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Leading the transition toward sustainability through digital capabilities and digital innovation: The role of employee characteristics

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A B S T R A C T

According to the United Nations (UN), digital innovation and sustainability performance are key pathways to achieving the Sustainable Development Goals. However, existing research has often overlooked the roles of digital capability and orientation in driving digital innovation. This study employed Drucker's productivity theory to examine the relationship between entrepreneurial leadership and digital innovation. Two studies were conducted on China's information technology (IT) industry. Study 1 used a three-wave design (N = 299), while Study 2 used a two-wave design (N = 341). Results demonstrate a significant correlation between entrepreneurial leadership, digital innovation, and sustainability performance, highlighting the mediating roles of employee digital capability and digital orientation in the relationship between entrepreneurial leadership and digital innovation. This study contributes to sustainability research by exploring employee-based mediating factors. The findings enhance the understanding of how IT organizations can foster employee dedication and commitment to achieving higher levels of digital innovation and sustainability performance through entrepreneurial leadership, ultimately supporting the broader UN SDGs.

Introduction

The increased emphasis on accomplishing the Sustainable Development Goals (SDGs) set out by the United Nations (UN) has profoundly transformed the global business environment, drawing significant attention to organizations' sustainability performance and innovation as the most reliable pathway to achieving the Sustainable Development Goals (SDGs) (Dzhunushalieva & Teuber, 2024; Malik et al., 2024; Pan & Nishant, 2023). Digital innovation serves as the backbone of digital transformation and is necessary for capability building toward future-focused growth (Kane et al., 2015; Ochinanwata et al., 2023; Opland et al., 2022). Although digital innovation is crucial for organizational growth, it also poses significant challenges for many organizations. These challenges often stem from the misalignment between employee-focused practices and evolving organizational performance goals (Reibenspiess et al., 2022). This can be solved through a holistic approach, with employee capability building being central to organizations' leadership practices. Organizations must adopt new leadership frameworks to cultivate employees' digital capabilities and foster a digitally oriented workforce (Gyamerah et al., 2025; Kane et al., 2017; Kohli & Melville, 2019; Nakpodia et al., 2023; Opland et al., 2022). This is especially important in the information technology (IT) industry, where digitization is introduced as a critical pathway to sustainability (Broccardo et al., 2023). While research on digital innovation has recently begun to attract further interest within the service sector (Aránega et al., 2023; Liu et al., 2023; Xie et al., 2022), previous studies have largely overlooked employee-relevant elements, such as leadership, which can enhance digital innovation and sustainability performance through capability building (Benitez et al., 2022; Casalegno et al., 2023; Opland et al., 2022).

Leadership in the IT industry is paramount to fostering a workforce capable of accomplishing sustainability performance goals, which can be done by encouraging risk-taking behaviors and developing future-focused initiatives, qualities inherent in entrepreneurial leadership.

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Emerging research has indicated that entrepreneurial leadership can enhance growth and performance under challenging and adverse conditions (Aránega et al., 2023) and identify opportunities in demanding, volatile, and competitive environments (Aránega et al., 2023). Recent studies have also suggested that organizations, particularly those within the IT sector, face a growing demand for entrepreneurial leadership, necessitating more research focused on service-oriented industries (Islam et al., 2024; Ma et al., 2024; Razzaque et al., 2024). This gap in the literature requires further investigation, suggesting that integrating entrepreneurial leadership frameworks could enrich our understanding of digital innovation strategies in IT contexts.

The effects of entrepreneurial leadership on digital innovation in the IT sector are complex and influenced by factors that can either strengthen or weaken this relationship. To explore these effects, we applied Drucker's productivity theory, which highlights the importance of employees' digital literacy and adaptability in driving organizational innovation (Nguyen et al., 2023; Shehzadi et al., 2021; Shujahat et al., 2021). It posits that digital workers, with adequate support to enhance their digital skills, play an essential role in fostering digital innovation by effectively integrating technological and human resources (Benitez et al., 2022). In the IT industry, digitally oriented employees are vital to interact with stakeholders and advance innovation (Renko et al., 2009). While prior research has examined digital orientation and digital capability separately (Ferreira et al., 2024; Proksch et al., 2024; Wang et al., 2024), this study investigates how these factors mediate the link between entrepreneurial leadership and digital innovation, addressing an overlooked area in IT-sector research (Hoang et al., 2024; Ibrahim et al., 2024). This dual mediation model aims to enrich sustainability-focused leadership insights and provide a foundation for future research.

Moreover, prior research has offered fragmented insights into the factors determining sustainability and has not adopted a comprehensive approach to establishing a coherent framework for attaining both digital innovation and sustainability performance (Chaudhuri et al., 2024; Rahmani et al., 2024). This gap limits research insights into the complex interplay between diverse aspects of digital orientation and their effects on sustainability outcomes. Thus, studying how entrepreneurial leadership influences workers' digital orientation and digital capability can improve the IT industry's digital innovation and sustainability performance. To address these gaps and provide an integrated overview of innovation and sustainability performance, we explore leadership practices that cultivate employees' capabilities in digital innovation and sustainability. This study proposes three primary research questions:

- *RQ1:* How does entrepreneurial leadership influence digital innovation?
- *RQ2:* To what extent do employee digital orientation and digital capability mediate the relationship between entrepreneurial leadership and digital innovation?
- *RQ3:* How does digital innovation contribute to organizational sustainability performance?

