with an exploration phase and then mature with exploitation at one point. Therefore, we recommend establishing a minimum level of collaboration, especially when separating exploration and when it is close to the core business. One study participant summarized it with the following statement: "[There] [s]hould be a[n] [***] intense link to the exploitation organization, that the transfer is fast because otherwise, the benefit out of the exploration [***] is maybe not that big." Therefore, we identified that the shift from exploration to exploitation can be a trigger to integrate activities into the core business. In addition, we identified the maturity grade incumbent companies within digital transformation as an impacting factor on separation and integration decisions. The *digital maturity grade* is a trigger point to rethink separation decisions. This can be connected to the three-phase approach we described in the Literature review. Similar to the guidance we provided in generating a startup culture, at the beginning of the digital transformation, a separation of all digital activities is recommended based on our study results. One of our interview partners explained this with the words: "In the beginning, it was very [***] central because that knowledge did not exist in the organization." So, generating digital literacy and creating first successes can help establish a digital mindset and acceptance with the company by having a dedicated separate unit. Depending on the closeness of the core business, the more mature companies become, the more pull for digital improvements for the core business is generated, which is a trigger to dissolve the digital hub.

Connecting to the color coding displayed in Figure 3, we identified that the traditional way of structural separation focusing on exploration and exploitation is associated with most counts. The comparable lower number of counts related to "Digital business separated" and the medium number of counts linked to the risks let us conclude that separating all digital activities can be recommended at certain times as a solution, but leaders need to be aware of the risks. As the risks are often closely associated with exploration and exploitation, which are different activities requiring different skills and leadership, this justifies the importance of the traditional ambidexterity concept. Therefore, we recommend that leaders monitor the impacting factors and risks to make a suitable decision on separation.

DISCUSSION

As the significant challenge of incumbent companies in digital transformation is related to organizational structures (Bjoerkdahl, 2020; Mirković et al., 2019) and limited in-depth research on organizational ambidexterity, our study answers this research gap. Our research addresses the lack of details on separation by investigating exploration/exploitation separation, its driving factors, and digital/core business separation. Figure 4 illustrates our main findings regarding separation and integration in a matrix. As our literature research in Table 2 illustrates, most authors do not distinguish between exploration/exploitation in digital transformation or provide only minimal details. Questioning our 33 interview partners enabled us to generate deeper insights and advance the research. We identified that the closeness of the digital activities to the core business and whether the activities are related to exploration or exploitation should drive the decision to separate or integrate those activities. We recommend separation if incumbent companies set an exploration focus for digital activities that are far from the core business. Concrete examples include a Research and Development organization, an exploration (digital) innovation hub, or a think tank for explorative activities. Separating distant digital exploration activities enables companies to ensure freedom, establishing different processes and dedicated budgets to drive digital exploration successfully. We see two options if incumbent companies target exploring digital activities but still have some closeness to the core business. On the one hand, companies can separate those activities but ensure collaboration with the core organization. On the other hand, incumbent companies can integrate those activities into the core organization but ensure enough freedom and a dedicated budget. This recommendation is based on our findings on exploration/exploitation distinguishing and closeness/distance to the core business. As the constellation of exploration of digital activities close to the core business affects both aspects, we see two options regarding organizational structures. In addition, our interview partners identified risks for integrating exploration activities closely connected with the core business, which are separated, but also recommended a dedicated budget and structures for exploration activities.

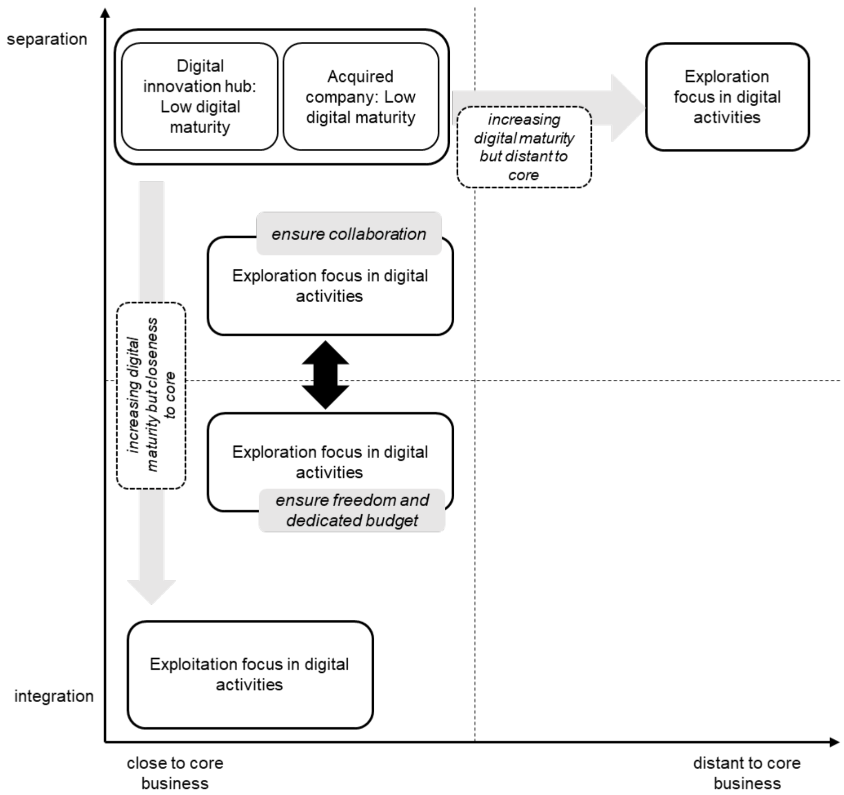

Figure 4. Decision-matrix for structural ambidexterity in digital transformation

Our interview results provide evidence of our recommendation to integrate digital exploitation activities closely related to the core business. We explain this with the need for core business knowledge such as process, product, and customer familiarity. Some authors refer in their work to the separation of digital business from the core business (Åkesson et al., 2018; Göbeler et al., 2020; Holotiuk, 2020; Kaiser & Stummer, 2020; Schiffer, 2021; Smith & Beretta, 2021; Sund et al., 2021) but also providing indicators of problems arising in this context (Göbeler et al., 2020). Based on our study results, we recommend that incumbent companies decide on separating digital and core business based on their digital maturity grade. Especially in the early stages of digital transformations, separating digital activities allows them to generate a startup culture internally. Higher flexibility, speed, and agility will enable an adaptation to the digital context. Connecting this to our guidance based on exploration/exploitation, we recommend seeing different innovation phases as trigger points for change. Moving toward integration in case of increasing digital maturity and closeness to the core business or continued separation in case of exploration focus distant to the core business.

Aside from the pure organization structure to support ambidexterity, our study addresses strategic leadership aspects that are necessary to foster ambidexterity (Alghamdi, 2018; Bell & Hofmeyr, 2021; Jansen et al., 2008; Keller & Weibler, 2015; Lin & McDonough III, 2011; Mueller et al., 2020; Probst et al., 2011). Figure 5 summarizes our recommendations on organization structures in digital transformation in a decision tree and connects it with strategic leadership aspects and a dynamic capability perspective. The baseline for organizational ambidexterity achieved through a structural separation is a cross-functional digital transformation strategy, which should be embedded in the company strategy. We identified a clear vision and strategy as crucial to guiding employees and managers. Senior leadership should be aware of the differences between exploration and exploitation, the role of those activities, and their balance in their digital transformation strategy. Using a portfolio approach to ensure balancing exploration and exploitation and then setting up organizational structures based on our recommended decision tree will foster ambidexterity in digital transformations of incumbent companies. In addition to the traditional concept of structural ambidexterity, our study includes the concept of temporal ambidexterity, which was developed in the digital context (Holotiuk & Beimborn, 2019). This could be applied in the case of separation based on digital/core business and exploration/exploitation. Nevertheless, we identified the necessity for a certain degree of consistency. Our identified leadership activities establishing clear responsibilities, collaborative decision making, candidate selection, and collaborating with IT are required to support the balance in digital transformation in incumbent companies continuously. As dynamic capabilities are often brought up in the context of ambidexterity, we incorporated related aspects based on the research of Hoessler and Carbon (2022) and Birkinshaw et al. (2016). Separation is associated with separated sensing and seizing units linked via resource-linking capability. Temporal ambidexterity adds a temporal focus-shifting capability.

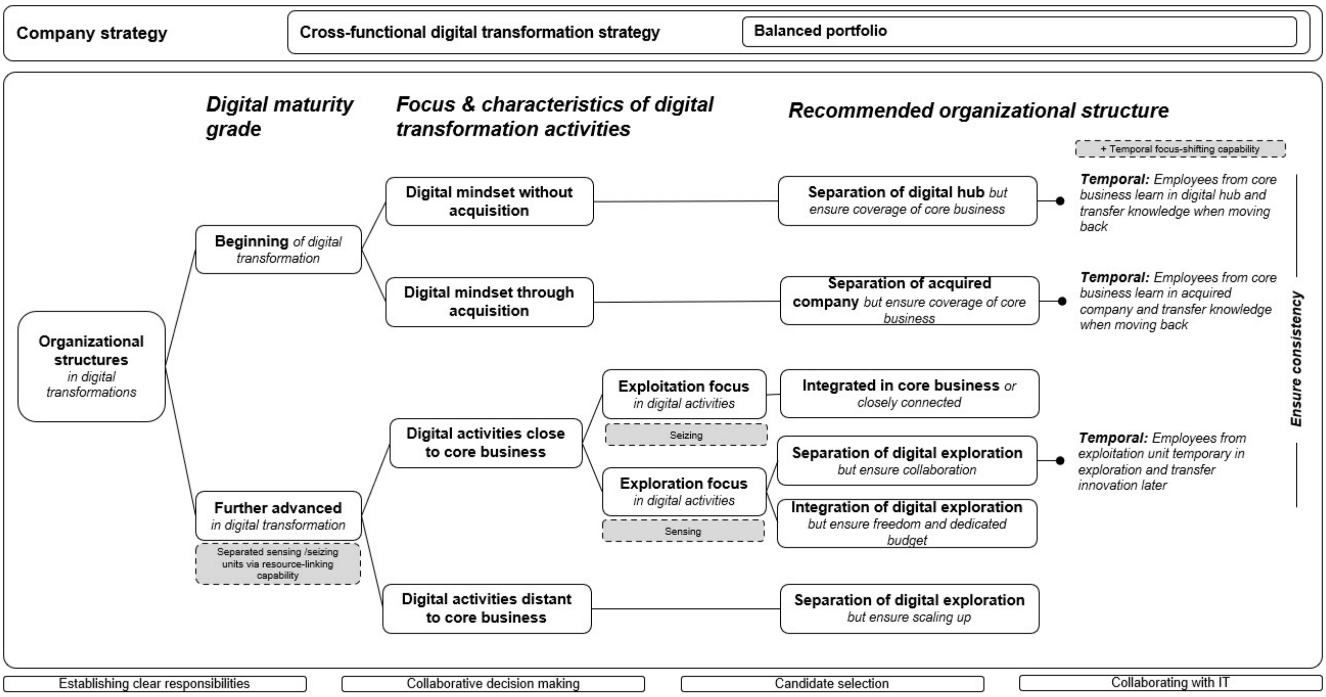

Figure 5. Structural ambidexterity in digital transformation: Decision tree embedded in a strategic framing

CONCLUSION

This study aimed to develop guidance for incumbent companies on the question of separation and integration in their digital transformations. Existing research either neglects or provides little insight into the differentiation between exploration and exploitation. Our results show the importance of understanding the differences between exploration and exploitation in digital transformation. Exploration is associated with piloting radical new things, a higher level of risk, and being more future-oriented. Exploitation is characterized by using the incumbent company's existing products or processes as a baseline. The returns are quicker and defined with a higher level of certainty. One of the major drivers for exploitation is incremental efficiency increase enabled by digital technologies. The understanding of exploration and exploitation in digital transformation follows March (1991). Our study helps incumbent company leaders overcome the challenges posed by digital transformation using structural ambidexterity. As incumbent companies often fall behind their expectations in digital transformation, we provide with our decision tree guidance to help them evaluate which activities should be separated or integrated to capture the expected results. We also provide descriptions and examples of exploration and exploitation activities to allow practitioners to apply this in their incumbent companies. Our study enlightens incumbent companies about the crucial differences between exploration and exploitation activities in digital transformation. For instance, we clarify the distinction between piloting radical new initiatives and targeting incremental efficiency increases enabled by digital technologies. This increased transparency about different digital transformation activities helps incumbent companies avoid separation based on digital vs. non-digital business without being aware of the associated risks, such as not addressing business and customer requirements. In addition, our study helps practitioners rethink their structural set-up over time, allowing them to adapt structures as necessary based on, for example, increased digital maturity grades. As incumbent companies see organizational structures as a major challenge, and there is evidence of a positive correlation between ambidexterity and digital innovation, we provide further insights with our study results. We reveal that the closeness of digital activities to the core business and whether the activities are related to exploration or exploitation are major decision-making criteria for leaders. Our recommendation for exploration digital activities that are distant to the core business is separation. In contrast, exploitation digital activities closely connected to the core business should be integrated. Exploration digital activities close to the core business can be either separated or integrated by including both decision-making criteria.

Nevertheless, we recommend ensuring collaboration with the core organization in case of separation and generating enough freedom and a dedicated budget in case of integration. Incumbent companies with a low digital maturity grade are supported with a separation to build up knowledge and have a digital startup culture. However, we recommend integration when increasing the digital maturity grade and closeness to the core business is given. The broader company vision provides guidance to leaders and employees about the targeted future state of a company to ensure that resources are used effectively, supporting the company's goals and a unified direction of ongoing and planned activities. Aligning the digital transformation strategy with the overall company strategy based on the vision is essential that digital transformation initiatives are prioritized based on their strategic impact. As a company's vision considers the target market, ensuring digital transformation projects are market-driven, and market changes will also be addressed. Furthermore, as the overall vision is long-term focused, an alignment supports concentrating on exploration and exploitation in digital transformation rather than prioritizing short-term gains due to quicker payoffs. In addition, breaking down the digital transformation strategy into a roadmap allows differentiation into exploration and exploitation. It helps to ensure effective and efficient resource management, supporting the long-term goals of the company if this is aligned with the broader vision.

Furthermore, integrating digital transformation with the company's strategy allows employees to identify their contribution to the overall goals and can support employee motivation and commitment. Especially in cross-functional digital transformation activities, the alignment can give a common purpose and enhance the required change management process. Therefore, incorporating a cross-functional digital transformation strategy in the company strategy and developing a balanced portfolio supports fostering ambidexterity in digital transformation. We identified the necessity for leaders to consider employees' skill sets and personnel preferences to foster innovation. Primarily related to exploration, leaders need to allow freedom to explore new digital technologies and apply them to business cases. Leaders driving exploration activities supporting innovation in the digital context must create trust and freedom to explore new solutions without fear. The fast-changing character of digital technologies requires leaders to engage employees in constantly scouting new technologies and piloting ideas to address the complexities of digital disruption. In addition, we identified that leaders need to consider a balance of exploration and exploitation to avoid a lack of innovation in the case of a pure focus on exploration or a lack of results in the case of only exploration. We identified temporal ambidexterity as a possibility for collaboration between employees working in a digital hub and the core business. Especially if exploitation activities in digital transformation are separated in a digital hub, this collaboration is required to ensure process and product knowledge, ensuring effective impacts of the activities. Leaders engaging employees moving between the departments support the needed collaboration. In addition, building cross-functional teams allows companies to leverage the expected results of digital transformation. The close alignment and interaction with the IT department support digital transformation efforts as expert knowledge about existing infrastructure or new trends is incorporated. We included aspects of strategic leadership in our qualitative study. Even though we included aspects of strategic leadership in our qualitative study, we see the potential for future studies to focus more on the role of leadership. We suggest examining how leadership fosters ambidextrous capabilities in the context of digital transformation. In addition, a study exploring the long-term effects of structural ambidexterity on the organizational performance of incumbent companies undergoing digital transformation would create additional insights and justify our results.

Our explorative research design includes a purposive sampling of 33 interview partners with work experience in digital transformations in incumbent companies or covering the research stream of digital transformation. Even though we covered various hierarchies and industries with our study participants, the count of 33 interview partners can still be seen as a weakness. Our clearly defined research process, including a detailed description of the conducted thematic analysis, and an explanation of how we achieved code saturation, helps offset this limitation.

In addition, we suggest further research to consider the digital maturity grade of the incumbent companies to cluster the findings further in that direction, as we identified this as one primary decision criterion. Combining this with how we achieved code saturation, we did not perform this check on the level of the digital maturity grade of the companies the study participants represent. This could influence our study results by achieving code saturation earlier and, therefore, missing some additional insights that are specifically relevant depending on sector experience or digital maturity grade. Therefore, we suggest that in a future study, the research sample can be clustered by sector experience, digital maturity grade, and testing for code saturation on this level. In addition, longitudinal studies with incumbent companies moving through different maturity grades could help gain further in-depth insights. The work of Del Giudice et al. (2021) provides evidence of the positive relation between ambidexterity and digital innovation. Coreynen et al. (2020) see limitations regarding digital servitization. Nevertheless, Coreynen et al. (2020) show that when reaching a medium level of exploitation, there is an exponential impact on the relation between exploration and digital servitization. Knowing this, we can see our study as a pilot for a quantitative study to investigate the correlation between digital maturity grades and our proposed organizational structure. Associated with this suggestion, future research could provide more in-depth insights into innovation phases. One interview partner provided insights on different phases in exploration, which could be seen to gain even further details on trigger points of separation/integration decisions within exploration activities. In addition, it is not part of this study to investigate different working methods and decision-making forms within different organizational units. New circumstances and the availability of new technologies require leaders to rethink and adapt existing processes. Existing research addressing the digital contexts often associates this with agile structures (Mustafa et al., 2022). Therefore, we see potential in addressing the applicability of agile work methods in digital activities related to the core business and how structures could change with increasing maturity grades. We addressed the concept of structural and temporal ambidexterity, therefore, we suggest future research to investigate the role of contextual ambidexterity in digital transformation or even combine this with this research in the form of hybrid ambidexterity.

We know that a potential analysis bias can impact our study results by having the risk of selective coding. To overcome this, one researcher did the initial transcripts coding, and the second researcher, acting as supervisor, performed an inter-coder check. In addition, we see the risk of interviewee bias leading to answers the interviewees think are expected rather than their honest opinion. Also, as we were aware of the company they work for, this could result in a potential bias toward reporting more positive aspects. To overcome this, we ensured the anonymity of the interview partners' personnel information as well as company-related information. In addition, interpersonal dynamics between the researcher and the interview partners can impact the level of detail and quality of the shared insights and, therefore, the quality of our study results. We mitigated this limitation by having semi-structured interviews and applying an interview guide. Another methodological limitation is the replicability of qualitative research. As interviews are associated with a defined context and a set of participants, replication is challenging. We address this limitation by describing our research process and clustering our participants by sector experience and hierarchy levels.

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Appendix

Table 4. Building 1st order concepts

Original Code (1st order concepts)	Count	Description of changes	Final code (1st order concepts)
Not close to core	10	Summarized	Distant to core business
Different location	1		
Explore and experiment	6	Summarized	Piloting radical new things
Piloting	4		
Research	3		
Scouting	2		
Searching new solutions	4		
Trust and freedom	15	Rephrased	Creating trust and freedom
Different processes	5	Summarized	Establishing dedicated budget and structures
Different structures	4		
Dedicated budget	4		
Innovation hubs, R&D, shares in start/ups	11	Summarized	R&D, innovation hub, shares in startups
Get ideas	1		
Built on existing in business or close	12		Built on existing in business or close
Customer relationships	3	Summarized	Having core business knowledge
Product and process know-how	5		
Understand core business	12		
Improve efficiency through digital technologies	12	Rephrased	Improving efficiency through digital technologies
M&A	6	Rephrased	Digital mentality through M&A
Startup culture	10	Rephrased	Generating startup culture
One better	7	Rephrased	Favor digital over core business
Need digital also in core business	8	Rephrased	Diminish digital activities in core business
difficult to differentiate sometimes	12	Rephrased	Difficulties in distinguishing digital and core
Integration if applications for core difficult with separation	14	Rephrased	Difficulties to integrate
needed product & process know/how missing	8	Rephrased	Missing process and product know-how
Costs	1	Eliminated	
Learn from each other	7	Rephrased	Mutual learning
Some fix people needed	6	Rephrased	Ensure consistency
Cross-functional	10	Rephrased	Digital transformation is cross-functional
Collaborating with IT	11		Collaborating with IT
Common vision and strategy	30	Summarized	Common vision and strategy
Communication of strategy	4		
Portfolio	22	Rephrased	Balancing portfolio
Clear responsibilities	11	Rephrased	Establishing clear responsibilities
Candidate selection	8		Candidate selection
Collaborative decision making	8		Collaborative decision making
Awareness	19	Rephrased	Being aware about differences
Integration e-->e	16	Rephrased	Innovation activities
Maturity grade	18	Rephrased	Digital maturity grade

Table 5. Building 2nd order themes

1st order concepts	2nd order themes
Distant to core business	Digital exploration separated
R&D, innovation hub, shares in startups	
Piloting radical new things	
Establishing dedicated budget and structures	
Creating trust and freedom	
Built on existing in business or close	Digital exploitation closely integrated
Improving efficiency through digital technologies	
Having core business knowledge	
Digital mentality through M&A	Digital business separated
Generating startup culture	
Favor digital over core business	Risks neglecting exploration and exploitation differences in digital
Diminish digital activities in core business	
Difficulties in distinguishing digital and core	
Difficulties to integrate	
Missing process and product know-how	
Mutual learning	Temporal ambidexterity
Ensure consistency	
Common vision and strategy	Strategy
Digital transformation is cross-functional	
Being aware about differences	
Balancing portfolio	
Establishing clear responsibilities	Leadership activities
Candidate selection	
Collaborative decision making	
Collaborating with IT	
Innovation activities	Impacting factors
Digital maturity grade	

Table 6. Building aggregated dimensions

1st order concepts	2nd order themes	Aggregated dimensions
Distant to core business	Digital exploration separated	Organizational separation: Exploration/ Exploitation
R&D, innovation hub, shares in startups		
Piloting radical new things		
Establishing dedicated budget and structures		
Creating trust and freedom		
Built on existing business or close	Digital exploitation closely integrated	
Improving efficiency through digital technologies		
Having core business knowledge		
Digital mentality through M&A	Digital business separated	Organizational separation: Digital/Core business
Generating startup culture		
Favor digital over core business	Risks neglecting exploration and exploitation differences in digital	
Diminish digital activities in core business		
Difficulties in distinguishing digital and core		
Difficulties to integrate		
Missing process and product know-how		
Mutual learning	Temporal ambidexterity	
Ensure consistency		

1st order concepts	2nd order themes	Aggregated dimensions
Common vision and strategy	Strategy	Strategic leadership
Digital transformation is cross-functional		
Being aware about differences		
Balancing portfolio		
Establishing clear responsibilities	Leadership activities	
Candidate selection		
Collaborative decision making		
Collaborating with IT		
Innovation activities	Impacting factors	
Digital maturity grade		

Biographical notes

Sabrina Hoessler is a PhD student at the University of Bamberg. She holds a Master's Degree International Management (M. Sc.) from the School of International Business and Entrepreneurship (Steinbeis University). Her research work is in the area of digital transformations and the implication on leadership.

Claus-Christian Carbon studied Psychology (Dipl.-Psych.), followed by Philosophy (M.A.), both at University of Trier, Germany. After receiving his PhD from the Freie Universität Berlin and his "Habilitation" at the University of Vienna, Austria, he worked at the University of Technology Delft, Netherlands and the University of Bamberg, Germany, where he currently holds a full professorship leading the Department of General Psychology and Methodology and the "Forschungsgruppe EPAEG"—a research group devoted to enhancing the knowledge, methodology and enthusiasm in the fields of cognitive ergonomics, psychological aesthetics and Gestalt (see www.experimental-psychology.com and www.epaeg.de for more details). He is the author of more than 500 publications, including more than 200 peer-reviewed international journal articles, mainly addressing perceptual topics, and has conducted more than a dozen research projects with a total budget amount of approx. 5 mill. EURO on perception and marketing issues and a renowned contributor and invited speaker at international research conferences. CCC is Editor-in-Chief of the scientific journal Art & Perception, Section Editor of Perception and i-Perception, Associate Editor of Frontiers in Psychology, Frontiers in Neuroscience, Journal of Perceptual Imaging and Advances in Cognitive Psychology and a member of the Editorial Boards of Open Psychology, Musicae Scientiae and Leadership, Education and Personality. Since 2023, CCC is an ordinary member of the European Academy of Sciences and Arts.

