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The role of strategic orientations for digital innovation: When entrepreneurship meets sustainability

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ABSTRACT

Today, firms increasingly need to strategically manage their digital innovation while aligning it with their strategic behaviors (i.e., entrepreneurial and sustainability orientations). Given the lack of previous research on alignment and digital innovation, our study explores and tests how a firm's sustainability and entrepreneurial orientations influence digital innovation. Given that firms can implement diverse digital technologies, we study how digital technologies applied in the firm moderate the orientations' effects on digital innovation. Following strategic alignment theory, we build a model that assumes positive and negative alignment effects. We test our model using primary and secondary data including 350 cases from manufacturing firms. Our findings reveal that a sustainability orientation improves digital innovation. Yet, its positive effect declines when the firm has a greater entrepreneurial orientation. Surprisingly, the positive effect of a sustainability orientation declines as well when the firm implements a greater set of digital technologies. Consequently, our study contributes counterintuitive insights towards understanding that 'the more is not necessarily the better'.

1. Introduction

Firms' digital transformation, digital ecosystems, and the increasing application of digital technologies (Bouncken and Qiu, 2021; Kraus et al., 2022; Leso et al., 2024) have instigated a substantial body of scholarly work on digital innovation (Firk et al., 2022; Felicetti et al., 2024). Digital innovation encompasses the conception and realization of novel market offerings, operational workflows, or paradigms stemming from the seamless integration of digital technology (Cheng et al., 2023; Nambisan et al., 2017; Deist et al., 2023). For example, General Electric's "Brilliant Factory" epitomizes digital innovation, seamlessly integrating cutting-edge sensors, data analytics, and IoT to revolutionize conventional factories into interconnected, efficient hubs. It orchestrates optimal production lines, foresees maintenance needs, reduces downtime, and enhances efficiency by enchanting real-time data. It nurtures a symphony of machine-to-machine and human-machine engagements (Nylund and Brem, 2023).

Digital innovation begets a multitude of advantages, including improved operational efficiency, enhanced customer experiences, and substantial cost efficiencies (Pesch et al., 2021). Nevertheless, the strong investments and changes in digital innovation demand strategic alignment with the firm's contexts, such as its strategic orientations. Researchers have been interested in explaining firm performance and innovation by strategic orientations for decades. Strategic orientations mark the "strategic directions implemented by a firm to create the proper behaviors for the continuous superior performance of the business" (Gatignon and Xuereb, 1997, p. 78). However, it is unclear if and which of the strategic orientations guide digital innovation. Likewise, previous strategic alignment research has put forward that firm performance hinges on how well different strategic orientations are aligned ("fit") with each other and the firm's digital technology context (Cragg et al., 2002; Venkatraman, 1989; Venkatraman et al., 1993). Alignment can refer to several dimensions; for example, studies have examined how digital technology fits a firm's strategies and strategic orientations (Oh and Pinsonneault, 2007).

A vast body of research has shown that innovation hinges on the entrepreneurial orientation (EO), which has been considered as one of the first and influential strategic orientations (McKenny et al., 2018b; Covin and Slevin, 1989). It is shaped by the subdimensions of innovativeness, proactiveness, and risk-taking. It accounts for how well the

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firm (its managers, employees etc.) can create future products and services and anticipates future market needs (e.g., Wales, 2016). Previous research has shown that ongoing digitalization strengthened the need for and the merits of an EO (Arzubiaga et al., 2018). Similarly, digital technology has to be aligned with proactive (Lu and Ramamurthy, 2010), risk-taking (Xue et al., 2017), and entrepreneurial posture (Guo et al., 2020; Swanson and Ramiller, 2004).

In addition, firms face the need to strategically embrace sustainability that serves as a reference point for the new solutions to today's challenges (Kuckertz and Wagner, 2010). Sustainability refers to a firm's attempt to respond to environmental, social and economic aspects of its strategy (Vaupel et al., 2022). Thus, with a sustainability orientation (SO), the firm strategically plans to achieve performance related to environmental stewardship and responsible processes (Jagani and Hong, 2022). In a nutshell, there is a substantial deficit, and there is a need to understand how EO and SO influence digital innovation and how they fit each other and the digital technology sets of a firm.

Following strategic alignment theory, our study develops a conceptual model of digital innovation influenced by EO, SO, and the firm's set of digital technologies. From a discussion of positive and negative effects, we develop hypotheses of positive and negative (mis)aligned effects of the two strategic orientations and the digital technology set on digital innovation.

Our model was tested by data of 350 cases from manufacturing firms. We measured firm's strategic orientations by applying established dictionaries of computer-aided textual analysis (CATA) on the firms' narratives, such as company reports and homepages (McKenny et al., 2012a; McKenny et al., 2012b; McKenny et al., 2018a). In addition, we collected information about firm's digital technologies from diverse sources like newspapers, magazine articles, and social media outlets, serving as valuable indicators (Batrinca and Treleaven, 2014). Each source provides unique perspectives and granular details about the digital technology adoption in the firm, such as 3-D printing, artificial intelligence/machine learning, robotics, cloud computing, social media, big data analytics, robots, cyber security, smart factory/Industry 4.0. We measured digital innovation by a survey study using an established digital innovation measure (Pesch et al., 2021). Our hierarchical regression-based estimations reveal positive direct effects of the SO and digital technology sets surprisingly, the EO has no significant direct effect and even a negative indirect one reducing the positive effect of SO. Our findings show ambivalent effects of digital technology. Greater sets can reduce the positive effects of a SO on innovation.

Our study provides novel insights about digital innovation that inform strategic alignment (Cragg et al., 2002; Venkatraman, 1989; Venkatraman et al., 1993) and strategic orientation research (McKenny et al., 2018b; Covin and Slevin, 1989; Kuckertz and Wagner, 2010). By integrating digital innovation as a new and vital performance variable, we convey counterintuitive negative effects on digital innovation from the (mis-)alignment of EO and SO and digital technologies. The strategic alignment lens of our study contributes insights into dangers from (mis-) alignment. Furthermore, it enriches strategic orientation research by releasing counterintuitive negative effects of greater levels of EO on the more novel measure of digital innovation (Firk et al., 2022). Previous EO research has mainly been positive about the influence of EO on diverse performance measures, even in sustainability contexts (Khan et al., 2023).