This study's significance lies in thoroughly examining previously unexplored connections within the sustainability literature by implementing a mediating model that incorporates employee factors to enhance digital innovation. Such an approach deepens our understanding of how IT firms, particularly those in the IT industry, can boost employee digital orientation and capability by leveraging entrepreneurial leadership to achieve higher levels of digital innovation and sustainability performance. This study rigorously examines the unique leadership and management challenges in the IT industry, maintaining an analytical viewpoint that distinguishes IT from the industrial sector. Furthermore, it makes a valuable contribution by conducting an exhaustive analysis of the critical association, utilizing a mediating model in two studies, and employing a research design with a time-lagged approach to produce broadly applicable results.

Theoretical lens and hypothesis development

Knowledge worker productivity theory

According to Drucker's theory of productivity (Drucker, 1999; Sahibzada et al., 2022; Shujahat et al., 2020), digital workers, a type of knowledge workers whose job is to innovate, need organizational support encompassing entrepreneurial leadership, digital orientation, and digital capability. Drucker (1999, p. 94) argued that the ability of knowledge-intensive firms to survive depends on their competitive advantage in making knowledge workers more productive. Digital workers are competent personnel capable of learning fast within a firm (Shahzadi et al., 2021). Knowledge workers face complex assignments and tedious and disorderly jobs (Bosch-Sijtsema et al., 2009); their productivity refers to their efficiency in creating intellect and knowledge-based innovative outputs such as software solutions (Drucker, 1999; Shujahat et al., 2020). Drucker's productivity theory also emphasizes that leaders should take the initiative in organizations to create digital resources and promote their use through learning programs (Afshari & Hadian Nasab, 2020; Faridian, 2023).

Entrepreneurial leadership and digital innovation

Entrepreneurial leadership is the leadership practice of exerting influence on organizations by actively creating value for stakeholders (Al-Sharif et al., 2023). This objective is achieved by using a distinctive combination of innovation and resources to harness forward-looking opportunities (Hoang et al., 2023; Kastelli et al., 2024). Entrepreneurial leadership innovatively transforms existing transaction sets into entrepreneurial actions, thus paving the way for future-focused progress and development (Hoang et al., 2023). Previous studies have proposed that entrepreneurial leadership is an effective leadership style in unpredictable and challenging environments, identifying opportunities and fostering innovation in organizations (Razzaque et al., 2024). Along with the principles of Drucker's productivity theory, entrepreneurial leaders are expected to promote digital innovation in the IT industry by facilitating the generation of new ideas, taking advantage of entrepreneurial opportunities in the workplace, and transforming them into innovative digital products. Additionally, these leaders serve as role models by exhibiting entrepreneurial behaviors (Shujahat et al., 2021).

Current trends in entrepreneurial leadership and innovation have led to the proliferation of studies that only focus on innovation performance (Al-Sharif et al., 2023; Hoang et al., 2023), adaptive innovation (Lin & Yi, 2023), and open innovation (Faridian, 2023). Additionally, many solely examine the link between entrepreneurial leadership and employees' innovative behavior (Abualoush et al., 2022; Malibari & Bajaba, 2022). Despite the increasing focus on how entrepreneurial leadership fosters innovation, studies exploring its relationship with digital innovation, especially within the IT industry, remain scarce (Razzaque et al., 2024). Therefore, we propose the following hypothesis:

H1: Entrepreneurial leadership positively affects digital innovation.

Entrepreneurial leadership, employee digital orientation, and digital innovation

Digital orientation refers to employee behaviors that facilitate the adoption of digital technologies (Wang et al., 2024). Digitally oriented employees tend to have a greater propensity to learn and effectively utilize cutting-edge technologies, such as the Internet of Things (IoT), big data, artificial intelligence (AI), and blockchain (Wang et al., 2024). Drucker's productivity theory highlights the idea that an organization's innovation is closely linked to its employees' digital literacy and comfort with technology (Shehzadi et al., 2021; Shujahat et al., 2021). These characteristics are nurtured only within an environment in which employees feel safe, are encouraged to take risks, and embrace future-focused opportunities (Kindermann et al., 2024). Entrepreneurial leadership establishes an environment conducive to growth and development, emphasizing the significance of digital technology in leveraging potential opportunities (Hoang et al., 2024). Research has shown that when leaders promote innovation and digital technology, employees are more likely to acquire digital abilities and become digitally oriented (Farhan et al., 2024; Gilli et al., 2024). However, few studies have examined the relationship between entrepreneurial leadership and employees' digital orientation. Gaining a deeper understanding of how entrepreneurial leadership can effectively promote employees' digital orientation in the IT service industry will open new avenues for practitioners. Drucker's productivity theory, which asserts that leaders must take the initiative within organizations to establish digital resources and facilitate their utilization through comprehensive learning programs, supports this association (Faridian, 2023).