Author Contribution

Sabrina Hoessler: Conceptualization, Sampling, Data Collection, Methodology, Formal Analysis, Project Administration, Visualization, Writing. **Claus-Christian Carbon**: Conceptualization, Sampling, Methodology, Formal Analysis, Project Administration, Visualization, Writing, Supervision, Review & Editing.

Conflicts of interest

The authors declare no conflict of interest.

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Leveraging green innovation from big data analytics: Examining the role of resource orchestration and green dynamic capabilities

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Abstract

PURPOSE: *The notion of big data analytics (BDA) has received increased attention from both researchers and managers. Keeping in view the significance of BDA, the current research aims to examine the role of BDA capability to leverage firm green innovation (GI). Drawing from the dynamic capability view, current study suggests that BDA capability prompts green dynamic capabilities (DCs), enabling organizations to attain GI successfully. Particularly, present study proposes that BDA analytics prompt GI directly as well as through green DCs. Moreover, this study also draws from complementarity perspective and proposes that resource orchestration capability (ROC) is likely to enhance the effectiveness of green DCs in eliciting GI. Thus, the objectives of the current study are threefold; first, it aims to unveil the role of BDA capability in prompting GI; second, it examines the mediating role of green DCs for the relationship between BDA capability and GI; and third, this research examines the moderating effect of ROC to examine if it strengthens the effects of green DCs.* ***METHODOLOGY:*** *This study involves testing hypotheses using primary data collected by using the method of survey questionnaire. The data were collected from 291 Pakistani organizations. Pakistan is an emerging economy where businesses are responsible for substantial amounts of carbon di-oxide and greenhouse gasses (GHG) emissions. Therefore, Pakistani organizations serve as a suitable context for the study. The respondent organizations were from both the manufacturing and service sectors. PLS-SEM was employed as an analytical approach for testing the hypotheses. Construct validity and reliability were confirmed prior to hypotheses testing.* ***FINDINGS:*** *Results demonstrate that BDA capability positively affects GI ($\beta=0.33$, $p<0.01$), indicating that organizations with strong BDA capabilities involve in GI activities. Likewise, results indicate a positive relationship between BDA capability and green DCs ($\beta=0.35$, $p<0.01$) and between green DCs and GI ($\beta=0.50$, $p<0.01$). Results also indicate that green DCs play a mediating role between BDA capability and firm GI ($\beta=0.18$, $p<0.01$). This indicates that BDA capability is an imperative capability of organization that promotes green DCs and fosters GI. Finally, findings indicate that ROC strengthens the effectiveness of green DCs in prompting GI ($\beta=0.14$, $p<0.01$).* ***IMPLICATIONS:*** *Findings imply that organizations that prioritizing green innovations (GI) should invest more in developing BDA capabilities. These actions may involve acquiring and analyzing large volumes of data associated with sustainability, which can provide insights and support decision-making processes. By leveraging BDA capability, managers can uncover insights and patterns that can help them make informed decisions, recognize areas for improvement, and devise innovative solutions to align organizational strategic objectives with sustainability goals.* ***ORIGINALITY AND VALUE:*** *This study contributes to the literature by offering an integrated framework based on BDA and DCs to seek solutions to economic concerns while ensuring the sustainability value of the business activities. The findings also imply that businesses should focus on developing ROC, and integrating them with green DCs to further enhance GI initiatives.*

Keywords: *big data analytics capability, green innovation, green dynamic capabilities, resource orchestration, PLS-SEM*

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INTRODUCTION

Over the past few years, big-data analytics' significance has gained growing attention (Jiang et al., 2024; Su et al., 2022). Big data are enormous, diverse sets of data having numerous kinds and quantities of information; they need peculiar infrastructure, resources, and platforms (e.g., big data analytics) to process and generate valuable results (Gupta & George, 2016). Big data analytics (BDA) explicates a general approach for processing, managing, and analyzing the volume, variety, velocity, veracity, and value of large data sets to generate superior solutions and innovative ideas for competitive advantage (Mikalef et al., 2020; Wamba et al., 2015). By using BDA, organizations can make sense of large amounts of data to generate better-informed decisions, gain valuable insights, and reconfigure their strategies (Brewis et al., 2023). BDA enables organizations to extract valuable information from various data sources (e.g., customer feedback, market trends, and competitor activities) to develop data-driven and evidence-based strategies (Garmaki et al., 2023; Su et al., 2022). Therefore, BDA capability has the capacity to transmute business activities and recognize challenges and opportunities of these activities so that the information can be used to formulate strategies and policies to achieve strategic goals (Su et al., 2022). The capacity to integrate BDA effectively helps organizations to achieve organizational goals, gain sustainable competitive advantage, and deliver values to stakeholders (Al-Khatib, 2022; Chen & Liang, 2023) because by incorporating BDA across decision-making, businesses can improve their agility and responsiveness to changes in the external environment. However, creating a balance between the BDA resources remains a challenge for the organizations to undertake environmentally friendly business activities through green innovation (i.e., innovations in products and processes that can direct the organizations to achieve competitive advantages ecologically) (Benzidia et al., 2024; Itani et al., 2024; Xin et al., 2023). Thus, the first objective of current study is to unveil the role BDA capability plays in prompting green innovation (GI).

It is suitable to argue that the organizations aimed at achieving green GI from BDA capability need to develop new and/or reconfigure existing capabilities, which could transform the impact of BDA towards GI more proficiently. This proposition is based upon the extant literature that recognizes the significance of firm capabilities and resources in attaining superior performance, innovation, efficiency, and competitive advantage by (re)constructing dynamic capabilities (e.g., Mikalef et al., 2020; Sing & El-Kassar, 2019), which are successively generated by combining and organizing several capabilities, and are difficult to imitate by the competitors (Leemann & Kanbach, 2022). In the present study, we argue that green dynamic capabilities (DCs) will likely offer an underlying mechanism for BDA capability (besides direct nexus) to promote GI. Green DCs denote the unique competence of the organizational ability of sensing, seizing, and reconfiguring internal and external resources, including technological and green processes, to meet the changes in the business environment and to develop new organizational strategic decisions (Eisenhardt & Martin, 2000; Zahra et al., 2022). Furthermore, the development of DCs helps organizations to align internal and external resources to foster performance and promote sustainability (Ahmad et al., 2024; Li et al., 2024; Zhu et al., 2023). However, it is imperative to comprehend how green DCs prompt sustainable and eco-friendly performance. Hence, the second objective is to examine the mediating effect of green DCs on the relationship between BDA capability and GI.

The influence of green DCs on GI is likely to be contingent on contextual factors, e.g. resource orchestration. Although green DCs are important in transforming business activities by capturing and developing knowledge regarding products, markets, customers, and environment; resource orchestration is essential to assess and apply such knowledge by mitigating internal conflict and enhancing resource complementarities in the organization (Grimpe & Hussinger, 2014; Sirman et al., 2011). Recent studies have highlighted the role of resource orchestration in terms of an organization's internal capacity that structures, bundles, and leverages resources to transform knowledge to achieve innovation and competitiveness (e.g., Wang et al., 2020; Xin et al., 2023). We assert that ROC complements green DCs in transforming and applying knowledge towards building GI. The third objective of this research is to investigate the moderating role of ROC and asses if it strengthens the effects of green DCs in determining GI.

To fill the research gap, this study attempts to highlight *why* and *how* BDA capability influences GI. To answer *why*, this study argues that BDA capability is an important source of knowledge derived through processing, organizing, and analyzing huge amounts of data and that organizations use such knowledge to respond to external changes and market through innovations that also reap ecological benefits along with economic return (first objective). To answer *how* this study proposes that organizations use knowledge derived through BDA capability to develop green DCs to achieve GI effectively (second objective). In this way, we suggest green DCs as mediating mechanisms linking BDA capability and GI. Furthermore, the literature suggests that various contextual factors influence the extent to which firm-level antecedents predict outcomes. In this regard, we argue that ROC plays a contingent role in complementing the effect of green DCs in predicting GI (third objective). Figure 1 displays the proposed research model.

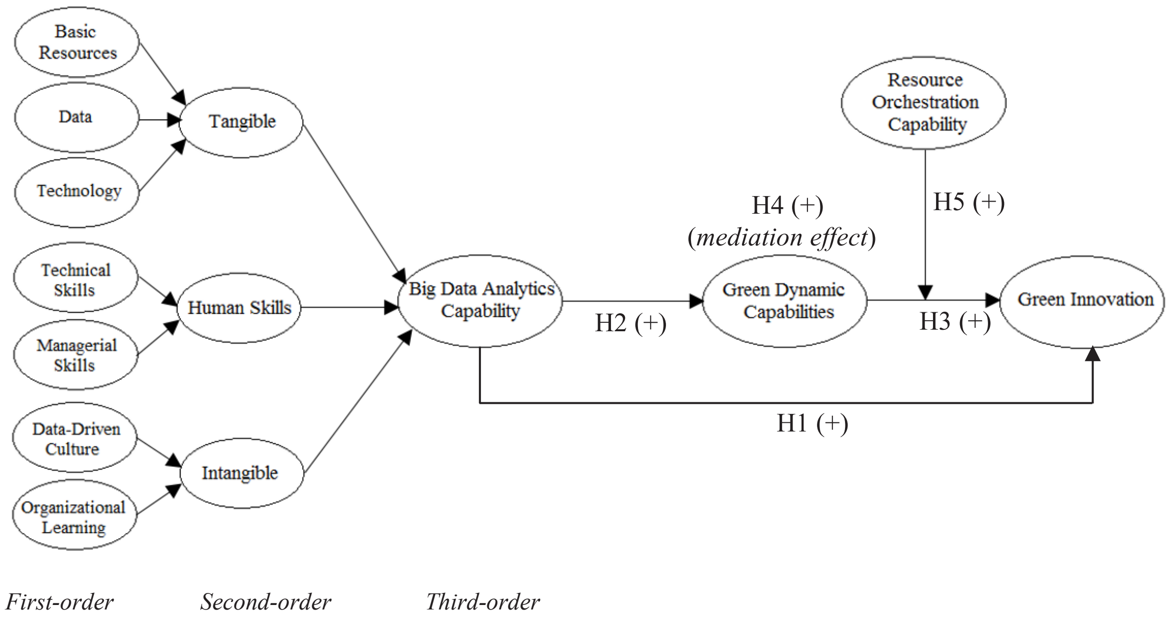

Figure 1. Proposed research model

LITERATURE REVIEW

Big data analytics capability

BDA capability refers to „ a firm's ability to assemble, integrate, and deploy its big data-specific resources" (Gupta & George, 2016, p. 1051). According to Gupta and George (2016), BDA capability is a third-order construct comprising human skills and tangible and intangible resources related to big data. These three pillars of BDA capability are second-order constructs and represent infrastructure, resources, technology, and skills essential for collecting, processing, and analyzing large volumes of data. Big-data related tangible resources encompass data, technology, and basic resources to implement BDA, whereas intangible resources focus on development of "data-driven culture" and "continuous organizational learning." These big-data-oriented resources provide necessary technology and basic resources to establish BDA infrastructure. However, human skills (i.e., technical and managerial skills) enable organizations to utilize these resources (Mikalef et al., 2020).

Past studies showed that organizations use market information as a key source to meet the customers demands by introducing innovative products and processes (Demirel & Kesidou, 2019; Zahra, 2021). Research on BDA suggests that organizations using data-related capabilities have more propensity to gain competitive advantage and environmental performance because incorporation of BDA enables organizations to make sense of and capture critical insights from huge volumes of data (Behl, 2022; Garmaki et al., 2023; Jiang et al., 2024; Ranjan & Foropon, 2021). Empirical studies have revealed that BDA capability is a key factor to prompt dynamic and operational capabilities which help organizations to achieve superior performance outcomes (Mikalef et al., 2019). Moreover, Mariani and Wamba (2020) noticed that BDA offers insights into market trends, external changes, competition, and consumer behavior based on information extracted from the huge amount of data (Bartosik-Purgat & Ratajczak-Mrozek, 2018). Given the advancement of big data, organizations need to cultivate big data analytic capabilities with the aim of deriving significant insights to make sensible decisions (Brewis et al., 2023; El-Kassar & Singh, 2019). Keeping in view the significance of environmentalism, that is why, this study attempts to examine if BDA capability plays a crucial role in prompting green DC and green innovation.

Big data analytics capability and green innovation

Due to the growing concerns about ecology and environmental protection, organizations are inclined to transform products, services, and processes to ensure that business operations are less harmful to society and the environment (Hofmann & Jaeger-Erben, 2020; Paredes-Chacin et al., 2024; Zhu et al., 2023). Under this motivation, green innovation (GI) has become essential to business activities. It revolves around the idea of improving existing and/or offering new products and processes that are more sustainable, eco-friendly, and protect the environment (Khanra et al., 2022; Takalo & Tooranloo, 2021). GI in processes gives the opportunity to save energy, prevent pollution, and recycle waste material, whereas offering green products helps capture increased market share. Extant studies indicate that green/eco-friendly products are gaining popularity across the atlas, and organizations are reaping financial benefits besides mere compliance with principles of environmentalism. For example, Yi et al. (2023), in a meta-analytical study, noted that green products lead to sales increase and enhance competitive performance. The „green" gives a direction in searching customers' concerns, seizing new market opportunities, and creating value for their customers by producing eco-friendly products. Indeed, green innovation is considered a strategic tool required for organizations that give the opportunity to fulfill customer demand without harming the environment (Dong et al., 2024; Xie et al., 2019).

Big data serves as a significant tool in enhancing a firm's efficiency in assessing new opportunities (Olabode et al., 2022). BDA capability is dynamic in nature as it fosters innovation by providing the organizations with innovative insights and actionable information. Valuable insights gained from BDA can help organizations to identify environmental problems and find innovative solutions to resolve such problems (Mikalef et al., 2018). Organizations can use BDA to identify trends and patterns of market changes, hence enabling to improve processes, reduce waste, and enhance energy efficiency to create economic value while ensuring environmental sustainability (Beier et al., 2022). Furthermore, BDA capability enables organizations to analyze consumer behavior and market preferences and gain insights into the demand for eco-friendly products, thereby promoting sustainable consumption through developing eco-friendly products and services (Chen et al., 2021). Furthermore, recent body of research has noticed that big-data analytics are important for fostering green practices, eco-innovation, and environmental performance. For example, Arici et al. (2023) found that BDA assists hospitality organizations in evaluating customers' feedback regarding green service quality and offers a roadmap to foster innovative green processes. Al-Khatib (2022) advocated that BDA capability enabled Jordanian firms to improve green supply chain performance by promoting GI. In addition, Chen and Liang (2021) and Dong et al. (2024) found that BDA capability strengths the effect of internal and external factors, which in turn facilitate the development of green solutions and innovation performance. Therefore, it is proposed that BDA capability is likely to promote GI.

H1: BDA capability has a positive relationship with GI.

Big data analytics and green dynamic capabilities

Green DC is defined as „ability of a company to exploit its existing resources and knowledge to renew and develop its green organizational capabilities to react to the dynamic market" (Chen & Chang, 2013, p. 109). Green DCs represent the firm's proficiency to identify, develop, and deploy resources and capabilities related to sustainable and environmentally friendly practices. These capabilities enable a firm to adapt and thrive in an ever-changing business landscape while addressing growing environmental concerns (Singh et al., 2022). As a result, green DCs create value for the organization by changing the ways of doing business with respect to changes in trends, competition, and the external environment (Chen & Chang, 2013; Yuan & Cao, 2022). Green DCs enable organizations to mitigate environmental risks and help them capitalize on emerging market opportunities related to sustainability, hence establishing a competitive advantage in the long run (Mazon et al., 2023). Studies have found the significance of traditional and green DCs in fostering competitive advantage, superior performance, firm green image, and goodwill (Singh et al., 2022; Yousaf, 2021; Zhu et al., 2023). We argue that BDA capability helps organizations prompt green DCs so that organizations could (re)shape how to create value and embed sustainable practices.

BDA offers organizations information about several aspects of business operations, such as external market trends, resource consumption, areas of excessive usage or waste, potential risks, and future demand, hence optimizing organizations' ability to monitor what is happening in terms of trends, opportunities, and threats related to green practices (Mikalef et al., 2019). Moreover, information through predictive analysis can be used to make informed decisions for utilizing and exploiting resources and opportunities to implement green initiatives (Bresciani et al., 2022; Zhu et al., 2023). Likewise, BDA helps organizations regularly update and revise their green practices based on feedback, learning, and improvements to achieve long-term sustainable outcomes (Su et al., 2022; Singh & El-Kassar, 2019). BDA capability, which encompasses the provision of valuable insights derived from diverse data sources across various business domains, is expected to prompt green DCs by letting the organizations aware of sustainability opportunities (sensing), taking action to capitalize on them (seizing), and continuously adapting to stay at the forefront (reconfiguring) of eco-friendly practices for overall business success. In this way, BDA capability prepares organizations to take proactive steps to tap into opportunities and improve environmental performance (Saeed et al., 2023; Wamba et al., 2024). Resultantly, BDA facilitates organizations to continuously review and adjust existing systems, processes, and strategies in response to changing environmental contexts, i.e., reconfiguration of resources.

H2: BDA capability has a positive relationship with green DCs.

Green dynamic capabilities and green innovation

Green innovation offers economic and environmental benefits by reducing greenhouse gas emissions (GHG), industrial waste, resource usage, and energy consumption and protecting the environment (Khanra et al., 2022; Singh et al., 2022). In this regard, extant literature suggests many antecedents that provide a significant contribution in developing and supporting GI. The present study proposes green DC as a key predictor of GI. Originating from RB-V, the dynamic-capability perspective advocates that DCs allow organizations to continuously adapt and innovate in response to changes in market trends, technological advancements, and evolving customer preferences (Teece & Pisano, 2003). With sensing, seizing, and reconfiguring at its heart, DCs facilitate organizations to effectively identify and seize new opportunities while enabling organization to successfully respond to potential threats and challenges in the business operating environment (Baia & Ferreira, 2024). Drawing from a dynamic-capability perspective, it is submitted that green DCs are expected to facilitate organizations to identify gaps, opportunities, and areas where sustainable actions are needed (Bornay-Barrachina et al., 2023; Alshanty & Emeagwali, 2019). For example, sensing enables organizations to monitor environmental and market trends, and recognize societal needs and challenges related to sustainability. By understanding the environmental needs along with customer demands and regulatory changes, organizations can gain valuable insights necessary for initiating GIs (Teece, 2018).

Similarly, green DCs facilitate resources allocation, goals setting, and establishment of strategic partnerships to address the identified gaps and/or market demands; ensuring that potential sustainable opportunities are not overlooked (Bogers et al., 2019). As a result, green DCs, through seizing, help organizations take proactive measures in developing and implementing green initiatives. Finally, the reconfiguring element of green DCs assists organizations in transforming their resources, existing business processes, and systems to accommodate GI (Conboy et al., 2020; Teece, 2018). These green initiatives involve many actions, including changes in production methods, energy usage, waste management, and product design. Hence, green DCs are expected to align an organization's activities with its commitment to green practices and ensure that innovation is well applied and integrated into products and core operations of the organization.

H3: Green DC has a positive link with GI.

Mediation effect of green dynamic capabilities

Green DCs are expected to serve as a mediating mechanism and link BDA capability with GI. Besides direct influence of BDA capability on GI, green dynamic capabilities are expected to mediate how BDA capability prompts green innovation through green capabilities. As argued earlier, BDA capability can influence green DCs by fostering sensing, seizing, and reconfiguring (Teece, 2018). BDA capability helps organizations collect, process, and analyze large volumes of data from various sources in real-time or near real-time (Mikalef et al., 2020). This enables organizations to sense changes, identify trends, and recognize patterns and anomalies in the data, which are not readily obvious through traditional methods. The ability to sense such information helps organizations make more informed decisions and take timely actions (Yousaf, 2021).

Contrary to that, organizations less proficient in sensing external changes are less likely to prepare and adapt to change and competition. BDA capability also allows organizations to seize strategic opportunities and competitive edge by identifying actionable insights from the data. Moreover, these actionable insights help organizations reconfigure and transform resource bases, processes, and business operations (Yuan & Cao, 2022). Green DCs, in turn, lead towards changes in existing and/or offering of new products, processes, and practices that are sustainable and eco-friendly, hence promoting green innovation (Yuan & Cao, 2022; Zhu et al., 2023). This implies that organizations' inability to tap into opportunities, mitigate risk, and respond to challenges may lead to operational and financial setbacks. In simple words, BDA capability is an important factor that determines green dynamic capabilities, which in turn promote GI. In this way, it is expected that green DCs serve as a mediating mechanism for the association between BDA capability and GI.

H4: Green DCs play mediating role between BDA capability and GI.

Resource orchestration capability as moderator

Resource orchestration capability (ROC) refers to a firm's ability to „structure the resource portfolio, bundling the resources to build capabilities, and leveraging those capabilities to create and maintain value for customers and owners" (Sirmon et al., 2007, p. 273). Rooted in the resource-based view (RBV), ROC indicates how effectively organizations combine, allocate, and deploy resources to achieve strategic goals. ROC comprises three elements: structuring, bundling, and leveraging (Sirmon et al., 2011; Sirmon et al., 2007). Structuring represents an organization's actions to acquire, accumulate, and divest resources. Bundling emphasizes building capabilities by improving and extending existing capabilities and developing new competencies and/or, finally, leveraging focuses on mobilizing resources to create value.

This research proposes that ROC may strengthen the nexus between green DCs and GI. Drawing from complementarity perspective (Adegbasen, 2009; Harrison et al., 2001; Song et al., 2005), we propose that ROC works together with green DCs to have a synergistic effect and increases the effectiveness of green DCs in eliciting green innovation. Since green DCs involve the continuous development and adaptation of innovative practices to address environmental challenges, resource orchestration capability allows for the integration, coordination, and efficient utilization of diverse resources (Sirmon et al., 2007), such as human, financial, and technological, to support green innovation initiatives. It also helps to coordinate and align the activities of different operational units within an organization toward green innovation goals. With ROC, organizations can effectively combine, allocate, and deploy pool of resources (Peterson et al., 2023; Wang et al., 2020) which allows for continuous development and adaptation of innovative practices to address environmental challenges.

Furthermore, ROC is likely to enable organizational learning and adaptation in the context of green innovation. ROC facilitates organizations to identify and acquire new resources, enhance employee learning and skills development, and adapt to changing environmental requirements (Kristoffersen et al., 2021). This improves a firm's ability to continuously innovate and create environmentally-friendly products and processes. Hence, Resource orchestration capability enables the efficient allocation, integration, and coordination of diverse resources, and innovative solutions enabling the organization to amplify the effect of sensing, seizing, and reconfiguring abilities to develop sustainable, innovative solutions (see Andersen, 2023; Mao et al., 2024). In sum, green DCs, when combined with ROC, increase an organization's effectiveness in fostering green innovation.

H5: ROC moderates the relationship between green DCs and GI in such a way that the relationship is strong at a high level of resource orchestration.

RESEARCH METHODOLOGY

Sample and data collection

The present research involves testing hypotheses using primary data collected by using the survey questionnaire. We collected data from service and manufacturing sector organizations working in Pakistan. Pakistan is an emerging economy where businesses are responsible for substantial amounts of carbon di-oxide and greenhouse gasses (GHG) emissions. According to the European Commission, Pakistan falls among polluted countries (low air quality index), and its economy is responsible for 1.02% of global GHG emissions (Crippa et al., 2023). Furthermore, as an emerging economy, businesses are embedding ICT solutions and big-data tools for improving economic, operational, and sustainability performance. Therefore, Pakistan represents a suitable study context.

Following the guidelines from extant studies (e.g., Del Vecchio et al., 2018; Maroufkhani et al., 2023), we targeted only medium-sized and large firms. In this regard, we used a criterion of a minimum of fifty employees working in the organization as firm size, hence to exclude small and micro firms. We used this criterion because it is expected that small and micro firms have strict financial constraints that lead them to outsource big data-related sources instead of investing in developing big data infrastructure within the organization. However, medium and large organizations are more capable of possessing their own data resources and infrastructure (Kim et al., 2022; McAfee & Brynjolfsson, 2017). Secondly, we set a minimum of six years as a criterion of firm age to select the sample because, for innovations, Li and Liu (2014) advocated that new organizations are more prone to innovations and newness, and it takes at least four years for a startup to get into routine. Therefore, there is a greater likelihood of nascent organizations inclined towards sustainable and eco-innovations. Hence, to reduce the potential influence of newness toward green innovation, we targeted organizations that had been working for at least six years at the time of data collection.