2. Theory

2.1. Theoretical framework

Strategic alignment theory assumes the importance of fit among a firm's strategic parameters and contextual factors on firm performance (Venkatraman, 1989; Venkatraman et al., 1993; Cragg et al., 2002). Alignment relates to firms' internal and external environmental factors (Venkatraman, 1989; Venkatraman et al., 1993). It covers different outcome variables, such as financial performance, productivity, and customer benefit (Gerow et al., 2014). Besides alignment's direct effects (Kearns and Sabherwal, 2006), studies have examined its indirect effects, such as creating spillover effects in downstream supply chain processes (Tallon, 2011) or returns from IT investments (Cheng et al., 2021). Some studies have integrated third variables such as mediating, moderating, or covarying variables, configurations, and the degree to which profiles align (Venkatraman, 1989; Venkatraman et al., 1993). Recently, research has emphasized that digital technology shapes core aspects of strategic alignment (Winkler and Wulf, 2019).

Digital technology specifies different hard- and software information technologies based on digital processing, such as smart manufacturing systems, 3D printing, and artificial intelligence (Nambisan, 2017). Strategic alignment studies investigated how digital technology relates to improvements in cost, process-time, business models, and digital innovation but also reveal that intended outcomes are not always achieved (recently: Chatterjee et al., 2021; Dong et al., 2021; Guo et al., 2023; Steelman et al., 2019 and meta-study: Lim et al., 2011). Digital technology may provide organizations with tools, platforms, and capabilities to effectively leverage their SO and EOs towards digital innovation (Bouncken and Qiu, 2021; Schröder et al., 2021; Cho et al., 2023; Zhu et al., 2006). It enhances the speed and ease of communication across time and space (Schröder et al., 2021), allowing organizations to share information about innovative digital solutions and their sustainability or entrepreneurial benefits (Cho et al., 2023). Digital technology also expands a firm's networks of potential adopters, facilitating more efficient and widespread dissemination of sustainable and entrepreneurial digital innovations (Jin et al., 2022). Digital technology also offers new avenues for entrepreneurial behavior, such as digital entrepreneurship, agile decision-making, and the development of innovative digital products, services, and processes (Modgil et al., 2022). To create novel outputs, they can combine hardware, software, data, and networks (Hukal and Henfridsson, 2017). Digital technology may accelerate sustainable and entrepreneurial digital innovation adoption and diffusion. Yet, there only scant research on digital innovation as an outcome variable.

Digital innovation incorporates digital technology into an inherently unbounded, value-adding novelty (e.g., product, service, process, or business model) (Hund et al., 2021). Digital innovation refers to implementing modern digital technologies and features that significantly enhance customer experiences and introduce new benefits or novel business models to the market in a radical and transformative manner (e.g., Hund et al., 2021; Nambisan et al., 2020; Schneckenberg et al., 2021). Digital innovation entails firms' strategic choice to implement digitally enhanced value-adding activities, overhaul their business models, and introduce novel product or service offerings (Hensen and Dong, 2020; Kohli and Melville, 2019). Digital innovation allows performance advantages, for example, operational efficiency, enhanced customer experiences, and cost reductions and growth (Ciarli et al., 2021; Pesch et al., 2021). Digital innovation has not been considered by strategic alignment research, which has shown considerable interest in examining firms' strategic orientations and their alignment with various variables.

Strategic orientations refer to the strategic directions a firm adopts to foster behaviors conducive to sustained superior business performance (Gatignon and Xuereb, 1997, p. 78). Previous studies have underscored the significance of EO, which comprises subdimensions such as innovativeness, proactiveness, and risk-taking (McKenny et al., 2018a; Covin and Slevin, 1989). Innovativeness reflects the degree to which a firm encourages and implements novel ideas, products, or processes to maintain competitiveness. Proactiveness pertains to a firm's ability to anticipate and seize opportunities ahead of competitors, while risk-taking involves the willingness to embark on ventures with uncertain outcomes in pursuit of potential rewards. Moreover, some theorists put forward two more aspects to the EO concept: autonomy and competitive adventurousness, which underline the significance of personal

autonomy and level of drive in competitive actions (McKenny et al., 2018a). EO evolves with a deeper understanding of entrepreneurial behavior. Autonomy and competitive aggressiveness may foster innovation and proactive engagement in the marketplace. They can broaden EO, incorporating tactics that enhance organizational performance and competitiveness (McKenny et al., 2018a).

Previous research has focused on the relationship between EO and performance (Gupta et al., 2019), growth (Wiklund and Shepherd, 2005), strategic context (Ritala et al., 2021), innovation (Covin and Slevin, 1989) and recently provided insights about a green EO (Khan et al., 2023). EO facilitates innovation by explaining how well the firm (its managers, employees, etc.) can create novel products and services for future market needs (e.g., Wales, 2016). It also influences the use of digital technologies (Arzubiaga et al., 2018) that call for proactive (Lu and Ramamurthy, 2010), risk-taking (Xue et al., 2017), and entrepreneurial behaviors (Guo et al., 2020; Swanson and Ramiller, 2004). EO can inspire innovations to become more 'green' (Khan et al., 2023).

In addition, research has shown the need to strategically embrace sustainability to create solutions to today's challenges (Kuckertz and Wagner, 2010). Sustainability is that firms make efforts to address environmental and social concerns (Vaupel et al., 2022). The SO includes social and business targets, environmental stewardship, and responsible processes (Jagani and Hong, 2022), defined by its three components: the environmental, social, and financial value orientation (Vaupel et al., 2022). The firms' social value orientation refers to their efforts to create social value. The environmental value orientation refers to firms' efforts to create environmental value and focus on environmental issues. The financial value orientation of a firm refers to its focus on maximizing shareholder returns and maintaining an attractive value proposition. As opposed to this, social and environmental value orientations describe a firm's focus on creating both social and environmental value.