Previous studies have demonstrated that organizational digital orientation ensures innovation across various sectors. Specifically, research indicates that digital orientation positively influences innovation performance in high-tech small- and medium-sized enterprises (SMEs) in India (Ranjan, 2024), modifies innovation outputs in firms in China (Wang et al., 2024), and affects innovation performance in the hospitality industry in the United Arab Emirates (Tajeddini et al., 2024). Previous studies have also not adequately explored the extent to which employees' digital orientation contributes to digital innovation. This oversight suggests that there is a need for further investigation into how employees' digital capabilities and engagement can influence an organization's capacity to innovate in the digital landscape, particularly within the IT industry. Understanding this relationship is essential for developing strategies that leverage digital workforce skills and drive successful innovation initiatives. This study addresses scholars' ongoing demands to elucidate the mediating mechanisms through which entrepreneurial leadership influences innovation in the service (IT) sector, as highlighted in the literature review (Hoang et al., 2024; Ibrahim et al., 2024).

Therefore, we propose the following hypotheses:

H2: Entrepreneurial leadership positively affects employee digital orientation.

H2a: Digital orientation positively affects digital innovation.

H2b: Digital orientation mediates the relationships between entrepreneurial leadership and digital innovation.

Entrepreneurial leadership, employee digital capability, and digital innovation

Digital capability, which refers to employees' skills, experience, and knowledge in managing digital technology to create new products, is essential for digital transformation (Kans & Campos, 2024). The ability to utilize digital technologies is demonstrated through employees' digital capabilities, expertise, and technical knowledge (Alexandro & Basrowi, 2024). This argument raises the crucial issue of cultivating digital capabilities, particularly in the IT industry. Previous studies have shown that entrepreneurial leaders can facilitate the advancement of employees' digital skills by offering opportunities for learning and growth (Malibari & Bajaba, 2022; Yadav et al., 2024). Entrepreneurial leaders can identify the specific digital capabilities and knowledge employees need to achieve strategic organizational objectives (Hoang et al., 2024). Previous literature has shown that leadership is a crucial factor in developing the digital capability required to promote innovation in SMEs (Aghazadeh et al., 2024). However, research on the connection between entrepreneurial leadership and digital capability in the service (IT) industry remains limited. This association is validated by Drucker's productivity theory, which suggests that leaders can promote the learning and communication of digital workers by effectively utilizing digital platforms such as collaboration tools and AI (Benitez et al., 2022; Wu et al., 2021).

Furthermore, existing literature highlights a significant gap in understanding the mediating factors that connect leadership to digital innovation (Bastidas et al., 2023). Previous studies have examined various mediating factors to assess the relationship between leadership and innovation. Furthermore, different mediating factors have been proposed to establish a connection between entrepreneurial leadership and innovation, including innovation strategy and knowledge acquisition (Hoang et al., 2023), innovation capability (Al-Sharif et al., 2023), team creativity and self-efficacy (Bagheri et al., 2022), and service innovation (Getaneh Kebede et al., 2024). However, empirical evidence on the mediating role of digital capability in the relationship between entrepreneurial leadership and digital innovation is lacking. Additionally, prior research has predominantly neglected employee-driven elements explaining the relationship between entrepreneurial leadership and digital innovation in the IT sector (Benitez et al., 2022; Opland et al., 2022; Straub et al., 2023). Furthermore, the role of digital capability as a mediator has received limited attention in previous studies (Proksch et al., 2024). Thus, this study tests the hypothesis that digital capability mediates the relationship between entrepreneurial leadership and digital innovation in the context of Chinese IT firms:

H3: Entrepreneurial leadership positively affects employee digital capability.

H3a: Employee digital capability positively affects digital innovation.

H3b: Employee digital capability mediates the relationship between entrepreneurial leadership and digital innovation.

Digital innovation and sustainability performance

Digital innovation is the invention of market offerings, business processes, or business models using digital technology (Felicetti et al., 2024). It has the potential to transform business operations through process optimization, cost reduction, and the development of new products and services (Han et al., 2023). The pursuit of innovation is related to what can and should be improved, which affects the acquisition and direction of opportunities that promote sustainability performance (Shah et al., 2024). According to Drucker's productivity theory, digital innovation is essential for generating new ideas by decisively capitalizing on entrepreneurial opportunities within the workplace. This strategic approach transforms these opportunities into innovative digital products, thereby significantly improving sustainability performance (Felicetti et al., 2024).

Sustainability performance ensures the efficient use of natural resources without jeopardizing future economic prospects and harming society and the environment. It incorporates environmental integrity, social equality, and economic prosperity into a firm's operations (Nicolo' et al., 2024; Siddik et al., 2024). Previous research has shown that innovation significantly affects sustainability performance in SMEs (Mokbel Al Koliby et al., 2024). Jum'a et al. (2024) acknowledged that sustainability performance depends on an organization's innovation in Jordanian manufacturing companies. Khin and Ho (2018) contended that various innovation-related factors may influence the interplay between a company's sustainable digital business performance and innovation. Despite many studies on digital innovation, the impact of digital innovation on the sustainability performance of IT firms remains under-researched. Addressing this gap is critical for attaining a comprehensive understanding of the direct influence of digital innovation on the sustainability performance of technology firms, thereby facilitating the enhancement of sustainable practices within the industry. Building on insights from previous literature and the principles of Drucker's productivity theory, our study shifts the focus toward digital innovation and tests the following hypothesis:

H4: Digital innovation positively affects sustainability performance.