The unit of analysis is organization; key respondents were top-level managerial employees, and one response was collected from each organization. Top-level managerial employees possess a broad perspective as they oversee the entire organization and have a holistic view of its operations. Hence, in the context of BDA and innovation capabilities, top-level managers possess the necessary information and can provide more accurate information regarding study constructs. We used convenience sampling and one of the authors approached the respondents using professional and personal linkages. The data were collected from 291 organizations from the following industries: textile (41), pharmaceutical (34), general electric and electronics (27), agribusiness (19), food and beverages (29), advertising (4), education (6), chemical (21), travel and tourism (31), leather (20), banking and financial (23), and FMCG (36).

Construct measurement

BDA capability was operationalized as a third-order latent construct, and the measurement scale was adapted from Mikalef et al. (2019). BDA capability has three dimensions: human skills and tangible and intangible resources. These three dimensions represent second-order latent constructs. Human skills comprise two first-order constructs with six items each (managerial skills, technical skills), and tangible resources comprise three first-order constructs (basic resources – 2-items, data – 3-items, technology – 5-items). Intangible resources comprise two first-order latent constructs with five items each (data-driven culture, organizational learning). A 7-item scale was adopted to measure green DCs (Chen & Chang, 2013). GI is operationalized as eco-friendly innovations in products, processes, and managerial activities. An 8-item scale was adapted from Chiou et al. (2011) to measure green innovation. To measure resource orchestration capability, a three-item scale was adapted from Wang et al. (2020). We controlled the effects of firm age and size.

RESULTS

Validity, reliability, and correlation analysis

Prior to hypotheses testing, we examined the validity as well as reliability of the constructs. We employed a PLS-SEM approach and used WarpPLS 7.0 (Kock, 2018) to perform confirmatory factor analysis (CFA) for construct validity. PLS-SEM has been preferred over covariance-based SEM (CB-SEM) because it considers measurement errors when aggregating latent indicators to calculate latent variables, unlike CB-SEM, which does not consider these errors. According to Henseler et al. (2015), neglecting measurement errors is likely to lead to bias as they serve as additional indicators. Additionally, PLS-SEM increases theoretical parsimony because it eliminates complexity when estimating hierarchical models by making flexible assumptions (Kock, 2018). Finally, BDA capability comprises formative indicators, which are limited in analysis by CB-SEM, while PLS-SEM allows the incorporation of both reflective and formative indicators (Sarstedt et al., 2021). The results in Table 1 show factor loadings, AVEs, and full-collinearity VIF. The values of factor loadings and AVEs ensure convergent validity as the values cross the threshold to accept the values, i.e., 0.5 (Hair et al. 2014). This ensures convergent validity. However, Kock (2015) advocated that full-collinearity VIF is an effective test in the context of PLS-SEM to address the issue of common method bias. A value of full-collinearity VIF less than 5 indicates that common method bias is not a significant issue.

Table 1. Results of confirmatory factor analysis for construct validity

Construct	Indicator	Loading	AVEs	Full collinearity VIFs
Data	DT01	0.870	0.791	2.035
	DT02	0.909		
	DT03	0.889		
Technology	TEC01	0.912	0.832	3.728
	TEC02	0.901		
	TEC03	0.922		
	TEC04	0.918		
	TEC05	0.908		

Construct	Indicator	Loading	AVEs	Full collinearity VIFs
Basic Resources	BR01	0.950	0.902	2.352
	BR02	0.949		
Technical Skills	TS01	0.893	0.811	4.254
	TS02	0.918		
	TS03	0.918		
	TS04	0.886		
	TS05	0.898		
	TS06	0.891		
Managerial Skills	MS01	0.858	0.776	2.576
	MS02	0.870		
	MS03	0.880		
	MS04	0.899		
	MS05	0.903		
	MS06	0.873		
"Data-driven-Culture"	DD-1	0.825	0.708	2.131
	DD-2	0.867		
	DD-3	0.839		
	DD-4	0.850		
	DD-5	0.824		
Organizational Learning	OL01	0.758	0.567	1.319
	OL02	0.789		
	OL03	0.782		
	OL04	0.702		
	OL05	0.732		
Tangible [a]	Data	0.838	0.748	3.071
	"Technology"	0.913		
	"Basic Resources"	0.842		
Human [a]	"Technical Skills"	0.931	0.867	3.347
	"Managerial Skills"	0.930		
Intangible [a]	"Data-driven-Culture"	0.847	0.718	1.707
	"Organizational Learning"	0.845		
BDA Capability [b]	Tangible	0.902	0.771	1.382
	Human	0.928		
	Intangible	0.799		
"Green Dynamic Capabilities"	GDC-1	0.749	0.580	1.740
	GDC-2	0.840		
	GDC-3	0.713		
	GDC-4	0.698		
	GDC-5	0.842		
	GDC-6	0.752		
	GDC-7	0.724		
"Resource Orchestration Capability"	ROC-1	0.796	0.678	1.180
	ROC-2	0.866		
	ROC-3	0.806		
"Green Innovation"	GI-1	0.815	0.580	2.071
	GI-2	0.635		
	GI-3	0.657		
	GI-4	0.762		
	GI-5	0.764		
	GI-6	0.796		
	GI-7	0.813		
	GI-8	0.823		

Note: All values of factor loadings are significant at $p<0.001$, [a] second-order latent construct, [b] third-order latent construct.

To examine discriminant validity, we used both Fornell and Larcker's (1981) approach and ratios of HTMT (Henseler et al., 2015). According to Fornell and Larcker (1981), discriminant validity among constructs exists if the square roots of AVEs are less than the respective correlation coefficients (see Table 3). Table 2 provides hetero-trait-mono-trait (HTMT) ratio values, which also support discriminant validity. These results support the presence of discriminant validity.

Moreover, values of construct reliability are displayed in Table 3 since the values of composite reliability and Cronbach's Alpha exceed the threshold value, i.e., 0.7 (Hair et al., 2014); therefore, data supported construct reliability.

Table 2. HTMT ratios for discriminant validity

Construct	1	2	3	4	5	6	7	8	9
1. Data	--								
2. Technology	0.740								
3. Basic Resources	0.580	0.639							
4. Technical-Skills	0.668	0.524	0.787						
5. Managerial-Skills	0.623	0.702	0.621	0.574					
6. Data-driven-Culture	0.592	0.687	0.551	0.663	0.669				
7. Organizational Learning	0.247	0.339	0.243	0.391	0.396	0.511			
8. Green Dynamic Capabilities	0.279	0.376	0.279	0.287	0.308	0.340	0.263		
9. Green Innovation	0.717	0.454	0.364	0.423	0.431	0.467	0.342	0.573	
10. Resource Orchestration Capability	0.093	0.056	0.146	0.124	0.057	0.069	0.124	0.180	0.247

Note: All values are significant at p<0.001; good if values <0.90, best if <0.85.

Once construct validity and reliability were established, we performed correlation analysis to seek mutual relationships between study constructs. Table 3 displays coefficients of correlation and indicates that all individual dimensions of BDA capability have a positive correlation with GI with green DCs as well. These results also show a positive correlation between green DCs and GI.

Table 3. Construct reliability and correlation coefficients along with square roots of AVEs

Constructs	1	2	3	4	5	6	7	8	9	10
1. Data	**0.889**									
2. Technology	0.671	**0.912**								
3. Basic Resources	0.512	0.682	**0.950**							
4. Technical Skills	0.609	0.787	0.725	**0.901**						
5. Managerial Skills	0.562	0.664	0.569	0.734	**0.881**					
6. Data-Driven-Culture	0.521	0.633	0.496	0.617	0.617	**0.841**				
7. Organizational Learning	0.204	0.297	0.207	0.344	0.345	0.437	**0.753**			
8. Green Dynamic Capabilities	0.244	0.342	0.246	0.264	0.282	0.302	0.221	**0.762**		
9. Green Innovation	0.389	0.425	0.335	0.398	0.400	0.420	0.295	0.506	**0.761**	
10. Resource Orchestration Capability	0.051	0.035	0118	0.090	0.024	0.021	0.052	0.094	0.204	**0.823**
"Composite Reliability"	0.919	0.961	0.949	0.963	0.954	0.924	0.867	0.906	0.916	0.863
"Cronbach's Alpha"	0.868	0.950	0.892	0.953	0.942	0.897	0.809	0.878	0.895	0.762

Note: Correlation coefficients with values less than 0.11 are statistically insignificant. "The square roots of AVEs are shown on a diagonal.

Hypotheses testing

To test the hypotheses, we performed an analysis by employing PLS-SEM in WarpPLS 7.0 (Kock, 2018). To perform the analysis, we combined the dimensions of BDA capability and used them as formative indicators to make BDA capability a third-order latent construct. Similarly, we used composite scores of all three dimensions of green DCs to measure green DCs as a second-order latent construct. Table 4 shows PLS-SEM results as well as model-fit indices.

Table 4: PLS-SEM results for hypotheses testing and model-fit indices

Path	Estimate (β)	Effect size (f^2)	Remarks
BDA→GI	0.33	0.174	H1 Supported
BDA→GDCs	0.35	0.122	H2 Supported
GDCs→GI	0.50	0.332	H3 Supported
BDA→GDCs→GI	0.18	0.092	H4 Supported
ROC*GDCs→GI	0.14	0.031	H5 Supported
Firm size→GI	-0.06	0.011	
Firm age→GI	0.04	0.006	
"Model-Fit Indices"			***Value***
"Average path coefficient (APC)" *Acceptable if p<0.05*			0.212, p<0.001
"Average R-squared (ARS)" *Acceptable if p<0.05*			0.336, p<0.001
"Average adjusted R-squared (AARS)" *Acceptable if p<0.05*			0.328, p<0.001
"Average block VIF (AVIF)" *Acceptable if<=5, ideally<=3.3"*			1.078
"Average full collinearity VIF (AFVIF)" *Acceptable if<=5, ideally<=3.3*			1.339
"Tenenhaus GoF (GoF)" *Small>=0.1, medium>=0.25, large>=0.36"*			0.526
"Sympson's paradox ratio (SPR)" *Acceptable if>=0.7, ideally=1*			0.857
"R-squared contribution ratio (RSCR)" *Acceptable if>=0.9, ideally=1*			0.991
"Nonlinear bivariate causality direction ratio (NLBCDR)" *Acceptable if>=0.7"*			0.929

Note: BDA=big data analytics capability; GDCs=green dynamic capabilities; GI=green innovation; ROC=resource orchestration capability.

Results presented in Table 4 indicate that BDA capability has a positive relationship with GI (β=0.33, p<0.01), implying that BDA capability elicits green innovations. Hence, these results support hypothesis 1. Likewise, results also show that BDA capability positively impacts green DCs (β=0.35, p<0.01), hence providing support for hypothesis 2. For hypothesis 3, data also provided support as results indicate a positive and significant path coefficient from green DCs to green innovation (β=0.50, p<0.01).

Hypothesis 4 states that BDA capability influences green DCs, fostering GI performance. Results presented in Table 4 also support mediation, implying that green DCs mediate the relationship between BDA capability and GI (β=0.18, p<0.01). Finally, hypothesis 5 states resource orchestration's moderating effect on the relationship between green DCs and GI. The results provide empirical support for hypothesis 6, which implies that resource orchestration capability complements green DCs to increase their effectiveness in eliciting GI (β=0.14, p<0.01). Figure 2 illustrates the results of PLS-SEM.

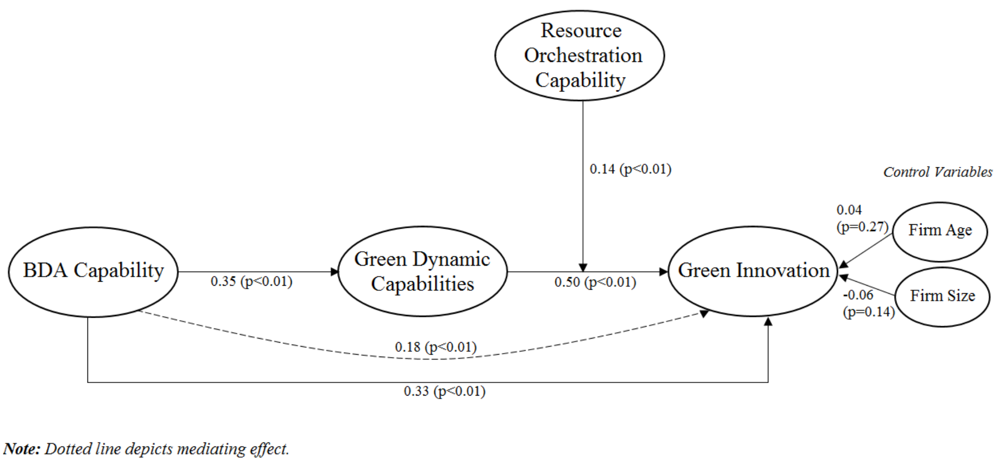

Figure 2. Graphical illustration of PLS-SEM results

DISCUSSIONS, IMPLICATIONS, AND LIMITATIONS

As the attention towards sustainability is growing continuously, this study attempted to investigate how green innovation can be leveraged from BDA capability, which is also gaining increased consideration due to the ‚era of data.' The value of green innovation has been recognized in recent research. Studies focusing on the economic value of green innovation recognized that these innovations are costly but payback in the form of improved financial performance in the long run. Knowing the significance and need for green innovation, this study used the BDA perspective to suggest that BDA capability could serve as an important element in fostering green innovation. These findings are comparable and in line with recent findings of Ahmad et al. (2024), Saeed et al. (2023), and Wamba et al. (2024), which highlight the significance of BDA in determining organizational outcomes, including innovation. In addition, the aforementioned relationship can be better understood by highlighting how BDA capability improves green innovation and suggested green DCs as an underlying mechanism. The findings are striking when many studies talk about the transformative value of BDA. Particularly, findings suggest that BDA capability enables organizations to collect, organize, process effectively, and analyze big data sources to identify and understand market trends, demand, production, resources, customers, and media, which helps organizations identify opportunities and gaps for green initiatives. Findings also suggest that BDA capability makes organizations more proficient in sensing ‚what is happening,' seizing potential opportunities and transforming resources to create value to support sustainability. These findings are consistent with the studies of Brewis et al. (2023), Itani et al. (2024), and Li et al. (2024), which found that BDA capabilities play a key role in fostering dynamic and operational capabilities to reap operational as well as financial benefits.

In addition, the results highlight the potential role of ROC in developing green innovation. RB-V advocates the significance of firm resources, capabilities, and competencies in creating value and gaining competitive advantages. However, organizations need to understand which resources or combinations of resources are imperative and how they should be utilized to achieve sustainability. Particularly, when one resource and/or capability is combined with another, they complement each other and bring a synergistic effect. The findings of this research show that ROC plays an important role as moderator and increases the effectiveness of green DCs in eliciting GI. It is important to note that the findings of Kristoffersen et al. (2021) and Mao et al. (2024) also support the notion that the orchestration of assets and resources is likely to have synergistic effects.

Theoretical implications

Our research provides important theoretical and practical implications. For theoretical implications and contributions, this research offers an integrated framework based on big-data and DCs to link BDA with innovation to seek solutions for environmental concerns while ensuring the economic value of the business activities. By suggesting a direct effect of BDA capability on GI, it adds to the existing literature regarding role of digital capabilities in promoting sustainability practices. Second, drawing from RB-V, BDA capability denotes an organization's skills and tangible and intangible resources to tap into big data resources to develop capabilities to create value. With increased competition and uncertainty, organizations have to continuously align and transform their capabilities to tackle risks and benefit from opportunities. In this regard, this study suggests a theoretical understanding of how organizations utilize BDA capability to develop, align, and transform their green DCs in the quest for sustainability. Third, our research provides a significant contribution to the literature by using a complementarity perspective. It explains that when one capability is integrated with another capability, they are expected to have a synergistic effect, which is bigger than the sum of individual effects. Since an organization is perceived to be a system comprising various departments, units, assets, and resources, these components and/or capabilities need to be coordinated and worked on in isolation to ensure that organizations achieve their goals. Further, exploiting resources and capabilities in the right combination and coordination may amplify their effectiveness in achieving business objectives. In this regard, our framework suggests that when combined with green DCs, resource orchestration capability catalyzes the development and implementation of green initiatives.

Practical and managerial implications

For practical implications, the findings suggest that organizations aiming to foster green innovation should invest in developing BDA capabilities. This may involve acquiring and analyzing large volumes of data related to sustainability, which can provide insights and support decision-making processes. Since investing in BDA could be costly, especially for small enterprises, managers can outsource and/or benefit from either cloud-based solution (e.g., Microsoft Azure HDInsight) or block chain-based solutions for big data analytics (e.g., Bluzelle, Ocean Protocol). Second, managers should also focus on building green DCs, which involve identifying and exploiting opportunities for sustainable innovation. This may be achieved by establishing cross-functional teams, nurturing a culture of environmental consciousness, and continuously learning and adapting to environmental changes. Third, this study highlights resource orchestration's importance in driving green innovation. Resource orchestration should be seen as a critical managerial task. Managers should invest in understanding and leveraging the sources of an organization and capabilities to maximize their effect on green innovation. Fourth, managers should strive to align organizational resources and capabilities to amplify their effectiveness in predicting and promoting sustainable outcomes. This can be done by developing effective coordination mechanisms, encouraging collaboration and knowledge-sharing, and allocating resources strategically. In a nutshell, managers should recognize the benefits of BDA in deriving sustainable practices. By leveraging BDA capability, managers can uncover insights and patterns that enable them to make informed decisions, identify areas for improvement, and develop innovative solutions that align with sustainability goals.

Limitations and future research

Besides offering important implications, this research also has limitations. First, the present study investigates the role of BDA capability in prompting GI. There is the possibility that BDA could be more beneficial in other forms of innovation and innovation capabilities. Future studies may develop and examine a comprehensive framework to evaluate the effectiveness of BDA in different forms of innovation (e.g., incremental, radical, exploratory). Second, the mediating mechanism we used is green DCs. However, future studies may attempt to explore other mechanisms (e.g., knowledge management, agility) to unveil the missing link between DBA and green innovation. Third, this study theorized resource orchestration capability as the complementary source. However, it is possible that ‚too good of a good thing' may not be useful in some circumstances, even if it can bring harm or substitute the key predictor. Considering this, future studies may examine the curvilinear nature of relationships among this study's variables. Last but not least, this study was undertaken in the context of a collectivist culture, which may restrict our comprehension regarding the implications of BDA capability for green innovation for organizations operating in communities with individualistic norms. Future studies may take a cross-cultural context to compare and comprehend the potential of BDA in deriving organizational outcomes.

CONCLUSION

The present study aimed to examine the role of BDA capability in leveraging GI directly and through the development of green DCs. Findings show that BDA capability positively influences both GI and green DCs. Moreover, green DCs are also linked with GI and mediate the effect of BDA capability on GI. The present research also investigated the moderating effect of resources orchestration. We argued that organizations' ability to structure, bundle, and leverage resources is likely to complement organizations' other strategic areas and capabilities to achieve amplified outcomes. Findings illustrate that green DCs, when combined with ROC, have a stronger effect in prompting green innovation. The findings of this study suggest that managers should recognize the potential benefits of BDA in deriving sustainable practices. By leveraging BDA capability, managers can uncover insights and patterns that enable them to make informed decisions, identify areas for improvement, and develop innovative solutions that align with sustainability goals.

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Authorship contribution statement

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The authors declare no conflict of interest.

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Defining analytical skills for human resources analytics: A call for standardization

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Abstract

PURPOSE: *Human resources (HR) analytics systems, powered by big data, AI algorithms, and information technology, are increasingly adopted by organizations to enhance HR's impact on business performance. However, despite the widespread acknowledgment of the importance of "analytical skills" among HR practitioners in successfully implementing HR analytics systems, the specific nature of these skills remains unclear. This paper aims to address this ambiguity by firstly clarifying the concept of "analytical skills," secondly identifying skill gaps that may hinder the effective utilization of computer-assisted analytics among HR practitioners, and thirdly advocating for standardization in the understanding of "analytical skills" within the business context, particularly within HR.* ***METHODOLOGY:*** *We examine business "analytical skills" through the theoretical framework of the knowledge, skills, and abilities (KSA) included in the Occupational Information Network (O*NET) content model. Using data from the O*NET database, occupations were classified into Human Resource Management (HRM) and Analytical occupations. Then, we identified the top highly required KSAs in analytical occupations and compared their levels with those of HRM occupations to pinpoint potential gaps hindering the effective utilization of HR analytics.* ***FINDINGS:*** *Using the O*NET database, which describes work and worker characteristics, we establish the highly required analytical KSAs in the business analytics context that might be labeled "analytical skills". Then, the gap analyses reveal that important analytical KSAs, such as knowledge of sales and marketing, skills in operations analysis, and abilities in mathematical and inductive reasoning, are not expected from HR occupations, creating serious barriers to HR analytics development. In general, we have found that while HR practitioners possess some of the necessary analytical KSAs, they often lack in areas such as mathematics, computers, and complex problem-solving.* ***IMPLICATIONS:*** *Our findings underscore the need for standardization in HR analytics definitions, advocating for the adoption of the O*NET content model as a universal framework for understanding HR analytical knowledge, skills, and abilities (KSAs). By identifying critical analytical KSAs, our research can assist HR departments in improving training, recruitment, and development processes to better integrate HR analytics. Furthermore, we identify significant gaps in analytical skills among HR practitioners, offering potential solutions to bridge these gaps. From a theoretical perspective, our precise definition of HR "analytical skills" in terms of analytic KSAs can enhance research on the effects of HR analytics on organizational performance. This refined understanding can lead to more nuanced and impactful studies, providing deeper insights into how HR analytics contributes to achieving strategic business goals.* ***ORIGINALITY AND VALUE:*** *Our research offers three original insights. First, we establish a standard for HR analyst skills based on the O*NET content model, providing a clear framework for the essential knowledge, skills, and abilities required in HR analytics. Second, we identify significant analytical gaps among HR professionals, highlighting areas that need development and attention. Third, we recognize the necessity for closer cooperation between HR and professional analysts, emphasizing that such collaboration is crucial for maximizing the benefits of computer-assisted HR analytics. These insights ensure that HR analytics can move beyond being a management fad and have a real, lasting impact on business outcomes.*

Keywords: *analytical skills, human resources analytics, HR analytics, knowledge, skills, abilities, HRM, analysts, O*NET, big data, AI, standardization*

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INTRODUCTION

Human capital management (HCM) software (see Aral, Brynjolfsson, Wu, 2012) and human resources information systems (HRIS) (see Rasmussen & Ulrich, 2015) together with a variety of other "people analytics" (Tursunbayeva, Di Lauro, & Pagliari, 2018; McCartney & Fu 2022), continue to be implemented across business organizations with a mission to improve human resources management (HRM) impact on business performance giving birth to a new field of computer-assisted human resources (HR) analytics - in short, HR analytics. Drawing from one of the reviews of approaches to HR analytics (Marler & Boudreau, 2017 p.15), it might be defined as: "*An HR [human resources] practice enabled by information technology that uses descriptive, visual, and statistical analyses of data related to HR processes, human capital, organizational performance, and external economic benchmarks to establish business impact and enable data-driven decision-making.*" The general idea behind HR analytics is to take advantage of information technology (IT) and the variety of workforce data that the HR departments possess but do not always use in the most effective ways. Employee pay levels across the organization, performance ratings, opinion survey results, sickness absences registers, recruitment process results, and exit interviews – are among many of those data which might be used for HR analytics to increase employee motivation, abilities, and opportunities and thus positively influence organisational performance (Blom, Kruyen, Van der Heijden, & Van Thiel, 2020; Marler & Boudreau 2017; Kryscynski, Reeves, Stice-Lusvardi, Ulrich, & Russell, 2018).

On the other hand, the promises of HR analytics to use technology as an enabler of evidence-based decision-making and increasing business outcomes, still lack their realization in the form of robust evidence (Boudreau & Cascio 2017, McCartney & Fu 2022), Instead, HR analytics might be seen as a modern management fashion (see e.g., Angrave, Charlwood, Kirkpatrick, Lawrence, & Stuart, 2016; Tursunbayeva, Di Lauro, & Pagliari, 2018) and like all management fashions (Abrahamson, 1996), it is driven by medial hype and naïve reasoning (just search for "HR analytics" in Google). There is a risk that HR analytics might end up as a buzzword (Rasmussen, & Ulrich, 2015) 'failing on big data challenges' (see Angrave, Charlwood, Kirkpatrick, Lawrence, & Stuart, 2016), adding nothing to the organisations' performance aside from a few marketing slogans. Moreover, there are more and more concerns that using technology in the form of HR analytics might have "dark sides" such as marginalizing human reasoning or impairing transparency with complex black-box algorithms (Giermindl, Strich, Christ, Leicht-Deobald & Redzepi, 2022) and ethical concerns related to privacy and data governance (Edwards, Charlwood, Guenole, & Marler, 2022).