The sustainable innovation framework emphasizes the importance of a SO. It is a structured approach that combines sustainability and entrepreneurial factors into the innovation process to compare environmental, social, and economic effects (e.g., Caputo et al., 2019; Schaltegger and Wagner, 2011). Green frameworks contribute to reducing the environmental impact of information technology (IT), with the attention paid to energy efficiency and waste management (e.g., Anthony Jnr, 2020). The circular economy framework suggests the strategy of resource regeneration and closing loops (Liu et al., 2022), and social innovation theory seeks to use digital technologies for the benefit of society (Howaldt et al., 2015).

In essence, the strategic alignment theory informs our conceptual model on how strategic orientations (i.e., the EO and the SO) influence digital innovation. It also frames our study of alignment influences of the EO and the SO with digital technologies on digital innovation.

2.2. Hypotheses

2.2.1. EO and digital innovation

Numerous prior studies have showcased the impact of on innovation (e.g., Wales, 2016). Recently, studies added that digital transformation demands incorporating digital technologies for exploring new business models and obtaining digital opportunities (Kraus et al., 2023; Kraus et al., 2019). EO promotes innovation, experimentation, and adaptability culture in firms; these firms are the early adopters and promoters of digital innovation diffusion (Testa et al., 2022). For example, Amazon, Google, Apple, and others represent firms with strong EO. They carry out constant experimentation, bold strategic moves, and 100 % dedication to customer value in a dynamic digital landscape, with new industries driven by innovative digital solutions.

As stated by Lumpkin and Dess (1996), *innovativeness* means that a firm is ready to introduce and practice innovation processes. EO stimulates risk-taking and resources for novel digital solutions and innovation (Benazzouz, 2019). *Proactiveness* predicts a firm's ability to take action independently of other companies and market trends (Hughes and Morgan, 2007). Proactive firms are more likely to be at the forefront of digital innovation (Jansen et al., 2006). Proactive companies use knowledge from other companies or scientists to drive digital innovation. *Taking risk*, a fundamental element of EO, involves investing significant resources despite the failure chance (Miller, 1983). EO has become increasingly critical in the digital era (Kraus et al., 2023). Therefore, we hypothesize:

Hypothesis 1. (*(H1)*) There is a positive relationship between EO and digital innovation.

2.2.2. SO and digital innovation

SO embodies an organization's commitment to sustainability across economic, environmental, and social dimensions (Beske et al., 2012; Jagani and Hong, 2022). The economic aspect of SO pertains to a firm's pursuit of desirable performance metrics such as revenue growth, cost management, and investment returns (Kuckertz and Wagner, 2010). As described by Kang and James (2006), social orientation concerns the firm's efforts towards achieving socially responsible outcomes and enhancing employee well-being. Meanwhile, environmental orientation reflects the proactive planning of a firm to attain desirable environmental performance (Elsayed, 2006; Menguc and Ozanne, 2005).

Organizations demonstrating a robust SO tend to embrace environment-friendly technologies and practices, incorporating sustainability considerations into their digital strategies (Kraus et al., 2020; Tsoutsos and Stamboulis, 2005; Trischler et al., 2020). Such firms are pivotal in driving sustainable digital innovation, acting as early adopters and catalysts for broader adoption within their industry or social system (Attié and Meyer-Waarden, 2022; Fichter and Clausen, 2016). An emphasis on sustainability may encourage digital innovation, with environmental orientation positively influencing product and process innovation performance (Ardito et al., 2021; Khan et al., 2023).

Moreover, SO stimulates digital innovation by promoting resource efficiency and waste reduction, aligning with advancements in data analytics and automation (Cheng, 2020; Vaupel et al., 2022). Firms investing in sustainability often develop environment-friendly technologies, integrating digital solutions for improved performance and transparency in response to stakeholder pressures (George et al., 2021). Collaborative innovation ecosystems, facilitated by digital platforms, foster strategic solutions through open innovation and knowledge sharing among stakeholders (Sivarajah et al., 2020; Thomas and Tee, 2021).

A firm that aligns with economic, social, and environmental values significantly enhances digital innovation by linking to and engaging stakeholders (Denicolai et al., 2021). Firms with this alignment are better at identifying market opportunities (Cheng, 2020), fostering creativity and diversity (Testa et al., 2022), mitigating risks (Amankwah-Amoah and Syllias, 2019), improving brand differentiation (Galpin et al., 2015), facilitating collaboration and partnerships (Hansen and Große-Dunker, 2013), increasing employee engagement and retention (Isensee et al., 2020), and promoting long-term sustainable growth (Trischler et al., 2020).

Therefore, we posit:

Hypothesis 2. (*(H2)*) There is a positive relationship between SO and digital innovation.

2.2.3. (Mis) alignment of EO and SO

Sustainability-oriented behaviors within an organization have the potential to inspire experimentation, risk-taking, and resource allocation towards digital solutions (Butticè et al., 2019; Si et al., 2023). Consequently, EO and SO might have complementary alignment effects. While both EO and SO individually contribute positively to the innovation landscape, their convergence may not always lead to synergistic outcomes.

When a firm with a strong EO encounters sustainability-driven

initiatives, potential conflicts may arise between the rapid pursuit of market opportunities and the integration of sustainable practices (Pesch et al., 2021). Prioritizing rapid innovation and immediate returns could lead to compromises in sustainable protocols, restricting or altering innovation aligned with sustainability goals to align with the organization's expansion strategies (Shevchenko et al., 2016). The competitive dynamics inherent in EO, focused on speed and agility, may introduce discord that impedes the seamless integration of SO into the broader innovation framework (Denicolai et al., 2021). Thus, the negative alignment influence of EO on SO suggests that the beneficial impact of SO on digital innovation may face obstacles or limitations within an entrepreneurial-driven context.

Different values and priorities cover the SO and EO (George et al., 2021; Kock and Gemünden, 2020). SO, characterized by long-term goals for the environment and society, and EO, which is more concerned with short-term profit and access to markets, develop differently (Covin and Wales, 2019; Jagani and Hong, 2022). The balance between not compromising one's principles to sustainability and fast-growing entrepreneurial priorities could become a hurdle in initiating sustainable digitization innovations.