Methodology

Sample

Software technology companies were included in our sample because they exhibit distinct characteristics relevant to our study. Entrepreneurial leadership is crucial in IT firms, given their dynamic environments that demand innovative leadership styles (Donate & Sánchez de Pablo, 2015). Additionally, knowledge workers in high-tech firms display a digital orientation that is essential for adopting and optimizing digital resources. Their digital capabilities, which are characterized by technical proficiency, are necessary to drive digital innovation and sustain competitive advantage (Yahya & Goh, 2002).

Research design

We conducted two parallel studies to empirically assess the proposed hypotheses, as shown in Figure 1. Study 1 was conducted to empirically test the model, utilizing a time-lagged research design with a sample of personnel from the IT industry in China. This methodology provided a solid analytical foundation for our study to address the multidimensional nature of links between entrepreneurial leadership, digital orientation, digital capability, and digital innovation in Study 1. Subsequently, Study 2 was undertaken with the dual purpose of filling a crucial research gap by identifying predictors of sustainability performance and validating the results of the first study, thereby reinforcing confidence in the attained results (Quade et al., 2020). Prior research on leadership also proposed using two frameworks for more robust findings (Quade et al., 2020; Rasheed et al., 2023).

Study 1

Study 1 empirically tested the model by utilizing a time-lagged study design. Using the Prolific data collection service, a web-based questionnaire was developed to gather information from IT professionals in three progressive IT cities in China: Shenzhen, Xi'an, and Beijing. The data collection for Study 1 was conducted between October 2023 and December 2023. The present study was executed in three distinct phases, with a 2-week interval between each phase. Previous studies on leadership have indicated that a 2-week interval should be observed during successive data-gathering phases (Quade et al., 2020; Rasheed et al., 2023).

At (T1), data were gathered from 327 contributors regarding their supervisor's entrepreneurial leadership (EL) approaches. Two weeks later, at (T2), 327 participants were asked to provide information on their digital orientation (DO) and digital capabilities (DC), in which 317 participants responded to the questionnaire. Two weeks after the T2 wave, the remaining participants were asked to rate digital innovation, and the data were gathered during the T2 phase. At T3, only 308 participants responded. Following the identification of multivariate outliers, nine responses were eliminated, leaving 299 valid responses for subsequent analyses.

Demographic profile for Study 1

As unique identifiers, the Prolific identifiers of the respondents were used to link and consolidate the information they provided in the three phases. Of the 299 participants, 62.4% were male and 37.5% were female. Furthermore, the analysis revealed that 35.6% of the participants were aged 30 to 39 years, whereas 24.8% were aged 20 to 29 years.

Study 2

A time-lagged technique and analysis were applied to the full model. We collected data for Study 2 from personnel in the Chinese IT industry using the Prolific data collecting tool. The second investigation was conducted in two phases, with a 1-month interval. For a more comprehensive analysis, it is advisable to conduct a follow-up study with a 1-month gap (Rasheed et al., 2023). Previous studies investigating leadership have also implemented a 1-month interval between successive rounds of data gathering (Khan et al., 2021; Rasheed et al., 2020). During the initial phase of data gathering (T1), data were obtained from 378 participants regarding metrics for entrepreneurial leadership, digital orientation, and digital capabilities. Data for Study 2 were collected from January 2024 to March 2024. The respondents' demographic data, including location, age, educational background, sexual orientation, and overall expertise in the IT sector, were collected during the T1 survey. We requested that the 378 participants in the T1 wave provided data about digital innovation and sustainability performance. The T2 survey included a total of 359 respondents. Among the entire participant pool, 341 individuals submitted responses that met the criteria for analysis. After excluding 18 responses as multivariate outliers, 341 responses were included in the final analysis.