From this perspective, there seems to be a consensus in the literature that to not fail in the HR analytics challenge, HR specialists must have professional "analytical skills" (Bondarouk, Parry & Furtmueller, 2017; Marler & Boudreau, 2017; Vargas, Yurova, Ruppel, Tworoger, & Greenwood, 2018; Kryscynski, Reeves, Stice-Lusvardi, Ulrich, & Russell, 2018; McCartney Murphy, & Mccarthy, 2021), and that the biggest risk factor for HR analytics to succeed in increasing business organizational performance is a lack of proper "analytical skills" across HR departments (Angrave, Charlwood, Kirkpatrick, Lawrence, & Stuart, 2016; CIPD, 2013, 2018b; Rasmussen & Ulrich, 2015; Levenson, 2011; Lawler, Levenson, & Boudreau, 2004; SHRM, 2016b). To manage and use emerging technologies introduced by digital transformation there is a need for specific skills (Kedziora, 2022). Although there is a consensus that HRM specialists need "analytical skills," there is no agreement on what these skills entail. Surprisingly, researchers and practitioners alike refer to "analytical skills" without a clear and commonly accepted definition of their content. However, how can we design effective training for HR if we do not fully understand what analytical skills are needed? How can we conduct HR analytics research that builds on previous findings if different researchers envision different constructs under the same label of analytical skills? Therefore, the main aim of this paper is to answer the research question (RQ) of what "analytical skills" are required to make sense of HR analytics. We aim to provide a comprehensive answer to this question by attaining three research goals: 1) Provide standardization to the meaning of the vague concept of "analytical skills" in terms of precisely defined knowledge, skills, and abilities (KSA), 2) Identify the top analytical KSA required to perform HR analytics, 3) Establish the gaps in "analytical skills" among HRM specialists that might create potential barriers to conducting meaningful HR analytics.

LITERATURE REVIEW

The ambiguity of HR "analytical skills"

To illustrate the importance of the questions regarding what "analytical skills" are required to make sense of HR analytics, we provide evidence of the ambiguity of HR "analytical skills" using a selective review of the current understanding of this topic in HRM literature. This analysis presents diverse perspectives on HR analytics capabilities drawn from a blend of sources, including scholarly and practical literature that provides definitions or descriptions of analytical capabilities in the context of HR. However, an extensive literature review on different perspectives on still emerging "analytical skills" needed for HR analytics exceeds the scope of this study. Rather, with our review, we would like to merely show that there is ambiguity around the meaning of "analytical skills," empirically supporting our calls for standardization in our understanding of "analytical skills." This is important, as some might state that as HR analytics is such a popular topic, there must be one common understanding or that the topic will not yield to such prominence without commonly accepted definitions. We suggest that even the selective review in Table 1 suggests that this is not the case. Our analysis in Table 1, by presenting various understandings of HR analytical skills, refutes the claim that one commonly accepted set of "analytics skills" is needed for HR analytics. The more nuanced analysis of the multidimensionality of HR analytics might be found in other sources, and we encourage interested readers to read the papers cited. However, we do not aim to repeat what is already available here (Bahuguna et al., 2024; Fernandez & Gallardo-Gallardo, 2021; Margherita, 2022; Shet et al., 2021; Suri & Lakhanpal, 2024).

Table 1. Illustration of ambiguity around HR analytical skill - the different approaches to HR analytical capabilities that can be found in the literature

What do HRM specialists need to make sense of HR analytics?	Source
Knowledge and skills in collecting the proper data, performing the right statistical analyses, and communicating the results in a meaningful and accessible way.	Marler and Boudreau (2017)
Human resource analytics personnel expertise includes business knowledge and analytical competency.	Thakur et al., (2024).
Analytical skills, which encompass the ability to utilize data and data-related processes to develop insights for decision-making, and storytelling skills, which involve communicating data effectively to influence decision-making, must work in synergy with each other.	McCartney & Fu (2024)
Analytical knowledge and experience to transform data into insights, and storytelling and visualization abilities to make complex data understandable to a wide audience.	Wang et al. (2024).
HR analysts' competencies should include a) storytelling and communication, b) consulting, c) technical knowledge, d) data fluency and analysis, e) HR and business acumen, and f) research and discovery.	McCartney et al. (2021)
Ask the right questions based on HR data; seek answers to these questions through longitudinal multivariate modeling; skills and knowledge to challenge the assumptions underpinning the analytical dashboards; ideally, knowledge of advanced statistical and econometrics techniques, necessary to disentangle correlation from causality through analysis of experiments and quasi-experiments.	Angrave et al. (2016)
Sufficient analytics skills and knowledge from the finance and IT domains, to be able to conduct HR analytics on both grounds.	Bassi (2011)
Business understanding, basic training in statistics and scientific methodology, skills in deploying a diagnostic framework, change management, and storytelling.	Rasmussen and Ulrich (2015)
Problem-solving, data analysis, visualization, statistics, data function and quality, business knowledge, consulting skills, cleaning data, maintaining data accuracy, and consistency across data stores.	Collins et al. (2018)
Skills in gathering, analyzing, and drawing practical conclusions from data, and communicating data findings to others.	SHRM (2016a)
Conduct root cause analysis, calculate univariate and multivariate statistics, communicate the results of statistical analyses understandably via presentation or public speaking, data preparation, survey design, qualitative data collection and analysis, obtaining data from others, and understanding what analytics to apply and when to apply them.	Levenson (2011)
Collect and store data, link different data, visualization, and presentation of the results; focus not only on reporting but also on data analysing and developing predictive models.	Heuvel and Bondarouk (2017)
Consultancy skills, skills in explaining HR analytics in a non-technical language via power points and visualization; knowledge of ANOVA, A/B testing, correlation and regression analyses, data cleaning and preparation; knowledge of analytics software and database structures. Focus on looking for insights that can help the business make a better decision not necessarily on scientific models.	Coolen and IJsselstein (2015)
Ability to understand and discover the cause-effect patterns hidden in employee-related data; understanding what HR analytics is not about; making judgments and assessments based on facts and data. The ability to benchmark how the organization is doing versus the outside world; some statistical knowledge but without seeing the lack of statistics competencies as a barrier; focus on helping executives make the right decisions.	Mondare, et al (2011)
The intellectual abilities to understand causal logic and establish causal models; ability to use appropriate analytics to test causal relationships in the data; ability to identify appropriate data, information, measures and metrics; ability to incorporate findings into processes of organizational decision-making.	Kryscynski, et al. (2018).
Critical causal thinking; understanding the principles of good measurement (psychometrics and econometrics); estimating causal relationships; communicating HR strategic performance results to senior line managers.	Becker et al. (2001). As cited in Kryscynski et al. (2018)
Knowledge of statistics and research design; skills in identifying key issues and asking valid questions; gathering and using appropriate data; setting the appropriate standards for rigour and relevance, ability to raise awareness of the analytical competencies of HR throughout the organization	Boudreau and Ramstad 2006
Ability to measure how human capital decisions affect the business and how business decisions affect human capital.	Lawler et al. (2004)
Ability to use Excel and PowerPoint; quantitative and mathematical skills, data gathering, survey design, root cause analysis, hypothesis generation and storytelling with data; data literacy - knowledge of how people data influence business data.	Zielinski (2019)

What do HRM specialists need to make sense of HR analytics?	Source
HR and Business domains knowledge; relationship management, problem specification; statistics, programming, data management; visualization, communication, web design, reporting results, data and systems awareness.	Reilly (2016)
Translating business issues into data analysis questions; ability to gather, structure, store, and manipulate data; knowledge of standard and advanced methods of data analysis; knowledge of statistics and machine learning; ability to present obtained results in a clear way.	Fairhurst (2014).
HR software expertise, statistical analysis and data mining, big data, machine learning; ability to understand data and choose the right tools to clean, extract, combine, analyse, and visualize data.	Chensoff et al. (2018)
Knowledge of database architecture, ability to generate and align people data with business data to inform strategic decision-making; applying modelling methodologies to people data; shaping research design to analyse organizational problems; understanding the value of multivariate analysis in addressing organizational problems; curiosity for innovations, knowledge of good practice in data presentation and storytelling techniques.	CIPD (2020)
Core skills - using appropriate data and metrics to address the most important issues; understanding concepts of correlation and causation; testing hypothesis to establish the root cause of workforce issues; optimization of the ROI from people programs; Communication skills - ability to effectively present analytics conclusions; Data science skills - use of scientific methods and algorithms to extract knowledge from various data structures.	CIPD (2018a)

Source: Authors own elaboration based on resources in the second column.

If we take a systematic look at the studies from Table 1, we might identify at least nine different categories of analytical capabilities, and each of these categories might consist of some more specific types. This illustrates the difficulty in capturing a single common meaning of "HR analytical skills." In the HR analytics context, "analytical skills" might include a variety of competencies such as:

a) Knowledge and abilities to understand the role of analytics in a broad business and organizational context:
- skills in asking insightful questions about key business issues and problems;
- skills in focusing on drawing practical business conclusions from data analysis;
- business understanding and business knowledge.

b) Skills in successful communication about HR analytics' findings and HR analytics itself:
- skills in communicating the results and insights via visualization and storytelling to managers and other stakeholders;
- skills in promoting HR analytics' importance and benefits throughout organization structures and levels.

c) Skills and knowledge necessary to think critically about the role and capabilities of HR analytics:
- understanding the limits of data analysis;
- knowledge necessary to challenge assumptions underlying HR analytics findings presented by someone else.

d) Skills and knowledge to use HR analytics to answer HR-specific questions with appropriate rigour and relevance:
- knowledge and skills in performing robust analyses of causes and effects, particularly of how people in the organization influence organizational business outcomes;
- knowledge and skills in calculating ROI from people programs;
- skills to conduct benchmarking based on HR analytics findings.

e) Knowledge and skills in using specific computer software:
- knowledge of analytical software;
- knowledge of HR-specific software.

f) Mathematical skills

g) Statistics - knowledge and skills in using various explanatory, descriptive, and inferential statistical procedure:
- basic statistical analyses;
- multivariate analysis;
- machine learning;
- data mining;
- predictive models;
- qualitative analysis.

h) Knowledge from the domain of research design, methods, and methodology:
- knowledge of hypothesis testing;
- knowledge of research methodology;
- knowledge of principles of good measurements.

i) Database knowledge and data manipulation skills:
- skills in collecting data;
- skills in preparing data;

- skills in storing and maintaining data;
- knowledge of database systems.

As can be seen in Table 1, the problem with current HR analytics research and practice is that there is no one common understanding of HR "analytical skills" and this poses a serious challenge for the effective use of IT in HR analytics development and implementation. HR "analytical skills" seem to be an umbrella term covering different visions of the successful application of HR analytics. This is challenging for HR analytics successful planning and adoption in organizations because decision-makers and HRM departments might be disoriented in the development of which "analytical skills" to invest in taking full advantage of HR analytics in enhancing organizational performance.

Thus, to fill this gap in the literature, we call for standardization in HR "analytics skills" by answering the question of what "analytical skills" are required to make sense of HR analytics. To make the first step in this direction and to gain more robust insights into the meaning of "analytical skills" we propose to based on the framework of the Occupational Information Network (O*NET) content model: (https://www.onetcenter.org/content.html) and split the vague "analytical skills" label into three occupational descriptors of analytical Knowledge, Skills, and Abilities (KSA) according to, i.e. knowledge – "organized sets of principles and facts applying in general domains," abilities – "enduring attributes of the individual that influence performance," and skills - basic skills "developed capacities that facilitate learning or the more rapid acquisition of knowledge" and cross-functional skills "developed capacities that facilitate performance of activities that occur across jobs (see also https://www.onetonline.org/find/descriptor/browse/).

Our attempt to provide standardization to HR analytical skills may contribute to the theory and practice of information management and human-computer interactions, helping HR analytics to realise its promises. First, by introducing clarity into an emergent but still ambiguous concept of "analytical skills" needed in the process of HR analytics. Second, our analysis might help to identify the analytical KSA lacking among HRM practitioners, and thus highlight potential barriers on the "human side" of HR analytics. Third, our elucidation on KSA needed in HR analytics might guide the debate on the training of HR analysts, and fourth, it might inspire further empirical research on the impact of HR analytics on organizational performance as precisely defined analytical KSA among HRM specialists might be important moderators of the effect of HR analytics on improvements in organizational performance.

METHODS

Data

In this study, we use the data from the Occupational Information Network (O*NET) database (O*NET® 24.3 Database is licensed under a Creative Commons Attribution 4.0 International License, the database source is: https://www.onetcenter.org/database.html; license terms: https://creativecommons.org/licenses/by/4.0/) developed under the sponsorship of the US Department of Labor, Employment and Training Administration. Although there are other occupation taxonomies e.g. European Skills, Competences, and Occupations the ESCO (see Popov, Snelson, & Baily, 2022 for review and comparison), we choose O*NET for several reasons. O*NET (2020) database contains occupation-specific descriptions of almost 1000 occupations and for each occupation, the data on the required level of specific knowledge, skills, and abilities are provided (for details see: https://www.onetcenter.org/overview.html and also Handel (2016) for discussion on the O*NET content model strengths and limitations). O*NET database is widely used in HRM scientific research. The wide use of the O*NET database and content model in scientific research is best illustrated by the high visibility of O*NET in academic journals. The O*NET homepage lists> 200 publications in career and vocational research, > 120 in education research, > 200 in health research, > 400 in industrial and organizational research and >600 in labor market research (see: https://www.onetcenter.org/references.html), the numbers that, according to our knowledge are unmatched by any other occupational taxonomy. What is more, the O*NET database not only describes skills, abilities and knowledge in occupations but also provides numerical estimates of levels of skills, abilities and knowledge, needed in those occupations. So in summary, although other occupation taxonomies exist and choices like this are always arbitrary to some degree we decided to use O* NET because of its comprehensive occupational data, it is widely used in HRM scientific research, its robustness is supported by the presence in peer-reviewed academic journals and it provides numerical estimates of skills, abilities, and knowledge allowing for quantitive calculations.

Strategy of analysis

To find out what analytical KSA (knowledge, skills, abilities) the HRM specialists might need to take full advantage of HR analytics, we adopted the following strategy. First, based on the occupations list from the O*NET database (see https://www.onetonline.org/find/career?c=0&g=Go), we created two separate categories of occupations: the HRM specialists' occupations and analytical occupations. Second, based on the O*NET database of KSA levels required in each occupation, we identified the top KSA required in analytical occupations. This approach allowed us to establish detailed lists of highly required analytical KSA clearly and objectively without subjective judgments. In the third step, we compared the level of the highly required analytical KSA to the required level of those KSA in HRM occupations to look for analytical KSA gaps that might constitute the barriers to the meaningful use of HR analytics (the visualization of our research strategy is presented in Figure 1). This strategy allowed us to attain the goals of this paper i.e.: 1) disentangle the vague "analytical skills" into precisely measured and objectively defined analytical KSA based on the O*NET content model, 2) identify the most significant analytical KSA, 3) establish gaps in analytical KSA.

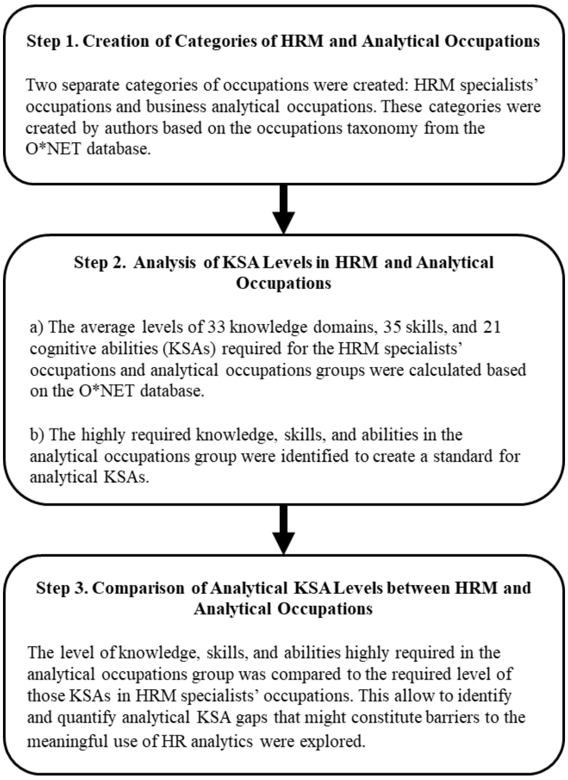

Figure 1. Visualization of the strategy of analysis

To create the HRM occupational category, we used occupations listed under the HRM career pathway in the O*NET OnLine website supplemented with the O*NET Industrial-Organizational Psychologists occupation category (https://www.onetonline.org/find/career?c=0&s=1&r=1; career clusters used in the O*NET OnLine are adapted from the National Career Clusters® Framework see: https://careertech.org/career-clusters;). We supplemented HRM occupations with IO Psychologist as this is an occupation closely related to HR Managers and HR Specialists and often its role encompasses involvement in HR analytics (see: https://www.onetonline.org/link/summary/19-3032.00). A list of eight HRM occupations from the O*NET OnLine used in this study to create a general category of HRM occupations is presented in Table 2.

Table 2. Occupations from The Occupational Information Network (O*NET) database used to create Human Resource Management (HRM) occupations category

O*NET Code	Occupation
11-3111.00	Compensation and Benefits Managers
13-1141.00	Compensation, Benefits, and Job Analysis Specialists
11-3121.00	Human Resources Managers
13-1071.00	Human Resources Specialists
13-1075.00	Labor Relations Specialists
11-3131.00	Training and Development Managers
13-1151.00	Training and Development Specialists
19-3032.00	Industrial-Organizational Psychologists

Note: The first seven occupations represent occupations from the O*NET, Human Resource Management Career Pathway.
Source: Retrieved from https://www.onetonline.org/find/career?c=4&g=Go

The creation of the analytical occupations category was more challenging. First, it is not clear what occupations are "analytical". No career pathway or job family is devoted to data analytical occupations in the O*NET OnLine. The second challenge in forming the analytical occupations for the purpose of this paper is that analytical occupations established in the search for HRM analytical KSA must perform the job in similar contexts as HRM specialists do i.e. using IT technology for analyzing data in the context of organizations, management, and business studies. Astronomers and biostatisticians are among the occupations highly involved in data analysis, but their descriptions of main work objectives do not include many tasks that deal with people management problems or issues. Thus, they might reflect analytical knowledge, skills, and abilities (KSA) not particularly relevant to HR analytics. Thus, after reviewing the lists of O*NET OnLine occupations and their descriptions, we decided to include three occupations in which incumbents have to successfully work with business and organizational data into the analytical occupations category: Business Intelligence Analysts, Management Analysts, and Operations Research Analysts. Detailed descriptions of these three analytical occupations can be found in Table 3.

Table 3. Occupations from The Occupational Information Network (O*NET) database used to create an analytical occupations category

O*NET occupational title and code	O*NET Occupation description
Business Intelligence Analysts 15-1199.08	Produce financial and market intelligence by querying data repositories and generating periodic reports. Devise methods for identifying data patterns and trends in available information sources.
Management Analysts 13-1111.00	Conduct organizational studies and evaluations, design systems and procedures, conduct work simplification and measurement studies, and prepare operations and procedures manuals to assist management in operating more efficiently and effectively. Includes program analysts and management consultants.
Operations Research Analysts 15-2031.00	Formulate and apply mathematical modeling and other optimizing methods to develop and interpret information that assists management with decision-making, policy formulation, or other managerial functions. May collect and analyze data and develop decision support software, services, or products. May develop and supply optimal time, cost, or logistics networks for program evaluation, review, or implementation.

Note: Please note that the analytical occupations category is not an official O*NET database category, it was created by the author, based on the list of occupations available in the O*NET database.
Source: Retrieved from https://www.onetonline.org/find/family?f=0

After identifying HRM and analytical occupations, we proceeded to establish the levels of knowledge, skills, and abilities (KSA) required in these occupations. Detailed data about the necessary KSA for each occupation in the Analysts and HRM categories were derived from the ONET 24.3 database levels (https://www.onetcenter.org/database.html#individual-files). In the ONET database, for each occupation, we utilized information about 21 cognitive abilities (https://www.onetonline.org/find/descriptor/browse/Abilities/), 35 specific skills (https://www.onetonline.org/find/descriptor/browse/Skills/), and 33 knowledge domains (https://www.onetonline.org/find/descriptor/browse/Knowledge/). Each occupation, knowledge domain, skill, and ability is rated on a 0 (minimum) – 7 (maximum) point scale according to the extent it is required or needed to perform the occupation successfully (for details see e.g. Tsacoumis & Willison, 2010; Handel, 2016; https://www.onetcenter.org/research.html). These raw scores are standardized into a scale from 0 to 100 for intuitive understanding, where 0 represents the lowest required level and 100 the highest (for details see https://www.onetonline.org/help/online/scales). To establish the KSA levels required for Analysts and HRM occupations, we averaged the levels of KSA required for occupations within each category. For example, for the Analysts category, consisting of three specific occupations, we computed the average levels among these occupations for each of the 21 cognitive abilities, 35 skills, and 33 knowledge domains available in the O*NET database. The same approach was applied to calculate the required levels of KSA for the HRM category, which comprises eight occupations. This procedure resulted in KSA lists for HRM and Analyst occupations, indicating the levels of KSA requirements for each of the 21 cognitive abilities, 35 skills, and 33 knowledge domains.

The procedure of creating occupation-specific ability requirements based on the O*NET database was previously adopted by Converse, Oswald, Gillespie, Field, & Bizot (2004), and this method is a cornerstone of widely used job analysis methodology (see also Sanchez and Levine, 2012; Reiter-Palmon; Brown, Sandall, Buboltz, & Nimps, 2006). Next, to identify analytical KSA, i.e., those most required for analytical types of jobs, we ranked them from highest to lowest according to their level of requirements to perform an analytical occupation. We considered as highly required those KSA with a score of 50 or higher on a 0-100 scale of O*NET database levels. Although the use of cutoff points is somewhat arbitrary, we believe that the 50 threshold for KSA levels adapted in our study is justified. This threshold represents a point above the central level on a 0-100 scale, suggesting that a given KSA is not irrelevant in a given occupation. For statistical reasons, a cutoff line of 50 allows for retaining a reasonable number of KSA. For example, adopting a slightly higher cutoff level of 60 would result in only two skills meeting this level, whereas with a slightly lower threshold of 40, 50 KSA would be considered highly required – which may be excessive for the informative presentation. While our threshold is not without limitations, it may be consistently applied, critiqued, and modified based on explicit rules, contrary to common sense reasoning around highly required “analytical skills.

Next, based on the sorted lists of the highly required KSA, we computed the percentage gaps between the KSA highly required to perform analytical occupations and levels of corresponding KSA required in the HRM occupations. These analytical gaps were computed similarly as the commonly used gender pay gap is calculated (see: https://www.gov.uk/guidance/making-your-gender-pay-gap-calculations#calculating-the-mean-average-gender-pay-gap-using-hourly-pay]), according to a formula: ((Analytical KSA – HRM KSA) / Analytical KSA) * 100%. The given KSA level for HRM occupation was subtracted from the given KSA level for analytical occupation, divided by the KSA level for analytical occupation and multiplied by 100%. In such a way, the positive gap reflects that there is a higher level of requirements for analytical occupations than HRM occupations for a given KSA. For example, the positive gap in mathematics skills = 25%, which means that, on average, analytical occupations need a 25% higher level of these skills than HRM occupations. This approach allowed for the identification of the highly required analytical KSA and the quantification of discrepancies (gaps) in the levels of analytical KSA required in analytical occupations and those required in HRM occupations.