EO and SO may not be compatible with digital innovation in firms where the reward and remuneration system is geared towards business targets rather than green innovation initiatives. Financial and budgetary restrictions on sustainable innovation projects may cause divergence in firms with a profit target (Butticè et al., 2019). Moreover, if the business prioritizes its financial goals over the higher priorities, it may negatively affect digital innovation (Bouguerra et al., 2022). The organization's values, priorities may thus regulate the synergy of EO and SO on digital innovation, and the level of harmony or discord existing between the two orientations. Therefore, we posit the following hypothesis:

Hypothesis 3. (*(H3)*) An EO and an SO have negative alignment effects on digital innovation.

2.2.4. Alignment and digital technologies

Digital technologies have created entrepreneurship with new chances for growth and transformation (Qiu et al., 2023; Kraus et al., 2019). Although the influx of entrepreneurial opportunities can provide benefits, at the same time, leaders and entrepreneurs should be aware of the challenges that may arise, therefore, the full potential of the EO might not materialize. These issues include cyber dangers, privacy risks, increased competition, and the fact that attention would be shifted from the main principles of EO and, as a consequence, its effectiveness would prevail (Alahmari and Duncan, 2020; Baruh et al., 2017; Teece, 2018). Technology prospects are a crucial aspect of digital innovation, even as overusing technology sometimes has the effect of making objectives grant entrepreneurship a back seat, showing that this can only work if there is a good mix of digital tools and innovation. The balancing act between nurturing the short-term profitability and the long-term sustainability of business in the face of fast-paced technological evolution can be a huge problem for firms (Kraus et al., 2022; Hund et al., 2021; Shen et al., 2021; Neus et al., 2017).

Given the arguments above, it would seem that digital technologies can be the source of both breakthroughs and setbacks in how EO supports innovation. Digital technology can also create obstacles and complications that hinder EO's positive impact (Fitzgerald et al., 2014; Nylund and Brem, 2023). Digital technology, in addition to hindering entrepreneurship, also generates financial challenges (Ardito et al., 2021; Cho et al., 2023). While significant challenges exist when it comes to the application of new technology, the strategic and balanced use of digital technology can provide tools and direction needed for new paths for innovation and progress (Wang et al., 2023). Thus, we propose the following hypothesis:

Hypothesis 4. (*(H4)*) Digital technologies are negatively aligned with the positive effect of EO on digital innovation.

Similarly, the relationship between SO and digital innovation may be negatively influenced when firms invest in large sets of digital technologies. SO insists on prudent resource management, environmental consciousness, and ethical decisions in innovation (Rubio-Andrés and Abril, 2023). This opposes a broad set of investments and uses of digital technologies (Khin and Ho, 2019; Nambisan, 2017). Furthermore, large sets of digital technology put the immediate profit ahead of the enduring sustainable strategies (Yoo et al., 2012). Research, also, has identified a negative association between digital and environmental orientations and process innovation performance (Ardito et al., 2021). Digital technologies oppose sustainability targets (Yousaf et al., 2021). For instance, digital technologies, which facilitate data-based decision-making and process optimization, demand big investments in infrastructure, education, and cybersecurity, which might mean diverting these funds from sustainability projects (Niehoff, 2022). Moreover, investments in digital technology tools may weaken dedication to environmental or societal programs (Fitzgerald et al., 2014; Trinugroho et al., 2022).

The inclusion of digital technologies in manufacturing goods usually translates to increased energy consumption and carbon emissions, offsetting the environmental gains of process efficiencies (Herring and Roy, 2007). Similarly, digital platforms can have negative socio-economic consequences on privacy and mental health, impeding sustainable digital innovation despite favorable consequences such as telecommuting or remote work (Amankwah-Amoah et al., 2021). Through such examples, we can see how digital technology hinders sustainability-focused digital innovation's growth and progress. Thus, we posit that:

Hypothesis 5. (*(H5)*) There is a negative alignment effect of digital technologies with the positive effect of SO on digital innovation.

Fig. 1 presents a complete theoretical model along with accompanying hypotheses:

3. Methodology

3.1. Sample

The survey-based data was collected (addressing the digitalization variables) from companies that attended the Hannover Fair 2022 in Germany, one of the largest industrial trade fairs in the world, which attracts >2500 exhibitors. It covered many important topics under one roof, including the critical themes of digitalization and sustainability in 2022. Those companies are generally from multiple industries worldwide. A paper-to-pencil-based survey was conducted by trained scientific personnel by interviewing firm representatives at their exhibition booths. The questionnaire's respondents were top-level executives or middle managers responsible for strategic functions. Of the 1296 contacted companies at the Fair, an unadjusted raw response rate of 37 % ($N = 481$) was obtained. After excluding invalid cases, our final sample involved 350 cases (adjusted response rate: 27 %; 13.7 % of the total population of the Fair 2022). Many questionnaire cases are from small firms according to their LinkedIn profiles, such as LabShare LTD with 2–10 employees, innoSEP GmbH with 11–50 employees, Dörr Kampen B.V. with 11–50 employees, and pironex GmbH with 11–50 employees, etc. The small firms tend to be less globally oriented and mainly serve the local markets. Overall, our sample includes a broad range of small-, medium-, and big-sized companies. Demographic information is shown in Table 1.