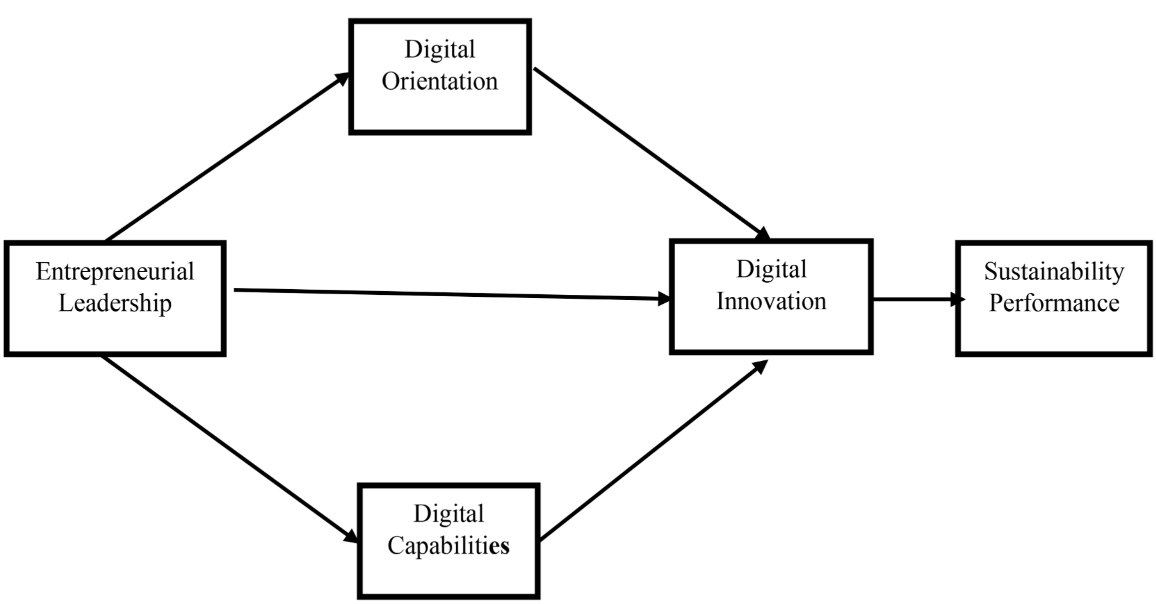

Figure 1. Theoretical framework.

Demographic profile for Study 2

As unique identifiers, the respondents' Prolific identifiers were used to correspond with and compile the information they provided in the two phases. Of the 341 survey participants 36.7% were female and 63.3% were male. Additionally, 25.8% of the respondents were aged 20 to 29 years, while 35.2% were aged 30 to 39 years. Furthermore, 47.6% had a master's degree, while 38.4% had 11 to 15 years of experience in IT organizations.

Measures

This study employed 28 measuring items. Slight modifications were made to the wording of the sections to adhere to IT standards (Latif et al., 2020). The survey employed a 5-point Likert-type scale, with 1 indicating strong disagreement and 5 indicating strong agreement. The study applied a scale developed by Renko et al. (2015) to assess entrepreneurial leadership. For instance, one of the items was, "My manager often comes up with radical improvement ideas for the products/services we are selling." The 4-item digital orientation measure was derived from Zhou et al. (2005) and Gatignon and Xuereb (1997), with one of the items being "I always look out for opportunities to use digital technology in our innovation." The 5-item digital capabilities measure was adopted from Zhou and Wu (2010), with one of the items being "I am developing innovative products/services/processes using digital technology." The 6-item digital innovation scale was altered from Paladino (2007), with one of the items being "I take pride in delivering digital solutions that surpass the quality offered by our competitors as part of my contribution to the company's success." Finally, five sustainability performance items were adopted from Gelhard and Von Delft (2016), with one of the items being "We develop new services or improve existing services that are regarded as sustainable for society and the environment."

Data analysis and results

The data were examined using several methods to verify the hypotheses. We employed a missing-value examination, multifactor identification of outliers, assessment of the normal data distribution, statistical analysis of variance, and correlation analyses for data filtering (Hair Jr et al., 2020). We also conducted a thorough evaluation to identify IT specialists with at least 1 year of full-time employment. These two studies used identical criteria for data evaluation (Rasheed et al., 2023). We chose PLS-SEM over CB-SEM because it suits the complex relationships between the latent constructs and exploration of theoretical levels (Hair et al., 2017). This approach has been extensively used in theory validation and testing and is appropriate for investigating multifaceted associations (Fornell & Larcker, 1981). PLS-SEM requires a twofold analysis: measurement model calculation (outer model) and structural model (inner model) analysis (Ringle et al., 2018). The measurement model specification ensured that these structures had appropriate pointer loadings, convergent validity, composite reliability, and discriminant validity when extended to the structural model. Structural model assessment requires measuring path coefficients and evaluating their consequences.

Common method bias and multi-collinearity

To mitigate the risk of bias, this investigation adhered to well-defined procedures (Podsakoff et al., 2003). Preliminary testing was conducted while preparing the questionnaire. It aimed to identify aspects of the survey's layout and items that required refinement to reduce the participants' workload. Additionally, the survey was created to clearly distinguish between the dependent and independent variables. The items were randomized to ensure an unbiased approach toward the specific responses. Therefore, every possible wording and arrangement of the parameters that may have induced a priming outcome was circumvented. Next, Harman's test was conducted to assess single variables. The analysis yielded no obvious concerns because a single item accounted for 41% of the discrepancy in the sample, which is well below the minimum requirement of 50%. Therefore, there was no need to consider common method bias (Volberda et al., 2012). In addition, a thorough examination was conducted to analyze the associations between the constructs. The results show that the relationships are relatively weak, with values above 0.90 (Lowry & Gaskin, 2014). Finally, variance inflation factors (VIFs) were used to inspect both the axial and horizontal collinearity among each construct (Kock, 2015). According to Kock (2015), one way to evaluate the potential bias of commonly used methods in research involving the computational modeling of structural equations is to conduct a collinearity test. VIFs were employed to determine whether the model was affected by common method bias. The model was considered unbiased if VIFs were 3.30 or lower. After conducting a comprehensive collinearity test, the results indicated a maximum VIF below 3.30 (range, 2.103–2.915), and the sample utilized in this study did not exhibit any issues associated with common method bias.