It is important to remember that this study was not conducted on the KSA possessed by individual employees but on the level of KSA required for occupations as estimated in the O*NET database. In that context, the fact that a set of KSA is required for a given occupation does not mean that every incumbent of this occupation has this desired level of KSA. However, we assume that, on average, the O*NET database of the required level of KSA in the occupation is closely associated with the average level of KSA possessed by incumbents. First, according to the gravitational hypothesis, people generally “gravitate” toward jobs that commensurate with their abilities (Wilk, Desmarais, Sackett, 1995; Wilk, Sackett, 1996). Second, we assume that people invest in developing those professional KSAs that are required from them and neglect those KSAs that are not required from them in the workplace. Thus, investing in KSA development in one area (e.g., in human relations) improves KSA in that area but might lower KSA in competing areas (e.g., mathematics) (see Von Stumm & Ackerman, 2013). Third, the list of KSA based on the O*NET content model is a reasonably reliable estimation of KSA required in a given occupation that is used by organizations to create job descriptions and hire employees. Thus, we assume that it is reasonable to predict that if in a given occupation, there is a requirement of a specific level of KSA, then on average, the incumbents of this occupation are close to this required level of KSA, rather than have a random distribution of different levels of KSA. Thus, for example, for analytics occupations, the required level of mathematics knowledge is 70 and for HRM occupations, it is 55.8. We assume that we might expect that the HRM specialists will have a lower level of mathematics knowledge on average. People with mathematics knowledge will gravitate towards occupations other than HRM, in which a high level of mathematics is more required (and rewarded). HRM occupation incumbents will not invest time and effort in developing and maintaining mathematics knowledge as it is not the most required HRM occupation. Our nomothetic perspective adopted in this study considers the whole HRM specialists group as one entity. This approach is not perfect, as it ignores individual differences among HRM specialists, but it might help to build a general model of KSA, and thus make the first important step towards a better understanding of which type of analytical KSA might create potential barriers when introducing HR analytics into HRM departments.

RESULTS

The O*NET database provides detailed lists of knowledge domains (33), skills (35), and cognitive abilities (21). Thus, to keep clarity, we limit the presentation of our results to the most highly required analytical KSA (i.e., with the level of 50 or higher on 0-100 scale). First, Table 4 presents the lists of KSA with the highest levels required to perform the analytical types of occupations in business and organizational contexts. As we explained earlier, we suggest that those KSAs are also highly needed for HRM specialists to conduct insightful HR analytics. Second, Table 4 also contains the comparison of levels of the analytical KSA to the level of these KSAs required in HRM occupations.

As we can see in Table 4, there are seven knowledge domains highly needed for analytical occupations, and in three of them, there is a positive gap between analytical and HRM occupations (i.e. higher requirements among analytical than HRM occupations): Mathematics (20%) - "*Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications*"(all KSA detailed descriptions in italics are quoted in this text from the O*NET database, https://www.onetonline.org/find/descriptor/browse/); Sales and Marketing (41%) "*Knowledge of principles and methods for showing, promoting, and selling products or services. This includes marketing strategy and tactics, product demonstration, sales techniques, and sales control systems*", and Computers and Electronics (14%) "*Knowledge of circuit boards, processors, chips, electronic equipment, and computer hardware and software, including applications and programming.*" In the case of skills, we have identified 13 highly required analytical skills. The gap can be observed in the case of 9 skills, with the highest gaps for Operations Analysis (31%) "*Analyzing needs and product requirements to create a design*"; Mathematics (25%) "*Using mathematics to solve problems*," and Complex Problem Solving (12%) "*Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions.*" For abilities, based on the O*NET database, we have established 13 highly required analytical abilities, and for 12 of them, there were positive gaps, with the three largest gaps for Mathematical Reasoning (20%) "*The ability to choose the right mathematical methods or formulas to solve a problem.*", Number Facility (17%) "*The ability to add, subtract, multiply, or divide quickly and correctly*", and Inductive Reasoning (14%) "*The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among seemingly unrelated events).*"

For some KSA, we observe a negative gap, meaning that a higher level of this analytical knowledge or skill is required for HRM occupation than for analytical occupation. For knowledge, the most visible negative gaps have been observed for Customer and Personal Service (-30%) – "*Knowledge of principles and processes for providing customer and personal services. This includes customer needs assessment, meeting quality standards for services, and evaluation of customer satisfaction*" and Education and Training (-21%) "*Knowledge of principles and methods for curriculum and training design, teaching and instruction for individuals and groups, and the measurement of training effects.*" For skills, the most visible negative gaps have been observed for monitoring (-9%) "*Monitoring/Assessing performance of yourself, other individuals, or organizations to make improvements or take corrective action*" and speaking (-8%) „*Talking to others to convey information effectively.*"

Table 4. Analytical Knowledge, Skills and Abilities (KSA) highly required for analytical occupations, levels of these analytical KSA required in Human Resource Management (HRM) occupations and "analytical gaps", the percentage gaps between the level of analytical KSA required for analytical occupations and those required for HRM occupations

KSA Category	Descriptor	Mean level required for analytical occupations	Mean level required for HRM occupations	% discrepancy "analytical gap"
Knowledge	Mathematics - knowledge	70	55.8	20%
	English Language	66.1	68.0	-3%
	Administration and Management	64	64.9	-1%
	Sales and Marketing	63.8	37.4	41%
	Education and Training	61.3	74.1	-21%
	Computers and Electronics	59.9	51.4	14%
	Customer and Personal Service	51.6	67.3	-30%

KSA Category	Descriptor	Mean level required for analytical occupations	Mean level required for HRM occupations	% discrepancy “analytical gap”
Skills	Critical Thinking	61.3	57.8	6%
	Reading Comprehension	61.3	59.6	3%
	Active Listening	58.3	59.1	-1%
	Complex Problem Solving	57.8	51.1	12%
	Systems Evaluation	57.8	52.3	10%
	Judgment and Decision Making	57.7	55.4	4%
	Systems Analysis	57.7	51.1	11%
	Writing	57.1	59.2	-4%
	Speaking	56.6	60.9	-8%
	Active Learning	56.5	54.9	3%
	Mathematics - skills	56	42.2	25%
	Monitoring	51.2	55.8	-9%
	Operations Analysis	50.6	34.8	31%
Abilities	Oral Comprehension	65.5	60.9	7%
	Oral Expression	65.5	61.1	7%
	Written Comprehension	64.3	60.5	6%
	Deductive Reasoning	63.7	58.0	9%
	Inductive Reasoning	61.9	53.4	14%
	Written Expression	60.1	60.5	-1%
	Problem Sensitivity	56.5	54.2	4%
	Information Ordering	56	50.3	10%
	Fluency of Ideas	54.7	51.8	5%
	Mathematical Reasoning	54.1	43.5	20%
	Number Facility	53	44.2	17%
	Category Flexibility	52.4	49.5	6%
	Originality	52.4	51.8	1%

Note: Table created by the author based on the O*NET database; only KSA with the average level of 50 on a 0-100 scale or more are presented; for detailed descriptions and KSA definitions please see https://www.onetonline.org/find/descriptor/browse/. Analytics occupations include Business Intelligence Analysts, Management Analysts, Operations Research Analysts; HRM occupations: Compensation and Benefits Managers; Training and Development Managers; Human Resources Managers; Compensation, Benefits, and Job Analysis Specialists; Human Resources Specialists; Industrial-Organizational Psychologists, Labor Relations Specialists, Training and Development Specialists; % discrepancy “analytical gap” = [(mean level required for analytical occupations - mean level required for HRM) / mean level required for analytical occupations] *100%.

DISCUSSION

Let’s be honest — most HR professionals are not attracted to HR because of the opportunity to work with data and analytics as part of their role.
Rasmussen & Ulrich (2015, p. 239)

The first goal of this study is to provide standardization to the meaning of the vague concept of “analytical skills”. Instead of relying on our subjective perception, we refer to the O*NET database, which is a reliable and widely used source of occupational information (see O*NET Reference List https://www.onetcenter.org/references.html). Based on the O*NET content model, we split the vague concept of “analytical skills” into a set of precise knowledge, skills, and abilities – KSA, and an illustrative description of this KSA is presented in Table 5. By doing this, we provide a standardization framework of “HR analytical skills” and suggest establishing a common standard by referring to the KSA description in the O*NET content model. Additionally, this multilevel approach might supplement other approaches to analytical ability by adding new layers beyond solely viewing analytical ability as the ability to analyze data or deal with organizational metrics (e.g., Kryscynski et al., 2018; Minbaeva, 2018). Moreover, the standard based on occupational taxonomy might also supplement approaches based on self-reported measures, self-evaluations, and HR practitioners’ perceptions (McCartney et al., 2021; McCartney & Fu, 2024; Minbaeva, 2018).

Table 5. Descriptions of the propositions of the five most important analytical knowledge, skills and abilities (KSA) in the business context, created by authors based on the O*NET Content Model and the O*NET database

	Mathematics	**“Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.”**
Knowledge	English Language	*“Knowledge of the structure and content of the English language including the meaning and spelling of words, rules of composition, and grammar.”*
	Administration and Management	*“Knowledge of business and management principles involved in strategic planning, resource allocation, human resources modeling, leadership technique, production methods, and coordination of people and resources.”*
	Sales and Marketing	*“Knowledge of principles and methods for showing, promoting, and selling products or services. This includes marketing strategy and tactics, product demonstration, sales techniques, and sales control systems.”*
	Education and Training	*“Knowledge of principles and methods for curriculum and training design, teaching and instruction for individuals and groups, and the measurement of training effects.”*
Skills	Critical Thinking	*“Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions, or approaches to problems.”*
	Reading Comprehension	*“Understanding written sentences and paragraphs in work-related documents.”*
	Active Listening	*“Giving full attention to what other people are saying, taking time to understand the points being made, asking questions as appropriate, and not interrupting at inappropriate times.”*
	Complex Problem Solving	*“Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions.”*
	Systems Evaluation	*“Identifying measures or indicators of system performance and the actions needed to improve or correct performance, relative to the goals of the system.”*
Abilities	Oral Comprehension	*“The ability to listen to and understand information and ideas presented through spoken words and sentences.”*
	Oral Expression	*“The ability to communicate information and ideas in speaking so others will understand.”*
	Written Comprehension	*“The ability to read and understand information and ideas presented in writing.”*
	Deductive Reasoning	*“The ability to apply general rules to specific problems to produce answers that make sense.”*
	Inductive Reasoning	*“The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among seemingly unrelated events).”*

Note: These propositions of business analytical KSA arrangement are not present in the official O*NET Content Model, they are created by the authors of this work based on their analyses of the O*NET database, but all KSA definitions are directly cited from The O*NET Content Model.
Source: Retrieved from https://www.onetcenter.org/content.html

In connection to the second goal, identification of the top analytical capabilities required to perform HR analytics, we assume that HR analytics is performed in the contexts of organizational and business studies and one of the main aims of HR analytics is to assist management and support organizational decision making and HR policy formulation. Therefore, we suggest that referring to those KSA needed for succeeding in analytical occupations performed in the context of business settings as Business Intelligence Analysts, Management Analysts, and Operations Research Analysts (see Table 3) might provide us with a reasonable approximation of what might be the highly required analytical KSA in HR analytics. This approach allows us to create a list of analytical KSAs containing: 7 knowledge domains, 13 skills, and 13 cognitive abilities. Table 4 provides a coherent overview of those analytical KSAs that might be most highly required for HR analytics (a detailed description of the O*NET database KSA might be found at https://www.onetonline.org/find/descriptor/browse/). These findings highlight the complexity of skills, abilities, and knowledge domains needed to succeed in analytics and are in line with approaches to HR analytics competencies that underscore that analytical skills are more than just data analysis (Angrave et al., 2016; McCartney et al., 2021; Rasmussen & Ulrich, 2015; Zielinski, 2019;). Analytical knowledge and experience (Wang et al., 2024) or analytics capabilities (Minbaeva, 2018) are seen in the literature as determinants of successful HR analytics implementation and organizational factors that enable HR analytics (Margherita, 2022 Fernandez & Gallardo-Gallardo, 2021), yet, the lack of analytical capacities among HR professionals is considered one of the important challenges for HR analytics (Shet et al., 2021). Thus, having precise standards of what knowledge, skills, and abilities to expect from HR analysts might be seen as one of the cornerstones of implementing HR analytics effectively in organizations. Moreover, Wirges and Neyer (2023) suggest that there is a need for clearer clarification of the role HR plays in the process of HR analytics and a clear definition of analytical KSA might help bring more clarity here.

Concerning the third goal of this paper, establishing the gaps in “analytical skills” among HRM specialists, that might create potential barriers to conducting meaningful HR analytics, the analysis presented in Table 4 allows us to establish gaps in required analytical KSA among HRM. It seems that the important barrier for HRM in conducting HR analytics might be mathematics, as there are gaps in mathematics knowledge, mathematics skills, and mathematics abilities. Although gaps in mathematics' KSAs might not be particularly surprising, as they represent what people generally think of analytical skills, nonetheless these gaps focus our attention on the somewhat painful truth that the organizations interested in HR analytics should concentrate on providing training in mathematics for HRM departments. It seems that mathematics is an unavoidable foundation for using IT technology in HR analytics, and basic math revision will be helpful in the curriculum of every HR analytics course. However, as the other KSA gaps discussed in the next section revealed, even the sharpest "mathematical mind" alone cannot guarantee success in HR analytics. There are important analytical KSAs around such capabilities as e.g. data communication and systems and critical thinking that are necessary but might be lacking among HR. In general, these findings, showing gaps between the desired analytical KSA and the actual KSA of HR professionals, are congruent with the discussion in contemporary HR analytics literature. It suggests that to fully harness the potential of analytics, HR specialists must cooperate with professional analysts. This type of expertise cooperation might bring to the table distinct yet complementary expertise of each group and generate value and benefits for organizations (Mondare et al., 2011; Wirges & Neyer, 2023; Barbour, Treem & Kolar, 2018).

Consequently, besides maths, the noteworthy gap is in sales and marketing knowledge – "*Knowledge of principles and methods for showing, promoting, and selling products or services. This includes marketing strategy and tactics, product demonstration, sales techniques, and sales control systems*" (all KSA detailed descriptions in italics are quoted from the O*NET database https://www.onetonline.org/find/descriptor/browse/). This is a more surprising knowledge domain for HR analysts, but also, in our selective literature review (see Table 1), some authors suggest that HR analysts' "must-have" is knowledge of how to "sell" HR analytics in terms of communicating the findings to decision-makers. This gap points to the role of HR analysts as technology and data translators (see Brady, Forde & Chadwick, 2017; Marr, 2018; Henke, Levine, & McInerney, 2018). HR analysts should be able to explain how IT works, interpret the language of data analysis in the HR domain and communicate them in an attractive way to bridge HR analytics with business and show its relevance to stakeholders.

Further among gaps in analytical skills, we might notice two broad categories. The first important analytical skill gaps category is represented by such skills as system analysis, "*Determining how a system should work and how changes in conditions, operations, and the environment will affect outcomes*," systems evaluation "*Identifying measures or indicators of system performance and the actions needed to improve or correct performance, relative to the goals of the system*," and operations analysis "*Analyzing needs and product requirements to create a design.*" These skills might be seen as system thinking - identifying, determining, and analyzing organizational processes as a part of one complex system (see Levenson, 2018). This suggests that, among HRM departments, there might be a need to develop skills in seeing the "big picture" of how HR analytics might not only help HRM departments in their jobs (e.g. by automatization everyday tasks) but also how HR analytics might influence the organizational performance at a more general level. This gap in system thinking seems to repeat Levenson's (2017, 2018) suggestions that HR must implement HR analytics with the broad context of the entire organizational system in mind. For example, Levenson argued (2017) that the sole fact that something could be improved (e.g., employee engagement) does not necessarily mean that this is the most important issue that should be improved in the first place. As HR might be concentrated on the improvement of dozens of processes, thus, system thinking is needed to prioritize and conduct HR analysis in the areas that might yield the highest returns of investment from HR analytics.

The second class of gaps in analytical skills is related to problem-solving and manifests itself in such skills as complex problem-solving skills - "*Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions*" and critical thinking skills - "*Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions or approaches to problems*." Since the use of HR analytics to solve meaningful business problems might be seen as the cornerstone of HR analytics, thus the gap in problem-solving skills might be a challenge for the successful adoption of analytics in HR departments. Moreover, it seems that the field of HRM is particularly receptive to intuitive rather than critical thinking (see: Abrahamson, 1996; Pfeffer and Sutton, 2006; Rynes, Colbert, O'Boyle, 2018). Thus, the existence of a critical thinking gap might be a barrier to insightful HR analytics and it suggests that the HRM departments should be supported in the development of critical thinking skills when engaging in HR analytics (e.g., Kahneman, 2011; Barends & Rousseau, 2018). These gaps, similarly to system thinking gaps, point to the under-appreciated fact that HR analytics is not only about mathematics and statistics. If we concentrate on more sophisticated analysis methods and bigger data sets, we might unintentionally hold back the development of HR analytics. This finding seems to repeat and support the previous voices (e.g., Boudreau & Cascio, 2017) that the impact of HR analytics lies not in the level of analysis sophistication, but in the critical understanding of the given HRM topic in a broader organizational context.

As the pioneer of data analysis John Tukey also emphasizes, "*Far better an approximate answer to the right question, which is often vague, than an exact answer to the wrong question, which can always be made precise*" (Tukey, 1962 p.13). However, to know what question is the right one, HR analysts should have the right capabilities in the system and critical thinking.

CONCLUSION

From a theoretical perspective, our analysis sheds more light on the ambiguous concept of "analytical skills" and might stimulate further research on information technology in human resource management. Particularly, a precise definition of HR "analytical skills" in terms of the O*NET content model KSA might contribute to more insightful research on the impact of HR analytics on organizational performance. If "analytical skills" might be split into detailed analytical KSA, this suggests that when investigating the effects of HR analytics on the organization's performance, it might be inevitable to account for specific aspects of analytical knowledge, skills and abilities possessed by HRM as moderators of these effects but not treating analytical skills as one unidimensional entity. For example, research by McCartney and Fu (2024) suggests that there is a need to build complementary capabilities among various people analytics capabilities. Our results on the knowledge, skills, and abilities needed in HR analytics might help provide guidance on which capabilities we should take into account (see also Thakur et al., 2024; Bahuguna et al., 2024 for the importance of moderators in understanding HR analytics capabities).

From a practical stance, our results call for standardization in HR analytics definitions and suggest the O*NET content model as a common framework for understanding HR analytical KSA. Also, our findings provide a list of the highly required analytical KSA, which might be of some help in the process of training, recruitment, and development of HRM departments willing to use HR analytics. This might be particularly important in light of previous studies that show a relationship between the analytical ability of HR specialists and their performance (Kryscynski et al., 2018). However, some gaps in analytical KSA revealed in this study might be more difficult to fill than others, and might need solutions other than simply an "HR analytics course". We propose that, to some extent, the barriers created by the KSA gaps might be compensated by 1) scientific and organizational knowledge possessed by HRM, and 2) cooperation of HRM with professional analysts as data translators. First, in everyday practice, HRM specialists do not often handle problems utterly unrelated to their prior experience and professional HRM knowledge (see Cappelli, 2017). The HRM field is well-grounded in the scientific theories of human behavior (e.g., see Miner, 2015). When conducting HR analytics on the "usual" HR topics (motivation, pay satisfaction, turnover, etc.) Instead of conducting sophisticated data mining procedures to search for patterns in data blindly, HRM specialists might draw from a body of relevant HRM knowledge to test theoretically expected patterns of relations. However, when the problems faced by HR analytics are novel and not related to the existing HRM body of knowledge, the other possible remedy for the analytical gaps might be cooperation with analytical experts external to the HRM departments (see Mondare et al., 2011; Wirges, & Neyer, 2023). This cooperation should allow not only for the outsourcing of HR analytics but for collaboration, leading to a synergy between the HRM specialists' expertise and the analyst specific analytical KSA in the process of business problem-solving (for a detailed description of this cooperation, see e.g. Barbour, Treem & Kolar, 2018). HR analytics might help to generate better insight into people's side of the organization, thus, improving HRM's positive impact on employee abilities, motivation and opportunities (Marler & Boudreau, 2017). However, to face challenges posed by HR analytics, we, as HRM specialists, should strive to learn how to fit our role into meaningful collaboration with professional analysts in the process of understanding an increasing amount of HR data. In this cooperation, HRM specialists might take the role of data translators who use critical and system thinking merged with HRM knowledge and business experience to point out the most important analytical problems and ask impactful analytical questions, leaving complex data analyses for professionals. However, all of this needs a common understanding of HR analytics skills, which will allow us to see HRM's analytical strengths and weaknesses and then compensate for weaknesses and build on strengths. If we are to avoid failing on big data challenges in HR (Angrave, Charlwood, Kirkpatrick, Lawrence, & Stuart, 2016) and want to see the realization of the promises of HR analytics (McCartney & Fu 2022) we must start with standardization in our understanding of what knowledge, skill and ability HRM need (and lack) to successfully conduct HR analytics. This might help to ensure that HR analytics will not be another management hype but has a real impact on business outcomes.

Limitations and further research

When discussing HR analytics, we often assume that the lack of "analytical skills" among HRM specialists might be fixed by proper training as soon as we build awareness of what is lacking. However, our results point to several gaps in analytical KSA across HRM, and these gaps pose a challenging question – if there are analytical KSA gaps, then to what extent is it possible to fill them? Is it possible to effectively teach HRM departments to think more critically about data or to look at organizations from a more systemic perspective that goes beyond HRM's local interests? Therefore, the important challenge for further investigation is to set out in which analytics KSA HRM might make the most progress and by what kind of training, and also in which of them providing training might be a difficult or uneconomical process, thus need action on a level of recruitment and selection of HR professionals.

Also, in this study, we have concentrated on analytical KSA, but we would like to avoid the illusion that providing HRM departments with appropriate analytical KSA will solve the problem of HR analytics. Referring to the Ability, Motivation, and Opportunity model of performance (see Blom et al., 2020), it is not only abilities (KSA in our case) but also motivation and opportunities that influence the level of performance. Thus, the HRM department needs not only analytical KSA but also motivation to use them (e.g. encouragement from stakeholders to take the risk of data analysis, pay for performance see: Aral et al., 2012) and opportunities (e.g. software, hardware, and access to cross-organization data). In other words, to make sense of HR analytics, HRM departments need not only "analytical skills" but also motivation and opportunities to use them.

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Authorship contribution statement

Konrad Kulikowski was responsible for all aspects of the study.

Conflicts of interest

The author declares no conflict of interest.

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Digital servitization and leadership: A holistic view on required leadership traits and skills

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Abstract

PURPOSE: *Digitalization and servitization are two major developments significantly disrupting companies' competitive landscape. The research area that combines both aspects, digital servitization, poses substantial opportunities and challenges for companies to navigate. It requires guidance from leadership to succeed and innovate, but current scientific research lacks a holistic view on leadership for digital servitization so far.* ***METHODOLOGY:*** *We conducted 30 semi-structured interviews with leaders active in digital servitization initiatives, holding positions ranging from first-level managers to vice presidents and executives. Eighteen have more than ten years of leadership experience. Through inductive coding, we derived 43 codes within a qualitative analysis. We applied thematic analysis to structure our findings, resulting in a thematic map of leadership skills for digital servitization based on the research participants' insights.* ***FINDINGS:*** *Our findings present a holistic view of leadership skills for digital servitization. Leaders need to consider the perspectives of strategic business and people leadership. Digital servitization requires leaders to engage in a wide range of activities. From a strategic business leadership perspective, this ranges from evolving goal setting, a comprehensive business understanding, the ability to find the right team composition, and understanding customer and market needs. The people leadership perspective requires leaders to create and communicate a vision for digital servitization and manage change and employees' fears while enabling and empowering employees. Furthermore, we identified that digital servitization requires a balanced level of cognitive, interpersonal, business, and strategic leadership requirements.* ***IMPLICATIONS:*** *We contribute to scientific research by providing a comprehensive definition of digital servitization and summarizing existing research focusing on leadership aspects of digital servitization. Our findings offer actionable insights for practitioners by approaching with a holistic view on digital servitization and considering strategic business and people leadership aspects. Applying our outlined themes will support leaders in improving the conditions and possibilities to successfully trigger and implement digital servitization activities within their companies.* ***ORIGINALITY AND VALUE:*** *Our research combines isolated leadership aspects for digital servitization and underlines the complexity of digital servitization, emphasizing the need for a holistic view. Outlining the element of balancing business and people skills provides novel insights on advancing digital servitization into the research domain, which is dominated by technical-oriented research.*

Keywords: *digital servitization, leadership, servitization, digitalization, change management, innovation, digital transformation, business, strategy*

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INTRODUCTION

Globalization and complex business environments are altering the business landscape for manufacturing companies (Kim & Toya, 2018). Within the last decade, transformational challenges such as globalization, demographic changes, or digitalization (Pęciak, 2016) have changed existing business models, customer relationships, and how products are developed, manufactured, and delivered (Frank et al., 2019). Manufacturing companies pursue differentiation by adding customer-oriented services to their existing offerings (Chen et al., 2021). Vandermerwe and Rada (1988) first described the phenomenon of adding value to the core offerings through services. They coined servitization as offering bundles of customer-focused combinations of goods, services, support self-service, and knowledge. Servitization can be seen as a strategic alternative to product innovation (Carlborg et al., 2014) and enhances customer relationships through customized and integrated offerings (Coreynen et al., 2017; Paschou et al., 2020). In addition to increasing service offerings, companies in almost all industries have conducted several initiatives to explore new digital technologies and exploit their benefits (Matt et al., 2015). Digitalization is described as using digital technologies (Fitzgerald et al., 2014) such as the Internet of Things (IoT), cloud and mobile services, artificial intelligence, big data, and social media (Mihardjo et al., 2019) to change existing processes, business models, and revenue streams. (Bloomberg, 2022; Clerck, 2017).