3.2. Measures

3.2.1. Strategic orientations

Researchers have used questionnaires to measure SO (Adomako et al., 2019; Ardito et al., 2021), EO (Bouncken et al., 2024; Ritala et al., 2021), and technologies (Chu et al., 2020). We applied a dictionary-based computer-aided text analysis (CATA) to measure the SO (Vaupel et al., 2022) and EO (McKenny et al., 2018a) constructs based on the

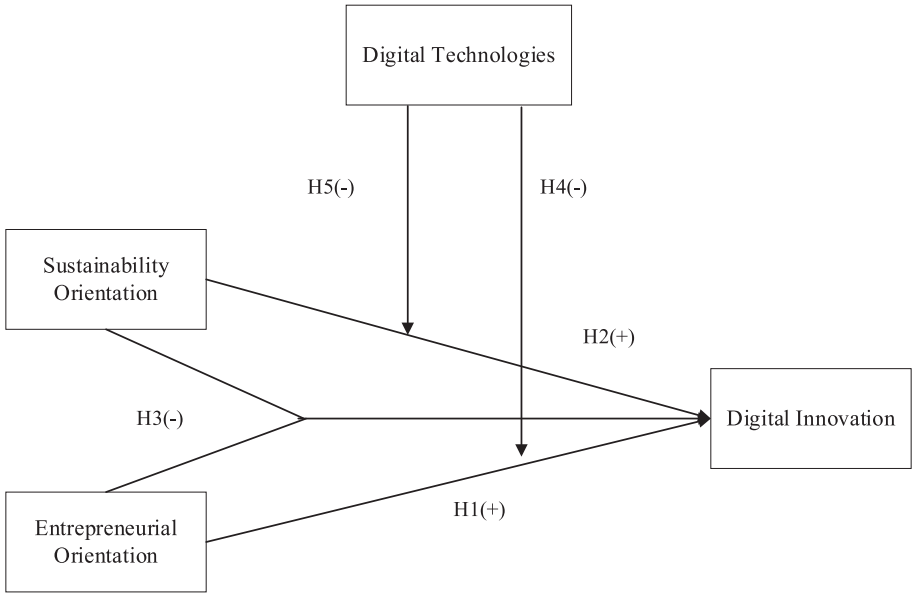

Fig. 1. Conceptual model.

Table 1
Sample demographics.

Sample (N = 350)	Mean	SD
Digital innovation	−0.001	0.965
Sustainability orientation ratio	6.131	11.176
Entrepreneurial orientation ratio	8.198	25.814
Digital technologies	2.225	1.492
Firm type	0.550	0.499
Firm age	50.252	44.361

firms' narratives on their websites. The narratives of those companies correspond to the questionnaire cases. In other words, we gathered data from the websites of each company from which we collected surveys. The CATA approach allows the measurement of a specific construct by counting the frequency of keywords representing it (McKenny et al., 2018a). CATA measures are claimed to have near-perfect reliability because they eliminate human errors (Short et al., 2009b) (Table 2).

Table 2
Variables and corresponding data sources and measures.

Variable	Data source	Measure
Firm age	Questionnaire	Numeric variable
Firm type	Questionnaire	Dummy variable: Family firm ("Yes" = 1, "No" = 0)
Sustainability orientation	Companies narratives	Dictionary-based CATA
Entrepreneurial orientation	Companies narratives	Dictionary-based CATA
Digital technologies	Companies narratives	Sum of dummy variables: 3-D printing ("Yes" = 1, "No" = 0) Artificial intelligence/machine learning ("Yes" = 1, "No" = 0) Robotics ("Yes" = 1, "No" = 0) Cloud computing ("Yes" = 1, "No" = 0) Social media ("Yes" = 1, "No" = 0) Big data analytics ("Yes" = 1, "No" = 0) Robots ("Yes" = 1, "No" = 0) Cyber security ("Yes" = 1, "No" = 0) Smart factory/Industry 4.0 ("Yes" = 1, "No" = 0)
Digital innovation	Questionnaire	5-point Likert scale

We conducted a dictionary-based computer-aided text analysis (CATA). Since its introduction by Short et al. (2009a), CATA has been widely used to evaluate how text documents convey specific themes (e.g., Vaupel et al., 2022; Meek and Cowden, 2023; Täuscher et al., 2021). The use of CATA allows for the processing of large amounts of data. Overall, using a pre-developed dictionary with several wordlists, the CATA method measures a specific topic. Specifically, we first conducted CATA based on pre-developed dictionaries. Vaupel et al. (2022) developed the CATA dictionary for measuring SO. The SO dictionary includes three wordlists: Environmental, Social, and Addition. Besides, the CATA dictionary for measuring EO is validated by McKenny et al. (2018a), and it contains six wordlists: Autonomy, Competitive Aggressiveness, Innovativeness, Proactiveness, Risk Taking, and Inductive. We accessed the two dictionaries from the website of "CAT Scanner" (McKenny et al., 2012a). Secondly, with the "CAT scanner" software (McKenny et al., 2012a), we removed special characters from the company narratives and calculated the frequency of keywords in SO and EO. Thirdly, we calculated each company's keywords frequency and narrative length ratio. The scale was adjusted per 1000 words and then standardized (Kindermann et al., 2021).

Digital technologies: refer to the underlying digital tools, systems, and capabilities that enable digital innovation (Bogers et al., 2021). We collected information about how firms implement digital technologies from different sources, specifically newspapers, magazine articles, and social media, providing hints about the different technologies companies are implementing (Batrinca and Treleaven, 2014). We used the set of dummy variables to measure whether the company uses digital technologies in their digital transformation process. In specific, the value of digital technologies is summed by the following nine dummy variables: 3-D printing ("Yes" = 1, "No" = 0), artificial intelligence/machine learning ("Yes" = 1, "No" = 0), robotics ("Yes" = 1, "No" = 0), cloud computing ("Yes" = 1, "No" = 0), social media ("Yes" = 1, "No" = 0), big data analytics ("Yes" = 1, "No" = 0), robots ("Yes" = 1, "No" = 0), cyber security ("Yes" = 1, "No" = 0), smart factory/Industry 4.0 ("Yes" = 1, "No" = 0).

One dummy variable represents one type of digital technology, and a set of dummy variables can be aggregated into a new variable by adding all the dummy variables together. Regardless of the specific type of technology, the new variable can capture the effect of using more or less digital technologies on digital innovation. For example, if the new variable is 3, the firm uses three digital technologies. This coefficient

represents the marginal effect of incorporating one more digital technology while holding other factors constant on digital innovation. One example is that Trinugroho et al. (2022) create a new variable that is the sum of all the dummy variables for digital technologies and find that greater use of digital technologies increases sales per employee positively.