Assessment results for Study 1

Measurement model assessment for Study 1

Ali et al. (2018) suggested using a model fit index to assess data. The estimation model in Study 1 demonstrated a satisfactory fit with the following statistics: $\chi 2 = 689.821$, df = 302, and $\chi 2/\text{df} = 3.359$. The GFI had a value of 0.984, the AGFI was 0.891, the NFI 0.836, the CFI 0.973, the IFI 0.907, the RMSR 0.037, and the RMSEA 0.072. The GFI and AGFI values should exceed 0.8, as suggested by Hu and Bentler (1999). The measurement model used in this investigation was believed to fit (Baumgartner & Homburg, 1996). The investigation began by assessing the internal reliability of the Study 1 model using composite reliability (CR) and Cronbach's alpha indicators.

Using outer loading analysis, average variance extracted (AVE), and Fornell–Larcker, this study additionally assessed the model's discriminant and convergent validity (Hair et al., 2017). To assess the internal reliability of the study, Cronbach's alpha and CR should be above the minimum threshold of 0.6, as indicated by Nunnally (1978). Table 1 lists the values that determine internal coherence. The AVE scores were evaluated to assess convergent validity. These findings suggest that each AVE value exceeds the minimum permissible value of 0.5. In addition, peripheral loadings were assessed to determine the reliability of the

Table 1
Item loadings, reliability, and convergent validity.

	Λ	Α	CR	AVE
		0.906	0.928	0.682
EL1	0.860			
EL2	0.873			
EL3	0.829			
EL4	0.829			
EL5	0.795			
EL6	0.766			
		0.833	0.889	0.667
DO1	0.781			
DO2	0.777			
DO3	0.864			
DO4	0.840			
		0.777	0.871	0.692
DC1	0.810			
DC2	0.863			
DC3	0.821			
		0.825	0.872	0.533
DI1	0.767			
DI2	0.781			
DI3	0.616			
DI4	0.706			
DI5	0.741			
DI6	0.759			

indicators. Values exceeding 0.6 were deemed suitable for additional data analysis, as per the methods outlined by Hair et al. (2017). At this point, four items were omitted from consideration because their factor loadings failed to meet the recommended threshold of 0.6. After verifying the convergent validity, we evaluated the discriminant validity according to the methodology outlined by Hair et al. (2017). This ensured that the correlation between items comprising the same construct was greater than that between items comprising other constructs. Following Hair et al. (2017), the discriminant validity was assessed using the heterotrait–monotrait ratios (HTMT). All HTMT statistics were below 0.85. Study 1 passed testing for discriminant validity (Tables 1 and 2).

Structural model assessment for Study 1

The examination of the structural model test constituted the second phase. These hypotheses were examined sequentially. The direct effect of T1-EL on T2-DI was also investigated. After examining the causal connections among T1-EL, T2-DO, and T2-DC, Study 1 examined the influence of T2-DO and T2-DC on T3-DI. To ascertain the significance of the estimated mean errors and direct paths, 5,000 bootstrap resamples were used (Ringle, 2005). The results presented in Table 4 indicate a statistically significant relationship between T1-EL and T3-DI (β = 0.255, t = 0.830, p = 0.406); thus, H1 is supported. Furthermore, the statistical analysis demonstrates that T1-EL exhibits a substantial influence on T2-DO (β = 0.568, t = 12.425, p < 0.000) and T2-DC (β = 0.617, t = 14,166, p < 0.000). Thus, hypotheses H2 and H3 are supported. T2-DO (β = 0.358, t = 5,480, p < 0.000) and T2-DC (β = 0.466, t = 7,255, p < 0.000) are found to have a significant effect on T3-DI, as confirmed in Study 1. Thus, H2a and H3a are supported (see Table 3).

Mediation analysis for Study 1

As hypothesized in H2b and H3b, this analysis evaluated the role of T2-DO and T2-DC in Study 1 to determine whether they mediate the correlation between T1-EL and T3-DI. The results indicate that when the mediators are included in the proposed model, there is a statistically significant and positive direct effect (β = 0.25, t = 0.43, p = 0.40). The study findings further indicate that the indirect effect is statistically significant for T2-DC (β = 0.288, t = 5.941, p < .000) and T2-DO (β = 0.203, t = 5.489, p < .000), suggesting partial mediation. Study 1 shows that the involvement of T2-DC and T2-DO influences the relationship between T1-EL and T3-DI (see Table 4).

Assessment results for Study 2

Measurement model assessment for Study 2

Similarly, for Study 2, the measurement model demonstrated satisfactory fit with the following values: $\chi 2$ = 889.801, df = 337, $\chi 2$/df = 3.829, GFI = 0.927, AGFI = 0.851, NFI = 0.981, CFI = 0.897, IFI = 0.891, RMSR = 0.050, and RMSEA = 0.082. The model is adequate when both the GFI and AGFI exceed 0.8 (Hu & Bentler, 1999). In general, this study's measurement model was deemed satisfactory (Baumgartner & Homburg, 1996). The research team initially assessed the internal reliability of Study 2 using Cronbach's alpha and CR metrics. Furthermore, the convergent and discriminant validity of the model was evaluated by examining the peripheral loadings, AVE, and Fornell–Larcker measures (Hair et al., 2017). To determine internal

Table 2
Discriminant validity (HTMT).