Despite originating from different research fields, scholars see a supporting link between servitization and digital technologies (Paschou et al., 2020; Vendrell-Herrero et al., 2017). The convergence of servitization and digitalization is called digital servitization and refers to developing new services or improving existing ones through digital technologies to enable new (digital) business models. (Gebauer et al., 2021; Paschou et al., 2019, 2020; Vendrell-Herrero et al., 2017). Large manufacturing companies such as General Electric or Rolls-Royce have introduced service business models enabled by digital technologies (Paschou et al., 2020). For example, whereas the aviation engine producer Rolls Royce implemented IoT technologies that allow monitoring engine data in real-time for compelling maintenance offerings, General Electric has developed analytic tools to enable remote monitoring services based on data analysis of the installed base (Evans & Annunziata, 2012; Lightfoot et al., 2013).

Nevertheless, scholars describe that most companies lag behind their expectations around digital servitization (Pham & Vu, 2022), mainly caused by complexity and interplay of involved stakeholders, making digital servitization challenging to manage (Kohtamäki et al., 2021). Utilizing digital technologies in servitization is associated with innovation (Coreynen et al., 2017). Especially when it comes to radical innovations and their realization, leadership is required and described as one of the most influential factors for innovation (Faix, 2020; Rosing et al., 2011). Reconfiguring business models, such as implementing digital services, requires organizational change (Bustinza et al., 2018), which Kotter (2000) defined as a leadership responsibility. Leadership requires a diverse set of skills ranging from cognitive, interpersonal, business, and strategic skills (Mumford et al., 2007), which extant literature emphasizes as important for building a true service culture (Dmitrijeva et al., 2020).

Digital servitization is a relatively new research stream (Paschou et al., 2020), mainly focusing on qualitative and case study-based research on how companies can supplement their service offerings through digital technologies (Gebauer et al., 2021). Some researchers point out certain aspects attributable to leadership concerning digital servitization. For example, Cimini et al. (2021) elaborated on employee competence development within digital servitization through case-study research. Another research contribution by Kohtamäki et al. (2021) provided insights into business skills for digital servitization through a single case study. Sklyar et al. (2019) investigated the scientific research on organizing activities for digital servitization, thus focusing on more strategic leadership aspects.

Despite its widely recognized importance for innovation and growth and rising research interest in digital servitization (Favoretto et al., 2022), current scientific research lacks a holistic view of leadership aspects and managerial decision-making models (Paschou et al., 2020). In the context of this study, a holistic view of leadership is understood as considering the multi-faceted aspects of leadership, such as cognitive, interpersonal, business, or strategic skills requirements (Mumford et al., 2007) and the different scopes of applicability ranging from leading individuals and teams (Day et al., 2004), building business models (Doz & Kosonen, 2010), financial and technology understanding to visioning and communication skills (Men et al., 2020).

The present, qualitative study aims to contribute through an exploratory research design, providing insights into relevant leadership skills for digital servitization through the following research questions: What are the relevant leadership skills for digital servitization? What is the scope of the leadership role, and what are the affected leadership skill requirements for digital servitization?

Using the data from thirty semi-structured interviews with leaders active in digital servitization activities, we examined which focus areas within companies and interpersonal relationships form a holistic view to support managing the inherent complexity of digital servitization.

LITERATURE REVIEW

The convergence of digitalization and increased service focus by building digitally enabled service business models are coined digital servitization (Paschou et al., 2019; Vendrell-Herrero et al., 2017). We first deconstruct the theoretical backgrounds of servitization and digitalization to introduce the current scientific discussion on digital servitization and highlight the connection to innovation. The following sections introduce the topic of leadership with a specific emphasis on the digital age before summarizing the current research contributions linking digital servitization and leadership.

Servitization, digitalization, and digital servitization

The term *servitization* was first introduced by Vandermerwe and Rada (1988) to increase value by adding services to a company's offering. Manufacturing companies transform from product-centric to service-oriented business models (Frank et al., 2019; Kowalkowski et al., 2017; Raddats et al., 2019). The change in business model expects a fuller market offering through the customer-oriented combination of goods, services, support, self-service, and knowledge (Vandermerwe & Rada, 1988). Baines et al. (2020) categorized services into base, intermediate, and advanced services (see also Figure 1). Whereas base services are related to warranties and spare parts, intermediate services can be understood as maintenance and repairs. Advanced services are more complex value propositions where companies provide performance outcomes such as pay-per-use contracts (Baines et al., 2020; Martinez et al., 2017).

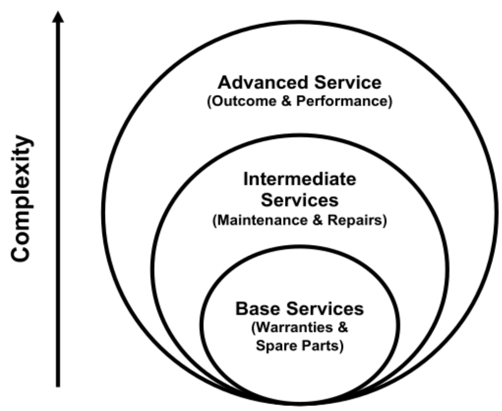

Figure 1. Service levels
Source: Own illustration based on Baines et al. (2020).

Servitization strategies can bring advantages compared to single product offerings. From a commercial perspective, adding service offerings leads to more steady revenue streams and higher profit margins (Baines et al., 2007; Bustinza et al., 2013; Gebauer et al., 2005; Wise & Baumgartner, 1999). Companies are more resistant to economic cycles than product-only businesses, especially in heavy investment industries (Oliva & Kallenberg, 2003). Servitization additionally creates the opportunity to achieve competitive advantages by addressing unmet customer needs (Oliva & Kallenberg, 2003). Manufacturing companies can offer customized and tailored service offerings to their customers, which are more difficult to imitate (Baines et al., 2007, 2009; Gebauer et al., 2005; Oliva & Kallenberg, 2003). Thus, manufacturing companies can avoid price-based competition (Baines et al., 2007). The servitization process describes a business model change from transactional to relationship-oriented interaction with customers (Oliva & Kallenberg, 2003) and increases customer loyalty by locking in customers, locking out the competition, and creating dependency for sustained business relationships (Bustinza et al., 2013; Vandermerwe & Rada, 1988).

Digitalization and the emergence of digital technologies offer new potential to facilitate service innovation of manufacturing companies (Ardolino et al., 2018; Coreynen et al., 2017). Technology development enables the incorporating of digital technologies into previously purely physical products (Hirsch-Kreinsen, 2016; Yoo et al., 2012). Digital technologies such as the Internet of Things, cloud and mobile services, artificial intelligence, big data, analytics, social media, and embedded devices are the foundation for companies' digitalization (Fitzgerald et al., 2014; Mihardjo et al., 2019; Vial, 2019).

A research stream that recently emerged is digital servitization. Several authors have published a definition of digital servitization. Vendrell-Herrero et al. (2017) described digital servitization as providing IT- or digitally enabled services that rely on digital components embedded in physical products. Another definition provided by Tronvoll et al. (2020) emphasized deploying digital technologies to support the transformation from a product-centric to a service-centric business model. Kohtamäki et al. (2019, p.4) presented a more technical-oriented definition as a "transition toward smart product-service-software systems that enable value creation and capture through monitoring, control, optimization, and autonomous function." Paschou et al. (2019) offered a very encompassing definition. They referred to digital servitization as developing new services or improving existing ones using digital technologies by enabling new digital business models, finding ways of co-creating value, generating knowledge from data, improving a firm's operational performance, and gaining competitive advantage. Despite defining the same term, we conclude that existing research has a different emphasis and focus areas when describing digital servitization. Whereas Vendrell-Herrero et al. (2017) relied on the connection to the physical product, Paschou et al. (2019) did not mention products in their definition when describing digital servitization. All definitions quoted above share that they see digital technologies as a core element of moving towards digital servitization. In addition, the aspects of value creation and business model changes are mentioned in all definitions except the one from Vendrell-Herrero et al. (2017).

Besides existing definitions of other researchers, we outline specific attributes of digital servitization to describe our understanding of the paper's central term (see Figure 2). Digital technologies enable several services and business models, such as remotely tracking and reporting real-time information, monitoring customers' usage behavior, responsive and proactive maintenance, remote control of operations, and availability services (Paiola & Gebauer, 2020). These digital services depend on data availability and analytics (Tronvoll et al., 2020; Ulaga & Reinartz, 2011). Manufacturing companies and product firms possess an existing customer base called an installed base. Access to this installed base based on previous product deliveries and the ability to harness and leverage customers' data is the basis for successful digital servitization (Paiola & Gebauer, 2020). Compared to a product-centric business relationship, where the product is the basis for the business relationship, the product only becomes one element of the interaction in a more service-centric business model (Paiola & Gebauer, 2020). Companies' customer relationship shifts from a transactional to a relational view (Ehret & Wirtz, 2017). Thus, digital servitization is underpinned by changing the business model and value creation processes (Chen et al., 2021). Companies help customers reach their goals by providing digitally enabled services (Coreynen et al., 2017). Based on the aspects mentioned above, we define digital servitization as generating additional value for the installed base of existing customers by providing product and service bundles enabled by digital technologies through newly created or revised business models. Our definition highlights the interplay of products and services, as both components are required to create value for the companies' customers. These services can only be assigned to customers where the manufacturing company sells a product-service bundle at the time of the transaction or previously supplied a product, which now enables the provision of digital services. Thus, the installed base is a core element of our definition as it initially defines the accessible market for digital servitization activities. Digital technologies enable new or revised business models due to the ability to access and connect information and data, which manufacturing companies use to create revenue streams.

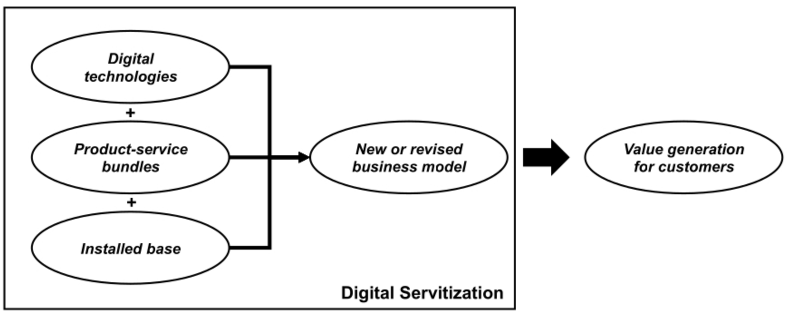

Figure 2. Definition of Digital Servitization

For manufacturing firms, servitization and digitalization are complex transformations requiring organizational changes. Thus, digital servitization requires new resources, capabilities, and collaborations to support value generation (Lerch & Gotsch, 2015; Peillon & Dubruc, 2019). Scholars proposed changes in the organizational structure to meet evolving customers within digital servitization (Baines et al., 2017; Bustinza et al., 2018). In the following section, we outline the impact of leadership on organizational changes and how to capture innovative business models within the context of digital servitization.

Leadership for digital servitization

Leadership is crucial for enabling innovations, shifting business models, and guiding organizational change (Faix, 2020; Mihardjo et al., 2019; Nadler & Tushman, 1990). Leadership has been widely researched (Kotterman, 2006), but focus areas and applications have developed over time due to changing boundary conditions and transformations in business and society (Larjovuori et al., 2018). Faix et al. (2020, p. 61) described leadership as "to lead oneself and human communities […] into an innovative and creative future in open and complex situations under unclearly defined and dynamic conditions while always considering the framework conditions and collective rationality." In his understanding of leadership, Kotter (2000) also highlighted producing change, setting direction, and aligning people toward a visionary goal.

Based on a concept developed by Mumford et al. (2007), leadership skill requirements can be categorized into cognitive, interpersonal, business, and strategic skills. Cognitive Mumford et al., (2007), skills are seen as foundational for leaders (Mumford et al., 2007), including communication skills (Yukl, 1989), learning (Jacobs & Jaques, 1987), adapting to deal with non-routine and dynamic job components (Kanungo & Misra, 1992), and critical thinking (Gillen & Carroll, 1985). Interpersonal leadership skills are associated with social skills such as interaction, influencing (Katz, 1974), or persuading others (Yukl, 1989), focusing on people orientation. The area of business skills can be associated with managerial leadership tasks such as management of resources (e.g., material, personnel, or financial) (Katz, 1974), also including functional expertise and technical know-how (Mumford et al., 2007). The final category, strategic skills, requires conceptual thinking in complex systems from leaders (Mumford et al., 2007; Zaccaro, 2001). The associated skillset includes topics such as visioning (Conger & Kanungo, 1987), problem-solving (Cox & Cooper, 1988), or decision-making (Mumford et al., 2007) abilities.

A research area that recently gained attention is "digital leadership." It describes the elements of strategic success of digitalization for enterprises and their business ecosystems (de Araujo et al., 2021; El Sawy et al., 2016). Authors highlighted specific leadership attributes positively influencing digitalization. For example, leaders in a digital world should have a clear vision of transforming their company and acting as active drivers for innovation (Kane et al., 2019; Westerman et al., 2014). Given the fast-paced VUCA (volatility, uncertainty, complexity, ambiguity) environment, existing research on digital leadership described the attributes of fast decision-making (Larjovuori et al., 2018; Neubauer et al., 2017), embracing change (Kane et al., 2019) and open-mindedness to new ideas (Guzmán et al., 2020; Imran et al., 2021) as required responses to digital changes. In line with the speed of the market environments, risk-taking (Kane et al., 2015) and creating environments for experimentation (de Araujo et al., 2021) were seen as supportive of creating digital innovations. Another significant aspect outlined by leadership research for digitalization is collaborating within ecosystems and engaging in partnerships. Companies benefit from networks with suppliers, customers, and other stakeholders such as universities or start-ups (de Araujo et al., 2021; Ivančić et al., 2019). Collaboration beyond organizational limits supports companies' ability to keep up with new developments and innovate in the digital age (Gurumurthy & Schatsky, 2019; Larjovuori et al., 2018). A holistic view covering the multi-faced leadership skill requirements in the digital context are for example, provided by Eberl & Drews (2021), Guzmán et al. (2020), Imran et al. (2020) or Tagscherer & Carbon (2023).

As indicated earlier, previous research on digital servitization emphasized certain aspects of leadership skills and activities. Struyf et al. (2021) summarized specific topics such as strategic development, organizational development, networking, and organizational decision-making in their research on a multilevel perspective on digital servitization. Kim and Toya (2018) researched the leadership style for servitization within Japanese manufacturing companies, not considering the digital context. Their empirical results indicated charismatic and transformational leadership styles supporting servitization efforts. On the other hand, autocratic and autonomous leadership styles impede successful servitization (Kim & Toya, 2018). Furthermore, we structured the extant contributions of digital servitization research and the associated leadership aspects in Table 1.

Table 1. The main outcome from the literature review on digital servitization and leadership

Reference	Research focus	Contribution
Kim & Toya (2018)	Leadership styles for servitization	Charismatic leadership style is supportive for organizational change required for servitization Required top-management efforts to inspire commitment from employees
Cimini et al. (2021)	Competence development for digital servitization	Agile and collaborative mindset is essential for digital servitization Training provisions for soft skills and digital literacy are important Competence development for sales and marketing employees involved in digital service offerings
Struyf et al. (2021)	Multilevel framework for digital servitization	Digital servitization is a complex and interrelated requiring proactive management to be overcome Effective management of digital servitization challenges is an iterative process and agile approach
Tronvoll et al. (2020)	Required change initiatives for digital servitization	Focusing on customer value Defining and maintaining a vision for digital servitization Cultivating agile ways of working Shorter timelines for target-setting
Sklyar et al. (2019)	Organizing for digital servitization	Setting out a comprehensive vision for digital servitization Close collaboration between service and product organizations

Source: Kim and Toya (2018); Cimini et al. (2021); Struyf et al. (2021); Tronvoll et al. (2020); Sklyar et al. (2019).

The identified studies elaborating on leadership aspects for digital servitization recognized the complexity of shifting towards digital servitization (Struyf et al., 2021). Common recommendations include the creation of a vision (Sklyar et al., 2019; Tronvoll et al., 2020) and applying agile ways of working (Cimini et al., 2021; Struyf et al., 2021; Tronvoll et al., 2020) asking for close internal and external collaboration for digital servitization (Cimini et al., 2021; Sklyar et al., 2019). Furthermore, extant literature highlights the requirement for top management involvement and commitment towards digital servitization (Kim & Toya, 2018; Struyf et al., 2021).

METHODOLOGY

Our research aims to gain exploratory insights into the research question of a holistic view on leadership skills for digital servitization due to its underexplored nature. The extant literature on digital servitization and leadership has been reviewed to build a theoretical background for formulating the distinct questions of the semi-structured interview guide. We selected the method of semi-structured interviews as a well-proven and fitting instrument for qualitative and exploratory research (Kallio et al., 2016). We generally used open-ended questions to support the exploratory nature of the research (Weller et al., 2018). Before inquiring about our main research question of required leadership skills for digital servitization, we ensured generating a common understanding for the two main subjects of the study: digital servitization and leadership. Furthermore, we added subsequent questions regarding change management, risk attitude, goal-setting process, role in ecosystems, and communication skills, which were identified as essential leadership aspects in our previous literature review on leadership, digital leadership, and the five articles referenced in our literature review on leadership for digital servitization. The interview guide with the respective questions is presented in Appendix 2. The applied research procedure is based on a combination of the works of Braun and Clarke (2006), Mayring (2014), and Thomas (2006) on qualitative research analysis and depicted in Figure 3 with a particular emphasis on the step of data analysis.

For the data collection, we used purposive sampling: We contacted potential research participants through the business network platform "LinkedIn" based on matching job titles to ensure their expertise in providing insights into our research question. This included the search terms "digital services," "servitization," "digitalization," and "digital transformation." Besides an initial check about the suitability of our research participants through conversation, we validated their contribution through their job titles, position in the company hierarchy, industry association of their company, and years of leadership experience. Our research participants held positions at different firm levels, ranging from first-level managers to Directors, Vice Presidents, and Executives. On the one hand, this spread allows insights from various perspectives based on hierarchy levels within the company but also allows strategic leadership relevance due to the significant number of senior-level leaders in our reference group.

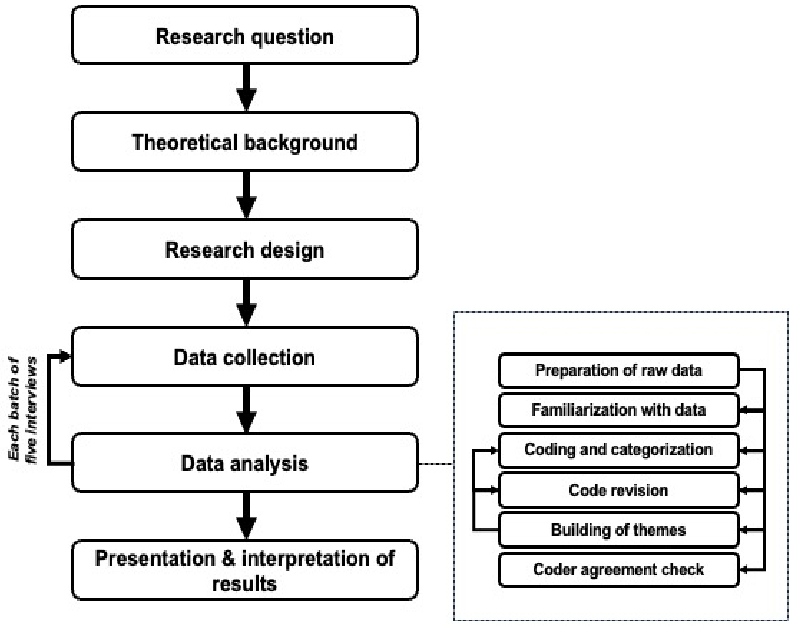

Figure 3. Research procedure

Source: Own illustration based on Braun and Clarke (2006,) Mayring (2014), and Thomas (2006).

Furthermore, we used the Global Industry Classification Standard (GICS) to present the industry in which the companies of our research participants were active (MSCI, 2022). Besides the leaders in the business or IT consulting, classified as professional services or IT services according to GICS, our research participants were also employed in companies active in the machinery or electrical equipment industry. As those industries are mainly concerned with manufacturing and servicing equipment, we can confirm their relevance for our study on digital servitization. Lastly, we present the years of leadership experience in defined categories. Similar to the spread at the company level, the range of leadership experience offers insights into different perspectives based on experience. Table 2 shows the distribution of leadership experience ranging from up to five years of leadership experience to very experienced leaders with more than twenty years in active leadership roles.

Table 2. Research participants

Identification of research participants by search terms	Amount	Share in %
Digital services	9	30%
Servitization	9	30%
Digitalization	5	17%
Digital Transformation	7	23%
Total	*30*	*100%*
Company level	Amount	Share in %
Executive	6	20%
Vice President	5	17%
Director	6	20%
Head of	7	23%
Manager	6	20%
Total	*30*	*100%*
Industry	Amount	Share in %
Professional Services	5	17%
Machinery	15	50%
Automobiles & Components	1	3%
Chemicals	2	7%
Electrical Equipment	3	10%
IT Services	4	13%
Total	*30*	*100%*

Leadership experience	Amount	Share in %
0-5 years	6	20%
6-10 years	6	20%
10-20 years	10	33%
>20 years	8	27%
Total	*30*	*100%*

One researcher conducted and recorded the interviews online via Microsoft Teams to ensure consistency from April 2023 to July 2023. We decided to include a loop between data collection and data analysis after each batch of five interviews to assess code saturation (Hennink et al., 2017), which was reached after thirty interviews. For the first step of the data analysis, we used the 2023 version of Microsoft Teams' system-immanent transcription function as an initial baseline and manually optimized the raw data through intelligent verbatim transcription while rehearing the interviews. This step ensured the correctness of the research participants' statements and improved readability, which formed the baseline for analyzing the interview transcripts (McMullin, 2023). After familiarizing with the data, we used the software MAXQDA (VERBI Software, 2021) for the code development. We followed Braun and Clarke's (2006) thematic analysis to identify codes and themes using an inductive approach following our exploratory research design. Nevertheless, we would like to acknowledge that parts of the codes are theory-driven (Braun & Clarke, 2006). They are based on the outcome of the previously conducted review about the theoretical background to formulate our interview questions. Thus, our study includes elements of deduction due to our research design (Mayring, 2014; Thomas, 2006), which are further refined by inductive elements based on the nuanced statements of the research participants (Fossey et al., 2002). Within a recursive process, we conducted our coding, which required refinements and optimization of the code structure (Braun & Clarke, 2006; Mayring, 2014). Additionally, we collated codes into perspectives, themes, and sub-themes to structure our findings based on their relations and connections. Within this step, initial codes were summarized, rephrased, or discarded to create a thematic map within a three-stage model to present the results (Braun & Clarke, 2006). The coding process is depicted in Appendix 1. One researcher performed the initial coding based on the outlined procedure. Researcher bias and the reliability quality criteria were addressed through an inter-coder check of the research partner, who served as a supervisor with access to all material, definitions, and codings (Mayring, 2014). The review did not result in disagreement with our coding results, thus supporting the conclusions on the basis of our findings and, thus, increasing cross-reliability.

We reviewed our transcripts inductively to set up the initial code set referring to our research question of leadership skills and traits for digital servitization. Afterward, we structured our initial code set of 43 items into sub-themes, themes, and perspectives through an iterative process. Twelve of our initial codes were not included in the thematic map while reviewing our themes. There was insufficient data to support them, or they were disqualified during the refinement process (Braun & Clarke, 2006). The exclusion criteria "insufficient supporting data", "mentioning specific communicational channels", and "no actional item for leaders" are assigned explicitly for each initial code in Appendix 1. In addition, we rephrased two of our initial codes after the initial coding procedure to better represent its content. Furthermore, we summarized the remaining 31 codes into 20 sub-themes, further clustered into five themes. During this process, we eliminated the initial "internal change management" code and labeled one "change management" theme to represent the associated content. Lastly, our presentation of the thematic map of leadership aspects for digital servitization was finalized by identifying two main perspectives (see also Table 3). The process of coding the interviews and reviewing the identified themes led us to structure our findings in a three-level setup. Furthermore, interview statements were included for further explanation and detailing based on research participants' quotations. The far-right column of the thematic map (Table 3) explains the themes' coding origin, whether they are inductive and emergent findings or entail a degree of deductive and theory-driven origin due to applied theoretical background to formulate the interview guide's research questions. Furthermore, we have included the sources for the theory-driven codes.