One advantage of an aggregated measure of digital technologies is that they can capture the overall effect of using more or less of them on the outcome variable, regardless of the specific type of technology. Furthermore, multiple dummy variables for different technologies can be estimated simultaneously to avoid potential multicollinearity issues. For instance, the study by Cragg et al. (2002) shows that sophisticated IT significantly impacts firm performance more than simple IT focused on administration.

Digital Innovation: refers to implementing and exploiting new digital technologies, platforms, and strategies to create innovative products, services, and business models that solve existing problems and improve organizational performance (e.g., Hund et al., 2021). Based on the established scales of Lee and Colarelli O'Connor (2003) and Garcia and Calantone (2002), four 5-point Likert-type items are used to measure digital innovation. The digital aspect of innovation extends each item. It involves combining information, computing, communication, and connectivity technologies to create new digital products, improve production processes, and transform business models, among other things (Fichman et al., 2014; Nambisan, 2017).

3.3. Analysis

We conduct confirmatory factor analysis (CFA) with maximum likelihood estimation to determine whether our measured variables can be distinguished (Anderson and Gerbing, 1988). The confirmation factor analysis (CFA) using the maximum likelihood method is highly fit for digital innovation. Specifically, DI1: "In the last three years, our company has achieved innovations incorporating digital technology which is radically new to customers," mean = 3.54, SD = 1.17, standardized regression weights =0.858; DI2: "In the last three years, our company has achieved digital innovations offering radically new benefits to customers," mean = 3.48, SD = 1.19, standardized regression weights =0.913; DI3: "In the last three years, our company has achieved digital innovations introducing completely new digital features to the market," mean = 3.25, SD = 1.265, standardized regression weights =0.884; DI4: "In the last three years, our company has achieved digital innovations allowing novel business models," mean = 3.40, SD = 1.27, standardized regression weights =0.814. Overall, Cronbach's a = 0.923, average variance extracted AVE =0.753, Comparative fit index CFI = 0.982, RMSEA = 0.168, SRMR = 0.02. (Bagozzi and Yi, 1988; Dunn et al., 2014; Hair Jr. and Hair, 2010; Hayes and Coutts, 2020).

Furthermore, the reliability and validity scores for the latent constructs are assessed. The hypotheses are tested using ordinary least squares (OLS) regression analysis. We examined the moderating role of EO between SO and digital innovation, corresponding to hypothesis 3. We also subsequently examine the moderating role of digital technologies in the relationships between SO and digital innovation & between EO and digital innovation, corresponding to hypothesis 4 and hypothesis 5, respectively.

Moreover, the firm's age and type (i.e., family/non-family) are considered control variables in this study to improve the reliability of the conclusion. Specifically, the firm's age is the current year, 2023, minus the year the company was established. The firm's age is controlled because established firms may have more resources, thus being able to innovate more significantly (Wang et al., 2023). Additionally, we controlled for the firm's type, indicating a company's need for entrepreneurship or radical innovation. We used a dummy variable to measure the firm's type ("Family firm" = 1, "non-family firm" = 0).

4. Results

Initially, control variables and the dependent variable, digital innovation, were integrated into the equation. Then, independent variables were added. Model 1 in Table 3 displays the insignificance of firm age ($\beta = -0.053$; $t = -1.025$; $p = 0.306$) and firm type ($\beta = -0.083$; $t = 1.61$; $p = 0.108$) in predicting digital innovation. In Model 2, EO was introduced as the independent variable predicting digital innovation. As the influence was not significant, we did not find support for H1. Model 3 utilized SO as the independent variable. Our findings support H2, indicating a positive association between increasing SO levels and firms' digital innovation ($\beta = 0.099$; $t = 1.925$; $p = 0.055$).

Model 4 included both EO and SO as independent variables. The result supports H3, representing that EO negatively moderates the positive relationship between SO and digital innovation. Afterward, digital technologies were added to test digital technologies' moderating effects on the positive relationships: EO and digital innovation (H4), SO and digital innovation (H5). We do not find support for H4 but find support for H5, showing that digital technologies negatively moderate the positive relationship between SO and digital innovation.

Following Aiken and West (1991), we investigated the slopes of the interaction effects of Hypotheses 3 and 5. The plots show that firms with a low EO achieve greater digital innovation the greater their SO is. Instead, firms with a high EO experience a decline in digital innovation the greater their SO is. The relationship between both orientations is substitutive on digital innovation (Fig. 2-A). EO is not bad for digital innovation but does not fit high DO. The finding further supports Hypothesis 3: An EO and an SO have negative alignment effects on digital innovation. The plots (Fig. 2-A and 2-B) also reveal digital technologies also negatively moderate the influence of SO on digital innovation. Digital innovation is reduced when a high SO is associated with a high range of digital technologies. When SO is low, then more digital technologies provide higher digital innovation than less. Hence, the plots further support Hypothesis 5, digital technologies negatively align with SO's positive effect on digital innovation.

5. Discussion

Following a strategic alignment theory lens, our study investigated how SO, EO, and digital technologies influence digital innovation in direct and aligned relationships. In short, our findings reveal interactions among these factors, highlighting the positive and negative effects they exert on digital innovation within organizations. We emphasize the positive effects of SO on digital innovation. Furthermore, we stress our counterintuitive findings on EO that have no direct but even negative interaction effects with SO on digital innovation.

5.1. Theoretical contributions

Our study provides several significant contributions to integrating strategic alignment research with the literature on EO, SO, digital technologies and especially digital innovation as the outcome variable. First, our study brings a new dimension to research on strategic alignment and strategic orientation by introducing digital innovation as a critical performance variable (Cragg et al., 2002; Kindermann et al., 2021; Venkatraman et al., 1993). Previous alignment research has considered IT investments but ignored digital innovation's importance (Byrd et al., 2006; Cragg et al., 2002; Pesce and Neirotti, 2023). In addition, strategic alignment research included EO but has so far ignored green and sustainability considerations. Accordingly, we provide essential and even negative relationships that inform strategic alignment research in general and misalignment dangers in particular. It is also worth noting that our findings suggest that digital technologies negatively moderate the relationship between SO and digital innovation. This leads to misalignment. Firms may face challenges in aligning their digital initiatives with sustainability goals because of the rapid

Table 3
Regressions' results.