	DC	DI	DO	EL
DC				
DI	0.827			
DO	0.751	0.772		
EL	0.733	0.489	0.646	

Note: All HTMT values are < 0.85.

Table 3
Results from SEM.

Hypotheses	Relationships	Sample mean	Standard deviation	T statistics	P values
H1	EL -> DI	0.255	0.067	0.830	0.406
H2	EL -> DO	0.568	0.046	12.425	0.000
H2a	DO -> DI	0.358	0.065	5.480	0.000
H3	EL -> DC	0.617	0.043	14.166	0.000
H3a	DC -> DI	0.466	0.064	7.255	0.000

consistency, Cronbach's alpha and CR values must surpass the lowest acceptable threshold of 0.6 (Nunnally, 1978). The results presented in Table 3 demonstrate internal consistency. Convergent validity was assessed by analyzing the AVE scores. The findings demonstrate that each AVE value exceeds the minimum permissible value of 0.5, as established by Hair et al. (2017). In addition, peripheral loadings were assessed to determine the dependability of the indicators. Values exceeding 0.6 were deemed suitable for subsequent data analysis in adherence to the guidelines of Hair et al. (2017). In this phase, each factor was excluded because its factor loadings exceeded the recommended threshold of 0.6. Study 2 examined discriminant validity following the confirmation of convergent validity to ascertain whether the correlation between constructs was more pronounced than that between constructs (Hair et al. 2017). After analyzing the heterotrait–monotrait ratios (HTMT), it was found that every statistic fell below 0.85, which is consistent with the guidelines proposed by Hair et al. (2017). Study 2 passes the discriminant validity test (see Tables 5 and 6).

Structural model assessment for Study 2

The structural assessment of the model entailed a sequential methodological analysis of all hypotheses. In Study 2, the effects of T1-EL on T2-DI were examined, followed by the effects of T1-DO and T1-DC on T2-DI. Moreover, we assessed the influence of T2-DI on T2-SP. To assess the significance of the direct paths and obtain standard errors and confidence intervals, 5,000 bootstrap resamples were used (Ringle, 2005). T1-EL substantially influences T2-(DI), as evidenced by the statistical results shown in Table 6 (β = 0.244, t = 3.256, p = 0.001). The findings of Study 2 support the validity of H1. Furthermore, the results demonstrate that T1-EL greatly influences T1-DO (β = 0.905, t = 51.918, p < 0.000) and T1-DC (β = 0.914, t = 52.155, p < 0.000). Thus, H2 and H3 are verified. In Study 2, the results confirm that T1-DO (β = 0.164, t = 2.580, p < 0.000) and T1-DC (β = 0.560, t = 9.432, p < 0.000) have a significant effect on T2-DI. Thus, H2a and H3a are supported. The results of Study 2 confirm the substantial effect of T2-DI on T2-SP (β = 0.814, t = 18.402, p < 0.000). Therefore, H4 is fully supported. (See Table 7).

Mediation analysis for Study 2

As hypothesized by H2b and H3b, Study 2 evaluated T1-DO and T1-DC to determine whether they mediate the relationship between T1-EL and T2-DI. The results indicate that incorporating the mediator into the model leads to a significant positive direct effect (β = .24, t = 0.90, p = 0.00). A significant indirect effect is observed for T1-DC (β = 0.417, t = 8.311, p < .000) and T1-DI (β = 0.121, t = 2.584, p < 0.010). Thus, the results suggest partial mediation in Study 2, which implies that the effect of T1-EL on T2- DI in Study 2 is partially mediated through T1-DC and T1-DO (see Table 8).

Assessing predictive relevance using PLS predict

The success of the model in explaining the variability observed in the sample is supported by the R2 values presented before. The predictive relevance assessment of the model developed for sustainability performance was conducted using PLS-Predict (Shmueli et al., 2016). Training samples, which comprise a subset of the data set utilized for model

Table 4
Mediation analysis results.

Total effect (T1-EL -> T3-DI)		Direct effects (T1-EL -> T3-DI)		Indirect effects of T1- EL on T3- DI				
Coefficient	P-value	Coefficient	p-value		Coefficient	SD	T value	P- values
0.43	0.00	0.25	0.40	H2b: T1-EL -> T2-DC -> T3-DI	0.288	0.048	5.941	0.000
				H3b: T1 -EL -> T2- DO -> T3-DI	0.203	0.037	5.489	0.000

Table 5
Item loadings, reliability, and convergent validity.

	Λ	A	CR	AVE
		0.932	0.944	0.677
EL1	0.811			
EL2	0.805			
EL3	0.846			
EL4	0.815			
EL5	0.841			
EL6	0.811			
EL7	0.823			
EL8	0.827			
		0.894	0.927	0.760
DO1	0.847			
DO2	0.889			
DO3	0.888			
DO4	0.861			
		0.905	0.930	0.727
DC1	0.840			
DC2	0.760			
DC3	0.909			
DC4	0.888			
DC5	0.858			
		0.930	0.945	0.741
DI1	0.834			
DI2	0.879			
DI3	0.898			
DI4	0.850			
DI5	0.865			
DI6	0.837			
		0.902	0.928	0.719
SP1	0.828			
SP2	0.814			
SP3	0.867			
SP4	0.862			
SP5	0.868			

Table 6
Discriminant validity (HTMT).