RESULTS

On the highest level of the thematic map, we present two perspectives – strategic business leadership and people leadership. Moreover, both perspectives entail further themes to specify the different aspects of required leadership skills for digital servitization. From the strategic business leadership perspective, this entails "strategic business decisions," "business building elements," and "market and customer." On the people leadership side, we summarized the sub-themes into the themes of "change management" and "employee orientation" themes. Table 3 outlines all 19 sub-themes categorized into the five themes, including exemplary interlocutors statements and the explanation of the coding origin.

Table 3. Thematic map leadership for digital servitization

Perspectives	Themes	Sub-themes	Interview statements	Coding origin
Strategic business leadership	Strategic business decisions	Conscious top management decision for digital servitization	• "We would always say that servitization is a C-level conversation first and foremost" • "Do you really want to do that as a company?" • When an organization and the leadership decides to build a business case in the area of digital servitization"	Inductive and emergent finding
		Evolving target setting within digital servitization journey	• "Every time you have two or three other metrics that are really defining your success" • "Don't do only financial targets, do some other measurable targets" • " […] it really depends where you are in your journey in digitalization. So if you are at the beginning, […] I would put very different targets."	Inductive findings but the degree of deduction and theory-driven codes due to interview question on goal-setting process derived from, e.g.: Tronvoll et al. (2020)
		Positive financial contribution	• "I think in the end, every business in the medium and long term must earn money" • "The end goal is to make money or to have a business that is sustainable"	Inductive and emergent finding
		Risk-taking and risk management	• "You have to manage the risks" • "I'm more used to actually take bigger risks, but controlled ones" • "You need to be open for an open failure culture as well"	Inductive findings but degree of deduction and theory-driven codes due to interview question on attitude towards risk derived from e.g.: Kane et al. (2015)
	Business building elements	Comprehensive business understanding	• "Obviously they need to understand technology and the business and strategy perspective" • "that means as a leader you have to have a complete oversight of the business" • "It is the strategy, the business case, the monetization"	Inductive and emergent finding
		Agile methods	• "You need to be very agile" • "I think here agile methods are a good thing in this field".	Inductive and emergent finding
		Cross-functional collaboration	• "You need to unite the different people. So from finance to HR to operations to all of the different teams and personas which you need to bring together." • "You need to really think beyond your department or your group" • "From the leadership perspective it's much more about collaboration and interorganizational collaboration"	Inductive and emergent finding
		Team composition	• "You need to have the right people in your team which are eager to create something new" • "I hate to say it, there is a pretty decent change you are going to have some attrition"	Inductive and emergent finding
		External collaboration	• "Partnering is extremely important because you have to be really aware all the time what kind of possibilities you have […] and that technology is changing so rapidly" • "When it's about developing some new thing you need also to get some outside impulses" • "Because the market is changing so fast, you need to have different partners for different things"	Inductive findings but the degree of deduction and theory-driven codes due to interview question on ecosystems and partnerships derived from e.g: Gurumurthy & Schatsky (2019); Larjovuori et al. (2018)
	Market and customer	Understand customer and market needs	• "You have to put yourself into the customers' shoes and being customer-centric" • "We have to collaborate closer with the customer already in the beginning and don't be afraid of talking about something that is not yet finished" • Be aligned with market needs because many organizations that do a lot of product development at the end, they come to the conclusion that the market doesn't need that"	Inductive and emergent finding
		Focus on value creation for customers	• "The value proposition should be very clear to the customer that what value they will get" • "Focus on the value" • "Speak about the value for the customers"	Inductive and emergent finding

Perspectives	Themes	Sub-themes	Interview statements	Coding origin
People leadership	Change management	Vision creation for digital servitization	• "They have to provide a vision to the employees" • "Leadership certainly demands an ability to create a vision and convey the vision" • "Create a joint vision" • "I would go back to the vision. That's one of the main drivers for that change management" • "You need to give them a vision. You need to give them a direction without setting too hard borders"	Inductive and emergent finding
		Communication of the vision understandably and regularly	• ""It must be easy to communicate and easy to understand" • "Speaking the language of the people you want to convince" • "Communication on a very frequent level" • "I wouldn't go too much in the technical terms"	Inductive findings but degree of deduction and theory-driven codes due to interview question on communication derived from e.g.: Mumford et al. (2007); Yukl (1989)
		Creation of a sense of urgency and why the change is required	• Build a sense of urgency around it, but also understand if we're not able to adapt at some point we're going to be in trouble" • "I think they should clearly explain why business model change is needed and why it's on the immediate horizon"	Inductive findings but degree of deduction and theory-driven codes due to interview question on enabling change derived from e.g.: Bustinza et al. (2018); Kane et al. (2019)
		Awareness of employees' fears	• "Take away that fear to the employees" • "I would want to address that fear or that anxiety" • "The fear of people, especially people above fifty"	Inductive and emergent finding
		Speed & patience	• "Things can move very quickly, so you have to be in a position to react quickly to that" • Especially in a subject like digital servitization, which is very fast" • "Digital servitization is nothing that you can do in three months. So that's a very long journey"	Inductive and emergent finding
	Employee orientation	Employee participation and feedback	• "You need to be able to go down into the trenches with the people and […] and one of the traits is be really open to feedback' • "I think giving feedback is really important"	Inductive and emergent finding
		Enablement & empowerment	• "To empower each and everyone to take her or his role and driving it jointly" • "But not control them in their jobs, but rather enable them in their jobs" • "Because you shoudn't do everything on your own, but you have to enable the people"	Inductive and emergent finding
		Training and skill development	• "It should go down to the point of whereby the leader has educated or trained the sales and service people who are actually on the customer front" • "So it's not only communicating, it's also training the sales force, the marketing, etc."	Inductive and emergent finding

Strategic business leadership perspective

Strategic business decisions

The first leadership decision is required by the firm's top management whether to pursue digital servitization activities. Based on this, leaders in charge of the needed undertakings should be assigned. Those individuals require full backing from the executive level in terms of financial and personal resources. One research participant stated: "It is a C-level conversation because of the substantially huge degrees of change" (Interview #24). On the contrary, top management must clearly state if they do not see digital servitization as the current focus topic to avoid a waste of resources if projects are pursued without aligned consent from the executive level. The following statements of the research participants support this: "Do you really want to do that as a company? […] I think leadership means that the company and the leaders provide a clear direction (Interview #8)." Another participant added: "You have to have the openness and I would call it the real commitment that you want to do that (Interview #12)."

From a goal-setting perspective, the research participants emphasized the importance of targets, KPIs (key performance indicators), and performance measurements to succeed within digital servitization. As digital servitization is a new approach to the business for most incumbent companies, the success of the new business model should not solely be measured by financial attributes such as order intake, sales, or profit as one research participant highlighted: "Don't do only financial targets, do some other measurable targets (Interview #2)." Instead, more qualitative and customer-oriented targets, for example, "I think other KPIs besides the pure money like customer satisfaction, customer loyalty, these are the important things (Interview #22)", should be focused on, especially in the beginning, on measuring building the business model.

Another comment recommended, "I think in the beginning it's much more relevant that you think about the customer backward in terms of customer experience, customer satisfaction, added value for customers. Because whenever you enter something new, I think these are the key elements, and they should be first (Interview #8)."

Based on the statements, we recommend an evolving approach, depending on the maturity level of the digital servitization topics. An executive's point of view underlines this: "At the beginning, you're managing are we learning? Then, are we innovating? Then, are we finding the our first business? Are we scaling? (Interview #16)" In addition, those KPIs and targets should be short-term and change along the development of the business model, emphasized by one research participant: "If you are at the beginning of the journey, I would put […] very short terms like quarterly targets (Interview #30)." The more digital servitization becomes a regular part of the traditional business, the more traditional goal setting can be applied to link business success to financial performance indicators.

Despite prioritizing non-financial measurements at the beginning of digital servitization activities, leaders shall emphasize the ultimate reasoning of business activities – profit contribution and positive cash flow. A research participant's statement underlines this as follows: "It must be a business model which flies, which means that you earn money (Interview #22)" and "to be really sure that you are able to make money with the business model (Interview #18)". Therefore, reaching a self-sustaining business model through digital servitization needs to be considered. Even though digital servitization is a new topic for the company, it shall not be excluded from basic economic principles, which is emphasized through the comments: "The end goal is to make money or to have a business that is sustainable (Interview #15)," or "I think in the end, every business in the medium and long term must earn money (Interview #22)."

Linked to the previous subject, pursuing digital servitization requires a certain amount of risk-taking, which we explicitly inquired about in our interview questions. One leader described a difference between investments in machinery and manufacturing lines and digital servitization: "The only thing that is different if we talk about digital is that the first step is cheaper. […] You can test much more in the early steps that you could do with other investments (Interview #15)." Nevertheless, we found consent when analyzing the interview sessions that active risk management is required for digital servitization, underlined with the following statements:

"You always have to manage the risk (Interview #9)." "You need to understand what is happening, and be able to manage [the risk] all the time (Interview #13)." "You have to make the risk manageable and make it transparent to do that (Interview #7)."

On the one hand, this means establishing mechanisms to identify and understand risks and their potential outcome. On the other hand, continuous control and mitigation of those risks are required to ensure the activities do not harm the overall business or customer relations. In addition, leaders must be aware that fast failure and a trial-and-error mentality are supportive in an uncertain digital environment, which our research participants stated as follows: "acceptance of failure (Interview #2)", "you need to be open for an open failure culture (Interview #7)", or "with digital you really have to accept that you will make errors simply because you cannot foresee everything (Interview #6)."

Business building elements

The second theme in the business perspective is "business building elements". Here, we summarize all relevant elements our research participants answered for building a successful digital servitization business model, including organizational setups or leadership focus areas.

Besides a basic understanding of the underlying technology, our research participants highlighted the need for a comprehensive business understanding. For example, "they need to understand technology, the business, and the strategy perspective (Interview #22)". One Director emphasized: "You have to understand the business that you're standing up (Interview #20)", which is supported by another statement: "As a leader, you have to have complete oversight of the business system (Interview #18)." This also includes the resulting impacts on accounting models, business processes, or sales approaches, which are crucial to understand and consider while steering digital servitization activities. Especially the aspect of monetization was mentioned during the interviews: "Sometimes also monetization models look very different than in a one-time payment world (Interview #22)." A Director added:

"How am I going to handle this asset, or are we going to own the asset? Are we going to sell this asset to a third party if I offer a service model? […]. So the leadership has to be holistic because you are literally standing up a new business (Interview #20)."

To develop and refine digital servitization business models, our research participants suggested applying agile methods such as SCRUM to ensure fast development and the ability to adapt quickly in case of changing settings in the surrounding areas. Especially in digital servitization, leaders can use those concepts to react to changing technology trends or shifting customer requirements. Agile aligns with the above-mentioned trial-and-error mentality due to the short-paced iterations within the sprints. The research participants' statements underlined this: "You need to be very agile (Interview #6)", "the agile way of defining leadership (Interview #9)," or "I think here agile methods are a good thing in this field (Interview #27)."

Another crucial leadership skill for digital servitization within the theme of business-building elements relates to cross-functional collaboration. This also links to the previously mentioned comprehensive business understanding, which emphasizes the holistic view of different aspects within the firm. This is typically structured within various departments with specialized domain know-how within companies. Focusing on including and fostering the collaboration and exchange between those different areas is beneficial during digital servitization activities. A Director highlighted: "There has to be a tremendous amount of collaboration between sales, marketing, finance, accounting, field operations, et cetera (Interview #20).". Therefore, "a collaborative culture where people actually desire to collaborate with all of these cross-functional teams (Interview #20)." Building a solid network within the company is imperative to gain access and ensure excellent cross-functional collaboration with the necessary individuals from the traditional departmental structures. Therefore, digital servitization leaders are often required to lead their teams without formal reporting lines and directional power.

"[Leaders] need to unite the different people, from finance to human resources to operations to all of the different teams and personas you need to bring together on this joint journey (Interview #22)."

Besides cross-functional collaboration, certain aspects of composing teams can be outlined. Especially at the early stages, our research participants recommended selecting team members interested in the topic as they declared it is self-motivating for these individuals. The research participants highlighted the importance of having the right people: "I think you need to have the right people in your team who are eager to create something new (Interview #26)." Nevertheless, leaders should consider balancing their teams with a good mix of experience, business knowledge, or educational background. This allows for diverse discussions to enable the potential best outcome of the exploratory phase of digital servitization. When the topic is scaling up within the company, it requires caution not to let unmotivated or unqualified managers or employees slow down or block this expansion due to wanting to stick to the historical or traditional way of doing their job.

"You are going to have x percent […], they just want to do things the way they've been doing it for the past 35 years. […] they could actually be contra to your desires (Interview #20)."

For those situations, leaders' bold action and moving those employees to other areas where they can contribute more or even terminate them not to harm the overall business development are proposed leadership activities as one research participant foresaw attrition as a required element in the team composition. This is underlined: "Who will not fit in some of these roles? I hate to say it, but there's a pretty chance you're going to have some attrition (Interview #20)."

Lastly, leaders responsible for digital servitization should consider developments outside the companies' boundaries and actively pursue external collaboration. Especially in the digital context of digital servitization, our research participants strongly suggested partnering with other actors such as start-ups or academia. One research participant stated: "If there are start-ups which have strong knowledge about a certain technology which you believe is relevant for you, you should certainly talk to them and set up partnerships (Interview #26)." Due to the rapid developments of technology, support is essential to gain access and speed in applying the know-how of external partners to advance companies' business models. This is emphasized by:

"Because the market is changing so fast, that you need to maybe have different partners for different things (Interview #30)" and "partnering is extremely important because […] the world and the technology is changing so rapidly. So if you try to do this alone without a good network, it is impossible (Interview #13)."

Several research participants concluded that pursuing their developments with internal resources would consume too many resources and drastically slow down the digital servitization journey, risking not keeping up with the market or competitors' pace. For example, this is underlined by "it is completely outdated to do everything on your own (Interview #25)" and "I think companies need to quit thinking only they can master a specific task (Interview #26)." By outlining internal and external collaboration, we underline the requirement for focusing on "when it's about developing some new things, you also need to get some outside impulses (Interview #11)."

Market and customer

Leaders associated with digital servitization business models should focus on the sales side in addition to the internal and organizational aspects. With the theme of market and customer, we conclude the strategic business leadership perspective by summarizing the responses covering these essential areas.

Our research participants emphasized the requirement to understand the needs of customers. Terms like "customer-centricity" or "put yourself in the customers' shoes" were highlighted to understand customers' needs. Understanding customers' problems and challenges is vital to tailoring the digital servitization offerings to address these. Therefore, close customer engagement and obtaining feedback on customer requirements were suggested. "We have to collaborate closer with the customer already in the beginning and don't be afraid of something that is not yet finished already or market ready (Interview #27)." On the contrary, developing a digital servitization business model that does not fulfill market needs can be avoided by this deep market understanding. One research participant brought up:

"Be aligned with market needs because many organizations that do a lot of product development, but in the end, they come to the conclusion that the market doesn't need that (Interview #11)."

Digital servitization offerings can often be new to customers from either the digital technology side or the aspect of offering new business models from the servitization point of view. Therefore, we summarize that leaders should keep the value creation for customers in mind when creating and marketing digital servitization offerings, which are underlined by a "focus on the value (Interview #27)." To enable customers to pay a recurring fee for the offerings, they need to be convinced of how these offerings generate value for them. Therefore, "[…] the value proposition should be very clear to the customer and what value they will get (Interview #4)." This aspect was mentioned in the context of customer interaction and communication "to speak about the value for customers (Interview #27)."

People leadership perspective

Besides the strategic business leadership perspective, our research participants highlighted the importance of people orientation of leaders for digital servitization. In the following, we outline the aspects assigned to the themes of change management and employee orientation.

Change management

As described in the previous strategic business leadership section, digital servitization changes and differentiates from the existing business models – "it's a huge change within your company (Interview #25)".

Additionally, it affects almost all employees, spanning practically all company departments. In addition to working with new digital technologies, the organization is also asked to change its way of working through the increased service orientation and the related business model alternations. Due to those circumstances, one research participant declared:

"[…] change management, in my opinion, is by far and above the single biggest barrier that digital leaders have, then it comes to trying to convince the rest of the organization (Interview #1)."

Therefore, in the following, we highlight the most frequently used recommendations leaders can apply to guide their organization and motivate the employees to follow the digital servitization journey. The first sub-theme relates to creating a compelling vision for digital servitization, which was described as "one of the main drivers for that change management because you need to be able to imagine […] but even more visualize the vision (Interview #3)." This vision builds the foundation on where the company wants to go with digital servitization and how it fits within its overall strategy and "[needs to be provided] to the employees and [the leaders] need to make clear that the vision is also shared by the employees, that they understand where they are going (Interview #25)." It is described as "some kind of understood picture of how this all could work in the future (Interview #15)." A strong vision was mentioned as a critical factor for leaders to guide and motivate their employees, which is recommended that "leadership demands an ability to create a vision and convey […] the vision (Interview #24)." One manager said "You need to give them a vision without setting too hard borders (Interview #3)." Additionally, our research participants recommended involving employees to create a "joint vision (Interview #22)" to increase the commitment to follow this vision in digital servitization change management.

Once created, the next crucial leadership task is to communicate the vision. Based on the expert opinions we obtained, we outline several success factors for this step. The vision should be translated and made understandable for all affected individuals within the company. This is underlined: "I think in the end, it must be easy to communicate and easy to understand (Interview #22)." Or "speaking the language of the people you want to convince (Interview #15)." On the one hand, this means explaining the technological changes comprehensively and refraining from technological buzzwords but emphasizing digital servitization's business model impacts and benefits. One Head of emphasized: "I wouldn't go too much in technical terms (Interview #15)." On the other hand, translating what the activities accompanying digital servitization change in the daily work lives of individuals within the company.

"People have to understand it, and the next step is that people have to understand what their own role is in this idea and what they have to contribute (Interview #12)."

Therefore, the impacts should be explained continuously to ensure they reach and convince their employees. This active communication helps generate a positive message and support throughout the organization for the change required for digital servitization. Lastly, our research participants emphasized the need for continuous, regular, and consistent communication to highlight the importance of the necessary change. Therefore, "communication on a very frequent level (Interview #28)," "there should be continuous communication (Interview #4)," and "sometimes you have to repeat it (Interview #25)" describe statements from the interviews.

The topic of highlighting the "why" and creating a sense of urgency for the change related to digital servitization was underlined during the interviews. Especially when companies still experience positive results through their traditional business "because a lot of the traditional manufacturing companies don't feel the pressure yet (Interview #29)", it is required that leaders explain why digital servitization activities should be pursued. As part of the change communication, highlighting the sense of urgency supports convincing employees to follow the new business model opportunity. Therefore, "you need to […] create a sense of urgency. Why do you need to change? (Interview #26)". Without initiating the change process, the company will miss out on future business potential through digital servitization offerings because "you need to build a sense of urgency around it, but also understand if we're not able to adapt to that we're going to be in trouble (Interview #16)." Leaders "should clearly explain why business model change is both needed and why it's on the immediate horizon (Interview #1)."

The introduction of digital servitization business models can significantly alter existing workplaces. It could make some obsolete and create new job profiles based on different skill set requirements. These changes can develop fears for employees holding these affected roles of losing their jobs or being unable to fulfill the upcoming requirements. One research participant described this: "I'm even scared that this is taking my job away because I don't have the education for that area (Interview #30)." Our research participants also highlighted a difference in openness for digital servitization due to generational differences, "especially people above fifty (Interview #5)." Leaders must know these fears to understand potential resistance to support the required change process as one leader described: "There was a lot of resistance inside this organization because they always thought […] I might lose my job (Interview #29)." Therefore, providing options for affected employees by either finding a new role within the company or upskilling them for the new requirements is an associated leadership task by explaining "We need you in a different position (Interview #10)." If appropriately accompanied, removing the fear from employees arising from emerging technologies or new business models is a vital success factor for the change management to pursue digital servitization successfully.

The final relevant item of the change management theme relates to the time perspective. In line with the fast-paced changes in digital technology, "trial and error"-mentality, agile methods, and required external collaborations for speed, our research participants emphasized the need for quickness within digital servitization: "Things can move very quickly, so you have to be in a position to react quickly to that (Interview #1)." Additionally, "in a subject like digital servitization, which is, I think, very fast, changing with a lot of new technologies coming (Interview #2)." Nevertheless, the overall change process of implementing digital servitization requires patience and time. One Head of emphasized: "Digital servitization is nothing that you can do in three months. So that's a very long journey (Interview #12)." Notably, aligned with the sub-theme "positive financial contribution", one of our research participants recommended, "be somewhat patient with time but be very, very impatient with the results (Interview #1)."

Employee orientation

The final theme of employee orientation focuses on the leaders' required soft skills for digital servitization, whereby its sub-themes complement the previously mentioned items due to their overarching nature.

Enabling their employees to actively participate and ask for continuous feedback during the digital servitization journey is crucial for leaders. This mindset supports several of the leadership themes. For example, our research participants recommended allowing employees to participate in the vision creation process to increase commitment. Secondly, leaders should consider gaining feedback from employees close to the customers regarding market developments and value creation needs for digital servitization solutions. A Head of pointed out: “Feedback is also very important because sometimes what we are offering, maybe they don’t need those things (Interview #4).” Another point described the closeness: “You need to be able to go down into the trenches with the people (Interview #29).” Leaders can, for example, use this continuous feedback in agile development cycles for business model development. Also, employees’ feedback should be actively heard and incorporated during the change process to avoid losing employee connection. A research participant’s statement underlined this: “I couldn’t agree more that the change management is the most crucial, but you need to involve the people (Interview #3).” Additionally, our digital servitization leaders emphasized the benefit of a mutual goal-setting process, which results in ambitious but realistic targets.

Within the set boundaries of the vision, strategy, and goals, freedom should be granted to employees. This includes enabling them to make decisions independently and structure projects within the set guard rails aligned with the leadership.

“Not to control them in their jobs, but rather enable them in their jobs (Interview #24).”

Due to the recommended application of agile methods and the trial and error mentality, enablement and empowerment benefit faster development times without constant alignment. Another aspect is the increased motivation by granting room for entrepreneurship and less micro-management. “[Leaders] shouldn’t do everything on [their] own, but enable the people (Interview #27)” and “empower each and everyone to take her or his role and drive it jointly (Interview #22).”

As the final sub-theme, our research participants recommended focusing on training and skill development as supporting elements for success in digital servitization. It requires general training to apply digital technologies, whereas increased knowledge supports the change process by reducing employees’ fears. “It’s not only communication; it’s also training the sales force, marketing, et cetera (Interview #14).” Critical is the education of the sales teams responsible for selling digital servitization offerings, which was described as follows: “It should go down to the point where the leader has educated or trained the sales and service people who are actually on the customer front line (Interview #1).” Besides understanding the underlying technology, customers should be convinced of the additional value creation through these new offerings. Additionally, sales education should incorporate the shift from asset to service selling, as “this will be something completely new in most cases (Interview #26).”

DISCUSSION

Our identified leadership skills address the complexity of digital servitization (Kohtamäki et al., 2021; Struyf et al., 2021) through the multitude and diversity of identified themes and sub-themes. The decision to pursue digital servitization activities has wide-ranging impacts on companies. Digital servitization influences existing organizations from several perspectives. Therefore, digital servitization requires a multi-faceted leadership approach. Although previous research focused on specific leadership elements, our research provides structured guidance and a holistic view of leadership skills for digital servitization. However, specific themes have also been also identified in extant literature. For example, Kim and Toya (2018) highlighted the need for top management involvement in successful servitization implementation in Japanese manufacturing firms. However, their research did not focus on the digital component, which we confirmed in our study. The topic of target setting has also been given attention in the research of Tronvoll et al. (2020), which recommended short cycles for target adjustments, similar to those proposed by our research participants. However, our findings contribute by adding qualitative content to the target-setting for digital servitization. Especially the insights of evolving targets and including customer-oriented measurements within the digital servitization journey add value to the scientific discussion. Whereas the theme of applying agile methods was already outlined in scientific research on digital servitization (Cimini et al., 2021; Struyf et al., 2021), the statements of our research participants about the need to focus on positive financial contribution and the leadership requirement of a comprehensive business understanding has not been explicitly mentioned. Notably, the need for a comprehensive business understanding ranging from technology, finance, or IT underlines the complexity of managing digital servitization activities described by Kohtamäki et al. (2021) and Struyf et al. (2021). The focus on customers and the value creation through digital servitization, which our research participants highlighted through statements such as “focus on the value” or “it’s important to speak about the value (Interview #27)”, is similarly presented by Tronvoll et al. (2020) as an essential success factor. Within the perspective of people leadership, we explicitly present change management and employee orientation as the central themes relevant to leading digital servitization. Although the connection between change and digital servitization is recognized in extant literature (Kohtamäki et al., 2021; Sklyar et al., 2019; Tóth et al., 2022; Tronvoll et al., 2020), the presentation of our research results provides a deeper understanding of required leadership activities. Ranging from "creating a joint vision (Interview #22)", "you need to have a clear vision (Interview #3)," and "speaking about the vision in a way people can relate to (Interview #5)", to "build[ing] a sense of urgency around it (Interview #16)", our research participants pointed out the required need for awareness of employees' fears and to "address the fear or that anxiety (Interview #5)." Lastly, the theme of employee orientation relates to the call of Cimini et al. (2021) for soft skill development and competence training for sales employees in digital servitization. However, the aspects related to employee participation, enablement, and empowerment provide further support for other leadership skills due to their overarching nature.