A.

	Model 1			Model 2			Model 3		
Dependent variable	Digital innovation			Digital innovation			Digital innovation		
	β	t	p	β	t	p	β	t	p
Intercept	−0.003	−0.051	0.96	−0.003	−0.051	0.96	−0.003	−0.049	0.961
Firm's age	−0.053	−1.025	0.306	−0.052	−1.012	0.312	−0.057	−1.107	0.269
Firm's type	0.083	1.61	0.108	0.081	1.558	0.12	0.084	1.626	0.105
Entrepreneurial Orientation (EO) (H1)				0.048	0.936	0.35			
Sustainability Orientation (SO) (H2)							0.099	1.925	0.055*
EO × SO (H3)									
Digital technologies (DT)									
EO × DT (H4)									
SO × DT (H5)									

B.

	Model 4			Model 5			Model 6		
Dependent variable	Digital innovation			Digital innovation			Digital innovation		
	β	t	p	β	t	p	β	t	p
Intercept	0.024	0.456	0.649	0.009	0.174	0.862	0.011	0.212	0.832
Firm's age	−0.067	−1.309	0.191	−0.088	−1.726	0.085*	−0.098	−1.921	0.056*
Firm's type	0.092	1.793	0.074*	0.092	1.826	0.069*	0.101	1.991	0.047**
Entrepreneurial Orientation (EO) (H1)	0.328	1.503	0.134	0.185	0.901	0.368			
Sustainability Orientation (SO) (H2)	0.203	2.211	0.028**				0.18	2.161	0.031**
EO × SO (H3)	−0.032	−2.202	0.028**						
Digital technologies (DT)				0.223	4.234	0.000***	0.217	4.135	0.000***
EO × DT (H4)				−0.052	−0.965	0.335			
SO × DT (H5)							−0.054	−2.066	0.040*

Estimated path coefficients are significant with *p*-values $t < 0.10$, * < 0.05, ** < 0.01, and *** < 0.001.

pace of technological change and environmental dynamism (Yousaf et al., 2021). This could result in unsustainable practices or inefficient resource allocation if digital technologies are misaligned with SO. Excessive focus on the use of digital technology can also lead to the decline of digital innovation in organizations. An overemphasis on digital technology might lead to neglecting other vital aspects of a business, such as human resources, organizational culture, and strategic planning (Stonehouse and Konina, 2020). In addition, excessive concentration on digital technology can lead to a false sense of security, leading companies to ignore potential disruptive threats and fail to adapt their mindset to new realities (Neus et al., 2017). Consequently, learning can be slowed, resources wasted, and digital innovation can decline.

Second, we strongly advance strategic orientation research. Traditional approaches to strategic orientation overlook the transformative impact of digital technologies on innovation. Recognizing this gap, we blend digital innovation into the strategic alignment framework, providing a comprehensive understanding of how firms can (mis)align their orientations with digital technologies to innovate efficiently. Scholars have long emphasized the need for a more integrated framework that combines entrepreneurship, sustainability, and innovation theories to address the complexities of contemporary business environments (Hansen and Große-Dunker, 2013; Schaltegger and Wagner, 2011). To bridge this gap, our study proposes a comprehensive framework that offers a deeper understanding of the complex relationships between these key variables. By linking sustainability and entrepreneurship orientations to digital innovation, we provide insights into how firms can or should not leverage these strategic orientations to drive innovation in the digital era.

Third, we contribute novel and counterintuitive findings to EO that have been seen as an 'all purpose weapon' to many problems in firms (Schröder et al., 2021). EO, characterized by traits such as innovation, risk-taking, and proactiveness, has long been recognized as contributing to various firm-level attributes and outcomes (e.g., Bouncken et al., 2020; Covin and Wales, 2019; Kock and Gemünden, 2020). Instead, our findings provide counterintuitive findings that reveal boundary conditions of EO, as we find no significant direct effect and a negative interaction effect with SO. Our results somewhat contrast the simple idea that EO automatically transfers to sustainability and digital innovation. We enrich and extend the study on green EO, which provided additional components needed for EO to align with green targets (Khan et al., 2023).

Fourth, our study contributes by incorporating SO from strategic business perspectives to influence digital innovation outcomes. Sustainability is an indispensable element that needs to be considered adequately in business structures seeking to intertwine environmental challenges and innovative solutions. The literature on SO has primarily centered on whether sustainability is financially beneficial or burdensome. Several studies have reported positive associations between a firm's sustainability practices and superior organizational outcomes (Cheng, 2020). However, other studies have found the opposite true (Amankwah-Amoah and Syllias, 2019). Through the targeted deployment of sustainability targets into digital ventures, a company not only increases its sustainability profile but spurs technological innovations in new and exciting ways. This contribution to the knowledge base deepens the understanding of the connection between digital innovation and environmental sustainability by introducing firms to how to make environmental sustainability complementary to their digital strategies to promote innovation and create sustainable value. It points towards the adaption of sustainable guidelines into the journey of digital innovation, which has implications for both environmental and business targets.

5.2. *Limitations and future research directions*

As every research, also our study has some shortages. One is the measurement of strategic orientations by secondary sources. Future studies might consider primary and secondary sources. In addition, we

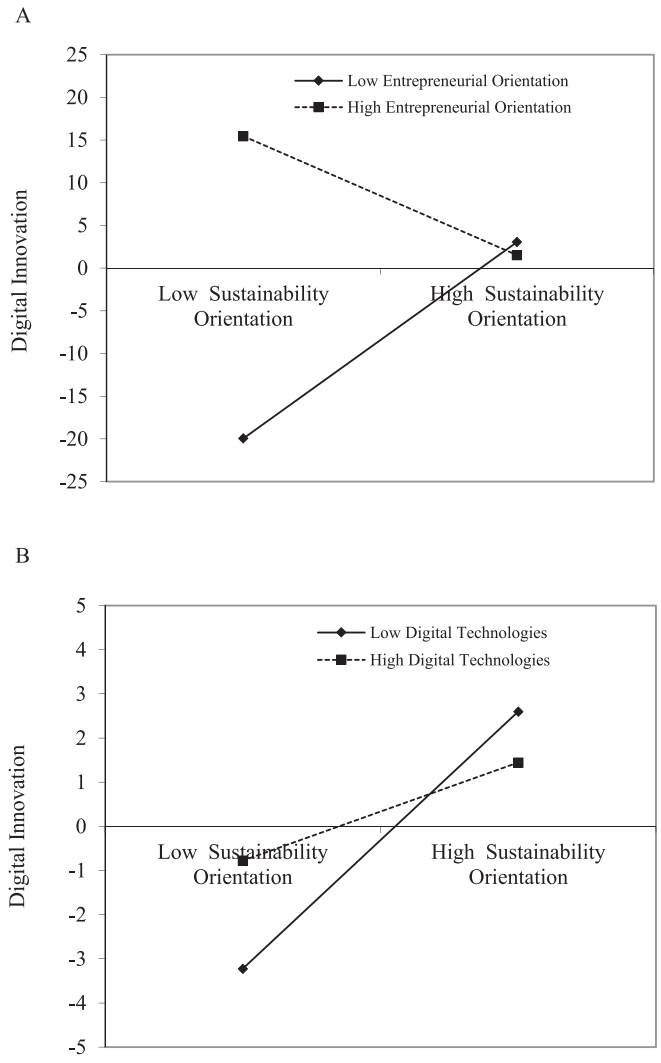

Fig. 2. A. Two-way interaction plot of sustainability orientation and entrepreneurial orientation on digital innovation.
B. Two-way interaction plot of sustainability orientation and digital technologies on digital innovation.

did not control for specific digital technologies. Future studies might dig into this and develop configurations of digital technologies while estimating how they relate to digital innovation contexts. Furthermore, we did not consider different types of firms. Future studies may examine whether the nature of digital technologies influences the connection between digital innovation and its antecedents in different types of companies. It is plausible that companies with a SO focus might thrive in stable environments (Jin et al., 2018), while entrepreneurial companies may do better in rapidly changing environments (Hughes et al., 2021). Some 'borderline' 10 % significance in our study underscores the need for careful interpretate the strategic approaches to sustainability and digital innovation, suggesting further investigation through replication with a larger sample size or exploration of additional influencing variables.

We did not include other firm characteristics, such as resource constraints, organizational culture and mindset, broader market dynamics, measurement issues, and contextual factors (Kraus et al., 2023; Ranjan, 2024). Future research may examine the triangular relationship of SO, EO, digital technologies, and innovation combined with information about the firms' organizational structure, leadership styles, cross-functional collaboration mechanism, or work environments (i.e., Bouncken et al., 2024; Isensee et al., 2023; Zhang et al., 2022; Zhou et al., 2021). The question of how work is locally or globally distributed may influence digital innovation (Bouncken and Tiberius, 2023). Another limitation pertains to the generalizability of the findings to firms operating in other countries, including Germany. While we have focused on the representativeness of our sample within Germany, it is crucial to acknowledge potential constraints that affect the generalizability of our findings across different countries. Variations in industry structures, regulations, and market dynamics can significantly impact the relationship between EO, digital technologies, and innovation outcomes. Additionally, cultural norms, institutional differences, and socio-economic factors influence organizations' approaches to risk-taking, technology adoption, and innovation, potentially affecting the repeatability of our research conclusions across diverse contexts. Therefore, upcoming research should consider industry-specific and contextual aspects to enhance the external validity of our results and develop a more nuanced understanding of the modelling discussed in our study across various national and industrial settings. Furthermore, the question where the headquarter of the firm is nationally embedded may be researched in future studies, because national regulations impact sustainability.

5.3. Managerial implications

Our study also holds a number of important managerial implications. It highlights the significance of positioning EO and SO with digital technology to achieve digital innovation. Managers must plan and execute digital innovation initiatives while balancing these firm orientations. As managers increasingly prioritize sustainability and entrepreneurship, understanding the effect of these orientations on digital innovation is crucial. Digital innovation is a vital strategic activity (Pesch et al., 2021), and evaluating its impact in this context is essential. This study serves as an initial guide for managers in this regard. The key takeaway from the findings is that prioritizing EO or SO at the expense of the other may not be a practical approach for achieving success and effectiveness in digital innovation. Especially EO may set dangers.

Designing and implementing organizational processes that align with sustainability and (while limiting) EOs is critical for fostering digital innovation. Given the strategic nature of decisions related to sustainability and entrepreneurship, senior management must take responsibility for these initiatives. To foster digital innovation, managers could encourage employees to exhibit behaviors that align with sustainability and entrepreneurship, particularly at the new product team level (Kraus et al., 2019). Implementing sustainability-based reward systems and providing resources and support can help promote congruency between these orientations (Galpin et al., 2015). However, a high focus on these orientations may be more challenging and expensive to develop, despite being more attractive for digital innovation in the firms. This is because it requires a greater emphasis on both orientations. Finally, managers must take responsibility for promoting sustainability and entrepreneurship in digital innovation by designing and implementing processes that support these orientations. However, managers must also be aware of the costs associated with high SO and EO.

6. Conclusion

Our study explores and tests how a firm's SO and EO influence digital innovation. We explore indirect effects among the orientations and how digital technologies applied in the firm moderate the orientations' effects on digital innovation. The theoretical frame of our study is strategic alignment theory. Our conceptual model, tested by primary and secondary data including 350 cases from manufacturing firms, shows positive and negative alignment effects. A SO improves digital innovation, but its positive effect declines when the firm has a greater EO. Surprisingly, the positive effect of a SO declines as well when the firm implements a greater set of digital technologies. Consequently, our study contributes counterintuitive insights towards understanding that 'the

more of EO not necessarily the better'.

CRediT authorship contribution statement

Kai He: Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Ricarda B. Bouncken:** Conceptualization, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Ataullah Kiani:** Writing – original draft, Writing – review & editing. **Sascha Kraus:** Writing – original draft, Writing – review & editing.

Data availability

The authors do not have permission to share data.

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