Leadership skills can be associated with strategic, business skills, interpersonal, or cognitive skills, overall supported by universal cognitive skills. Consequently, we underline the importance of applying a holistic view of leadership to address hurdles in establishing digital servitization (Figure 4).

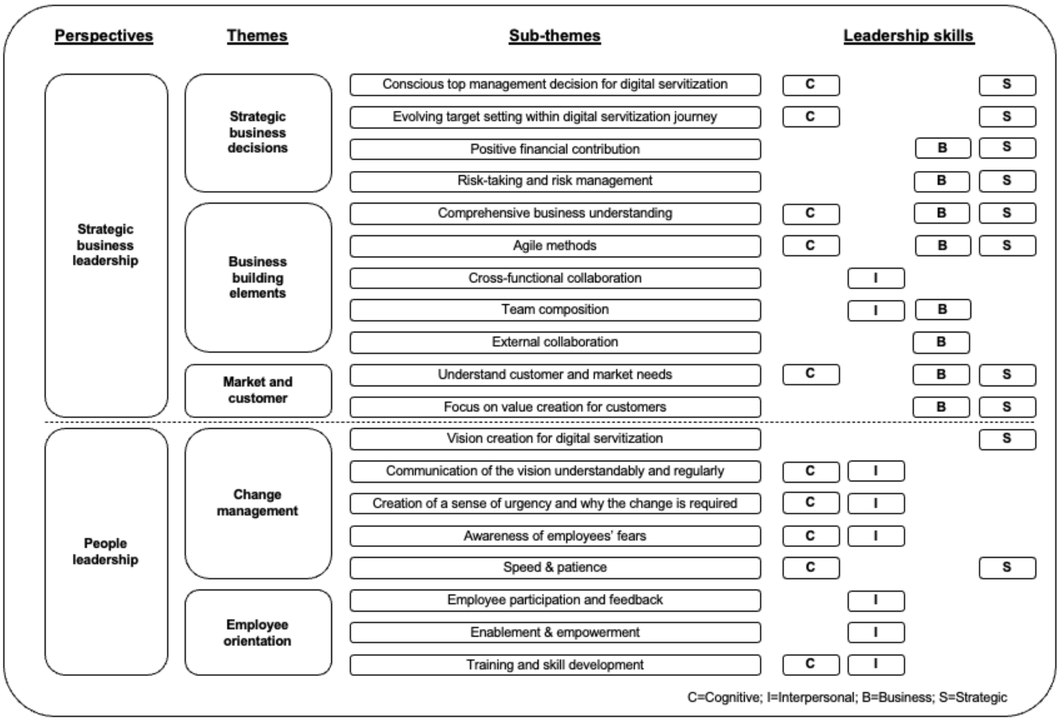

Figure 4. A holistic view on leadership for digital servitization

Source: Own illustration based on findings: association of leadership skills based on Mumford et al. (2007).

Based on mapping our thematic map to the four leadership skills described by Mumford et al. (2007), we see a balance between cognitive, interpersonal, business, and strategic skills among our 19 sub-themes. Cognitive skills as a foundational layer (Mumford et al., 2007) are identified as critical for leading digital servitization. This can be explained by their supportive nature, including understanding, comprehending, and communicating, which is required for strategic business and people leadership. On the other hand, we see tendencies of allocation of interpersonal, business, and strategic leadership skills to our identified leadership themes. Whereas the strategic business leadership perspective requires efforts in business and strategic skills, the people leadership perspective is reflected in cognitive and interpersonal leadership skills. The combination of the diverse skill requirements within digital servitization of applying strategic decision-making but also being close to employees is a significant ask to leadership. Furthermore, we point out that leadership for digital servitization involves several, sometimes opposite, touchpoints. For example, leaders active in digital servitization need to collaborate "typically [with] a lot of players (Interview #24)" inside and outside their company. Moreover, they interact with stakeholders such as customers, suppliers, and employees. As companies have the conception of falling behind their progress expectations on digital servitization (Pham & Vu, 2022), we offer support with our holistic view on the role and tasks of leaders to avoid missing out on understanding the diverse outlined leadership themes of strategic business leadership and people leadership or the lack of understanding of the lengthy duration as "it takes time (Interview #23)." Additionally, digital servitization interferes with several actors. On the one hand, digital servitization requires cross-functional collaboration of several departments and "unit[ing] the different people (Interview #22)." On the other hand, companies are interacting with customers, suppliers, or other ecosystem stakeholders. Thus, our findings that digital servitization affects several departments require change management, and a long implementation period contributes to the research from Sklyar et al. (2019) on how to organize digital servitization with specific leadership aspects. In summary, our research questions are answered by displaying our thematic map of a holistic view on leadership for digital servitization by pointing out specific elements within the expressed sub-themes. The required scope of leadership is presented by diverse perspectives describing the need to focus on strategic business and people leadership, which are further detailed by the presented themes: strategic business decision, business building, market and customer, change management, and employee orientation. Lastly, mapping the required leadership skills to cognitive, interpersonal, business, and strategic skills describes the leadership skill requirements, which underline the holistic view on leadership for digital servitization.

CONCLUSION

Our findings outline essential decisions along the digital servitization journey, starting from the very first decision on whether those business models should be pursued at all. The identified leadership themes also give insights into the required considerations, skills, and traits for leaders to moderate the change process and motivate and educate their employees to implement digital servitization business opportunities successfully. Failure to build successful digital servitization business models can result in multiple adverse outcomes, such as lost financial funds or misallocated personal resources. Even more critical could be the loss of differentiation criteria against competitors or failure to fulfill potential customer needs. Furthermore, employees could feel misguided and lose faith in their leadership. Our research work supports reducing the risks above by raising awareness of the different aspects and multitude of activities, ultimately contributing to growth and profit expectations from digital servitization.

We contribute to scientific research and the practical digital servitization community. Firstly, we define digital servitization as "generating additional value for the installed base of existing customers by providing product and service bundles enabled by digital technologies through newly created or revised business models," which is customer-oriented and value-based. Furthermore, we conducted a qualitative study combining the aspects of digital servitization and leadership, acknowledging the diverse set of skills ranging from the strategic, business, or personal side, which has lacked scientific attention so far. Furthermore, mapping the identified leadership skills with cognitive, interpersonal, business, and strategic leadership requirements exemplifies the need for diverse competencies to manage complex digital servitization activities. The resulting leadership themes provide guidance to practitioners on what to consider leading for digital servitization and which leadership skills are required for which aspect of digital servitization. Our contribution of pointing out the holistic view on leadership can support digital servitization leaders as guidance within the daily practice to avoid missing out or neglecting vital leadership themes due to insufficient knowledge or resource allocation. Furthermore, executives can apply our research findings to staff their leadership teams assigned for digital servitization diversly to balance out different leadership personalities with the requested skillset. Without either of our outlined perspectives, strategic business leadership and people leadership can significantly harm companies' advancements in digital servitization. On the one hand, a strategic decision-making process neglecting customer or market needs or lacking a comprehensive business understanding could steer companies in the wrong direction. On the other hand, missing out on the people's perspective and neglecting the importance of change management harms employee motivation and, thus, companies' performance within digital servitization.

As we based our findings on a holistic view on leadership for digital servitization (Table 3) based on qualitative interviews and inductive analysis of the responses, we acknowledge the limitations of this research approach. Despite the significance of 30 research participants, it simultaneously corresponds to the limitation of the research material. Nevertheless, the variation of job titles, hierarchical levels, and industries of our research participants offers a broad range of viewpoints. Our identified themes representing a holistic view on leadership are set up based on a well-proven scientific method through gathering qualitative interview statements and our approach structuring them through inductive coding. Nevertheless, we recognize additional research potential to solidify our findings further.

Firstly, we recommend testing and confirming our leadership themes through quantitative research. On the one hand, this method can be used to statistically confirm the initially created theme structure through an increased number of responses. Furthermore, a quantitative research method with the presented leadership aspects as a baseline can create a ranking or weighing of the identified sub-themes to provide further insights into the identified items' prioritization, importance, or impact. Another proposal for continuing research builds on a more long-term oriented case-study research design, where researchers accompany leaders applying the leadership skills for digital servitization in their practical business environment. While closely surveying the usefulness of our proposed themes and sub-themes, this research approach can give detailed insights into the applicability and effectiveness of our research results. Additionally, this could be compared to leaders and firms who follow our recommendations for a holistic view on leadership versus others who do not and pursue digital servitization activities without this guidance.

Our final further research recommendation links to the multitude and diversity of identified leadership themes for digital servitization. As leaders inherit different personality types or practice certain leadership styles, we propose further research to map digital servitization to the fit of specific personality types or leadership styles. This aspect can give more precise guidance for leadership on appointing to lead digital servitization within companies.

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Appendix

Appendix 1. Coding system and building of thematic map

1) Initial coding result

Initial code	**Coding origin**	**Action**
Conscious top management decision for digital servitization	Inductive and emergent	
No quarter-to-quarter	Degree of deduction and theory-driven due to interview question on goal-setting process. Derived from, e.g.: Tronvoll et al. (2020)	Summarized to „Evolving target setting within digital servitization journey"
Customer-oriented KPIs	Degree of deduction and theory-driven due to interview question on goal-setting process. Derived from, e.g.: Tronvoll et al. (2020)	
From quality to financial targets	Degree of deduction and theory-driven due to interview question on goal-setting process. Derived from, e.g.: Tronvoll et al. (2020)	
Positive financial contribution	Inductive and emergent	
Trial & Error		Summarized to risk-taking and risk management
Digital is rather cheap at the beginning		
Risk Management & Risk Calculation	Degree of deduction and theory-driven due to interview question on attitude towards risk. Derived from, e.g.: Kane et al. (2015)	
Cross-functional collaboration	Inductive and emergent	
Comprehensive business understanding	Inductive and emergent	
Agile methods	Inductive and emergent	
Have the right people	Inductive and emergent	Rephrased to „Team composition"
So fast or new you need external help	Degree of deduction and theory-driven due to interview question on ecosystems and partnerships. Derived from, e.g.: Gurumurthy & Schatsky (2019); Larjovuori et al. (2018)	Rephrased to „External collaboration"
Understand customer and market needs	Inductive and emergent	
Focus on value creation for customers	Inductive and emergent	
Vision creation for digital servitization	Inductive and emergent	
Creation of a sense of urgency and why the change is needed	Degree of deduction and theory-driven due to interview question on enabling change. Derived from, e.g.: Bustinza et al. (2018); Kane et al. (2019)	
Internal Change Management	Degree of deduction and theory-driven due to interview question on enabling change. Derived from, e.g.: Bustinza et al. (2018); Kane et al. (2019)	
Continuous & regular communication	Degree of deduction and theory-driven due to interview question on communication. Derived from, e.g.: Mumford et al. (2007); Yukl (1989)	Summarized to „Communication of the vision understandably and regularly"
Communicate understandably	Degree of deduction and theory-driven due to interview question on communication. Derived from, e.g.: Mumford et al. (2007); Yukl (1989)	
Not too technical communication	Degree of deduction and theory-driven due to interview question on communication. Derived from, e.g.: Mumford et al. (2007); Yukl (1989)	
Generational differences	Inductive and emergent	Summarized to „Awareness of employees' fears"
Employees fears	Inductive and emergent	
Job changes	Inductive and emergent	
Fast & flexible	Inductive and emergent	Summarized to „Speed & patience"
Patience / it takes time	Inductive and emergent	
Feedback	Inductive and emergent	Summarized to „Employee participation and feedback"
Participation & Involvement	Inductive and emergent	
Leader not as expert	Inductive and emergent	Summarized to „Enablement & empowerment"
Enablement & empowerment	Inductive and emergent	
Training and skill development	Degree of deduction and theory-driven due to interview question on communication. Derived from e.g.: Mumford et al. (2007); Yukl (1989)	

Digital channels	Degree of deduction and theory-driven due to interview question on communication. Derived from, e.g.: Mumford et al. (2007); Yukl (1989)	no further consideration due to: - Iinsufficient supporting data (Data security, convince customers, change from engineering mindset, change of traditional after market mindset, convince traditional business leaders, balance existing and new business, bring in external people) - mentioning of specific communication channels (Digital channels, face to face, trade shows) - no actionable item for leaders (Topic itself is motivating, trust)
Face to face	Degree of deduction and theory-driven due to interview question on communication. Derived from, e.g.: Mumford et al. (2007); Yukl (1989)	
Trade shows	Inductive and emergent	
Data security	Inductive and emergent	
Convince customers	Inductive and emergent	
Change from engineering mindset	Inductive and emergent	
Change of traditional after market mindset	Inductive and emergent	
Convince traditional business leaders	Inductive and emergent	
Balance existing and new business	Inductive and emergent	
Bring in external people	Inductive and emergent	
Topic itself is motivating	Degree of deduction and theory-driven due to interview question on communication. Derived from, e.g.: Mumford et al. (2007); Yukl (1989)	
Trust	Degree of deduction and theory-driven due to interview question on communication. Derived from, e.g.: Mumford et al. (2007); Yukl (1989)	
2) Building of sub-themes		
Sub-theme	**Initial code**	**Action**
Conscious top management decision for digital servitization	Conscious top management decision for digital servitization	Grouped into „Strategic business decisions"
Evolving target setting within digital servitization journey	No quarter-to-quarter	
	Customer-oriented KPIs	
	From quality to financial targets	
Positive financial contribution	Positive financial contribution	
Risk-taking and risk management	Trial & Error	
	Digital is rather cheap at the beginning	
	Risk Management & Risk Calculation	
Cross-functional collaboration	Cross-functional collaboration	Grouped into „Business building elements"
Comprehensive business understanding	Comprehensive business understanding	
Agile methods	Agile methods	
Team composition	Have the right people	
External collaboration	So fast or new you need external help	
Understand customer and market needs	Understand customer and market needs	Grouped into „Market and customer"
Focus on value creation for customers	Focus on value creation for customers	
Vision creation for digital servitization	Vision creation for digital servitization	Grouped into „Change management"
Creation of a sense of urgency and why the change is needed	Creation of a sense of urgency and why the change is needed	
Internal Change Management	Internal Change Management (Eliminated as summarized in theme „change management")	
Communication of the vision understandably and regularly	Continuous & regular communication	
	Communicate understandably	
	Not too technical communication	
Awareness of employees' fears	Generational differences	
	Employees' fears	
	Job changes	
Speed & patience	Fast & flexible	
	Patience / it takes time	
Employee participation and feedback	Feedback	Grouped into „Employee orientation"
	Participation & Involvement	
Enablement & empowerment	Leader not as expert	
	Enablement & empowerment	
Training and skill development	Training and skill development	

3) Summarizing to themes			
Themes	**Sub-theme**	**Initial Code**	**Action**

Strategic business decisions	Conscious top management decision for digital servitization	Conscious top management decision for digital servitization	Clustered into „Strategic business leadership"
	Evolving target setting within digital servitization journey	No quarter to quarter	
		Customer-oriented KPIs	
		From quality to financial targets	
	Positive financial contribution	Positive financial contribution	
	Risk-taking and risk management	Trial & Error	
		Digital is rather cheap at the beginning	
		Risk Management & Risk Calculation	
Business building elements	Cross-functional collaboration	Cross-functional collaboration	
	Comprehensive business understanding	Comprehensive business understanding	
	Agile methods	Agile methods	
	Team composition	Have the right people	
	External collaboration	So fast or new you need external help	
Market and customer	Understand customer and market needs	Understand customer and market needs	
	Focus on value creation for customers	Focus on value creation for customers	
Change management	Vision creation for digital servitization	Vision creation for digital servitization	Clustered into „People leadership"
	Creation of a sense of urgency and why the change is needed	Creation of a sense of urgency and why the change is needed	
	Communication of the vision understandably and regularly	Continuous & regular communication	
		Communicate understandably	
		Not too technical communication	
	Awareness of employees' fears	Generational differences	
		Employees' fears	
		Job changes	
	Speed & patience	Fast & flexible	
		Patience / it takes time	
Employee orientation	Employee participation and feedback	Feedback	
		Participation & Involvement	
	Enablement & empowerment	Leader not as expert	
		Enablement & empowerment	
	Training and skill development	Training and skill development	
4) Building of perspectives → Thematic Map			
Perspective	**Theme**	**Sub-theme**	**Initial code**
Strategic business leadership	Strategic business decisions	Conscious top management decision for digital servitization	Conscious top management decision for digital servitization
		Evolving target setting within digital servitization journey	No quarter-to-quarter
			Customer-oriented KPIs
			From quality to financial targets
		Positive financial contribution	Positive financial contribution
		Risk-taking and risk management	Trial & Error
			Digital is rather cheap at the beginning
			Risk Management & Risk Calculation
	Business building elements	Cross-functional collaboration	Cross-functional collaboration
		Comprehensive business understanding	Comprehensive business understanding
		Agile methods	Agile methods
		Team composition	Have the right people
		External collaboration	So fast or new you need external help
	Market and customer	Understand customer and market needs	Understand customer and market needs
		Focus on value creation for customers	Focus on value creation for customers

People leadership	Change management	Vision creation for digital servitization	Vision creation for digital servitization
		Creation of a sense of urgency and why the change is needed	Creation of a sense of urgency and why the change is needed
		Communication of the vision understandably and regularly	Continuous & regular communication
			Communicate understandably
			Not too technical communication
		Awareness of employees' fears	Generational differences
			Employees' fears
			Job changes
		Speed & patience	Fast & flexible
			Patience / it takes time
	Employee orientation	Employee participation and feedback	Feedback
			Participation & Involvement
		Enablement & empowerment	Leader not as expert
			Enablement & empowerment
		Training and skill development	Training and skill development

Appendix 2. Interview guide and interview questions

Research on Digital Servitization and Leadership

Interview on digital servitization and leadership

- Thank you very much for taking the time for this interview.
- Your expertise and experience are highly appreciated for gaining valuable research insights.
- Within the research, we are elaborating on the required leadership skills for digital servitization
- The research is conducted by me, xxx xxx, and supervised through xxx xxx (University of xxx)
- The interview is targeted for 45 to 60 minutes.
- Your contributions will be treated anonymously, and your responses will not be linked to your name or company/association in publications.
- To be able to concentrate during the interview as well as simplify the analysis, I would like to record this interview. Please confirm if this is ok for you.

- Before starting the recording – are there any questions from your side?

Interview section	Subsection	Questions / Probing / Detailing
Introduction		**Name** **Age** **Company size (# of employees)** **Industry** **Product portfolio** **Position**

Research on Digital Servitization and Leadership 1

Research on Digital Servitization and Leadership

Digital Servitization & Leadership	**Digital Servitization introduction**	*Digital servitization is a sub-stream of digitalization to provide digitally enabled services for manufacturing companies.* *Definition: Generating additional value for the installed base of existing customers by providing product and service bundles enabled by digital technologies through newly created or revised business models* *Examples could be maintenance offerings based on real-time engine monitoring (Rolls Royce) or remote monitoring offerings for the installed base (GE)* **What is your understanding of digital servitization? Do you have a similar/different view on digital servitization or anything to add?**
	Digital Servitization and Leadership	**How would you describe the term "leadership" in the context of digital servitization?** **Which attributes/traits/competencies are required for leaders in digital servitization?** o What are the relevant attributes for leaders to enable change towards digital servitization? o How would you characterize leaders' attitudes towards risk for digital servitization? *(Rather risk tolerant or risk averse?)* o How can the goal-setting process for digital servitization look like? *(Vision, strategy, operationalization, targets)* o What role does the work in ecosystems and partnerships play in digital servitization? (Customers, competitors, suppliers, start-ups, universities) o How should a leader communicate for digital servitization? (internally/externally)*
Closing	**Additional comments**	**Are there any further comments or personal experiences you would like to share with regards to digital servitization and leadership?**
	Thank you	*Thank you very much for your responses and valuable insights.* *Please read the consent form and send back a signed copy.* *Once the results are available, I will be more than happy to share them with you*

Research on Digital Servitization and Leadership *additional questions not analyzed / relevant for this study 2

Appendix 3. Interviews and research participants

Interview	Industry	Company level	Identification	Leadership experience
Interview #1	Professional Services	Executive	Digital Transformation	>20 years
Interview #2	Machinery	Vice President	Digitalization	0-5 years
Interview #3	Machinery	Manager	Digital Services	0-5 years
Interview #4	Machinery	Head of	Digital Services	10-20 years
Interview #5	Machinery	Manager	Servitization	>20 years
Interview #6	Machinery	Director	Digitalization	10-20 years
Interview #7	Machinery	Director	Digital Services	>20 years
Interview #8	Automobiiles & Components	Executive	Digitalization	10-20 years
Interview #9	Chemicals	Manager	Digitalization	6-10 years
Interview #10	Machinery	Director	Servitization	6-10 years
Interview #11	Machinery	Executive	Digitalization	10-20 years
Interview #12	Machinery	Head of	Digitalization	6-10 years
Interview #13	Machinery	Manager	Digitalization	10-20 years
Interview #14	Professional Services	Executive	Digital Services	>20 years
Interview #15	Chemicals	Head of	Digital Transformation	6-10 years
Interview #16	Professional Services	Executive	Digital Services	>20 years
Interview #17	Electrical Equipment	Head of	Digital Services	6-10 years
Interview #18	Professional Services	Executive	Digital Transformation	>20 years
Interview #19	Electrical Equipment	Director	Digitalization	0-5 years
Interview #20	IT Services	Director	Servitization	>20 years
Interview #21	Electrical Equipment	Vice President	Servitization	10-20 years
Interview #22	IT Services	Vice President	Digital Transformation	10-20 years
Interview #23	Machinery	Head of	Digital Services	10-20 years
Interview #24	Professional Services	Manager	Servitization	10-20 years
Interview #25	IT Services	Manager	Digital Services	0-5 years
Interview #26	Machinery	Director	Servitization	0-5 years
Interview #27	Machinery	Head of	Digitalization	0-5 years
Interview #28	Machinery	Vice President	Servitization	>20 years
Interview #29	IT Services	Head of	Digital Transformation	6-10 years
Interview #30	Machinery	Vice President	Digital Services	10-20 years

Biographical notes

Florian Tagscherer is a PhD Student at the University of Bamberg. He holds a Master's Degree in International Management (M.Sc.) from the School of International Business and Entrepreneurship (Steinbeis University). His research interests focus on the intersection of emerging digital technologies and their implication on leadership and organizations.

Claus-Christian Carbon is Full Professor and the Head of Department of General Psychology and Methodology at the University of Bamberg. He studied Psychology (Dipl.-Psych.), followed by Philosophy (M.A.), both at the University of Trier, Germany, and received his PhD from the Freie Universität Berlin and his "Habilitation" (venia docendi) at the University of Vienna, Austria. Currently, he leads the "Forschungsgruppe EPAEG" – an international research group devoted to enhancing the knowledge, methodology, and enthusiasm in the fields of cognitive ergonomics, psychological aesthetics, and Gestalt. Furthermore, his research interests include design, aesthetics, product innovation, innovation leadership, and processing of visual arts. Since 2023, he has been an ordinary member of the European Academy of Sciences and Arts.

Authorship contribution statement

Florian Tagscherer: Conceptualization, Sampling, Data Collection, Methodology, Formal Analysis, Project Administration, Visualization, Writing – Original Draft. **Claus-Christian Carbon**: Conceptualization, Sampling, Methodology, Formal Analysis, Project Administration, Visualization, Writing, Supervision, Review & Editing.

Conflicts of interest

The authors declare no conflict of interest.

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