	DC	DI	DO	EL	SP
DC					
DI	0.813				
DO	0.774	0.884			
EL	0.579	0.673	0.809		
SP	0.488	0.489	0.468	0.794	

Note: All HTMT values are < 0.85.

Table 7
Results from SEM.

Hypotheses	Relationships	Sample mean	Standard deviation	T statistics	P- values
H1	EL -> DI	0.244	0.074	3.256	0.001
H2	EL -> DO	0.905	0.017	51.918	0.000
H2a	DO -> DI	0.164	0.065	2.580	0.010
H3	EL -> DC	0.914	0.018	52.155	0.000
H3a	DC -> DI	0.560	0.060	9.432	0.000
H4	DI -> SP	0.814	0.044	18.402	0.000

estimation, and holdout samples, which contain the residual portion of the data set not employed for parameter estimation, are at the core of this methodology (Hair Jr et al., 2020; Shmueli et al., 2016). Holdout samples were used in PLS prediction to make case- or item-level predictions. PLS prediction can assess model accuracy and predict novel case outcomes (Shmueli et al., 2016). Following the guidelines by Hair Jr et al. (2020) and Shmueli et al. (2016) regarding the predictive importance of our model, we initiated the PLS prediction method using 10 folds (k = 10). Each fold of the training sample was carefully inspected to ensure compliance with the minimum sample size requirements specified by Kock and Hadaya (2018). The calculations were performed using the G* Power software. The analysis examined the Q^2-Predict values generated by the PLS-SEM model.

The PLS-SEM analysis exhibits superior performance in indicators for our primary target construct compared to the benchmark linear regression model (LM), as evidenced by the Q^2 predict value for sustainability performance. This finding implies that relying solely on the median values of the markers in the training sample reduced the precision of our analysis. Following this, we investigated the variability of estimation errors in the predictive framework that we developed and identified an asymmetrical distribution. Consequently, the acquired mean average error data were applied to the LM and PLS-SEM benchmarks. The results presented in Table 9 indicate that the mean average error values for all indicators evaluated using the PLS-SEM were significantly lower than those obtained using the LM. The predictive capability of the model was moderate.

Discussion

Statistical analysis showed that there is a positive association between entrepreneurial leadership and digital innovation. It has been proven that entrepreneurial leadership has a positive effect on innovation performance (Al-Sharif et al., 2023; Hoang et al., 2023), adaptive innovation (Lin & Yi, 2023), and open innovation (Faridian, 2023) within organizational contexts. Hence, the results obtained from Studies 1 and 2 align with those of the existing body of research. Additionally, the findings indicate that IT firm managers who demonstrate an entrepreneurial leadership style are more inclined to enhance digital innovation. Leaders use their entrepreneurial skills in competitive settings to attain digital innovation. This finding strengthens confidence in the significant impact of entrepreneurial leadership on digital innovation in the Chinese IT industry.

We discovered that the mediation analysis results of both investigations were similar. These findings indicate that there is partial mediation of the dual pathways. The results obtained from both studies are consistent with those reported in the current literature (Al-Sharif et al., 2023; Hoang et al., 2023). Research indicates that employee digital orientation is a significant predictor of digital innovation and that this correlation is strengthened by entrepreneurial leadership support. Our results show that digitally oriented employees are more receptive to digital technologies. They quickly adopt digital initiatives with dedication, which enables them to create innovative products, services, and solutions. Such cognitive abilities and ideation can only be fostered by entrepreneurial leaders who generate novel concepts and integrate innovation into management practices. Employees' digital orientation extends beyond digital technology (Meske & Junglas, 2021). It also empowers workers to feel competent in risk-taking, become

Table 8
Mediation analysis results.

Total effect (T1-EL -> T3-DI)		Direct effects (T1-EL-> T3-DI)		Indirect effects of T1-EL on T3-DI				
Coefficient	P-value	Coefficient	p-value		Coefficient	SD	T value	P- values
0.90	0.00	0.24	0.00	H2b: T1-EL -> T2-DC -> T3-DI	0.417	0.051	8.311	0.000
				H3b: T1-EL -> T2-DO -> T3-DI	0.121	0.048	2.584	0.010

Table 9
Assessment for predictive relevance for competitive advantage.

	PLS-SEM		LM	PLS-SEM-LM
Items of the dependent variable	MAE	Q2 Predict	MAE	MAE
SP1	0.817	0.228	0.801	–0.052
SP2	0.897	0.249	0.838	–0.034
SP3	0.702	0.316	0.688	–0.019
SP4	0.871	0.307	0.724	–0.027
SP5	0.773	0.218	0.750	–0.073

self-sufficient, and engage with others. Following our research findings, entrepreneurial leadership provides support to employees by fostering a culture that encourages them to enhance their digital skills and knowledge. It also promotes a sense of collective ownership and accountability toward achieving the overarching goal of digital innovation.

The evidence supporting the mediating role of digital orientation in the relationship between entrepreneurial leadership and digital innovation aligns with Drucker's productivity theory. According to this theory, digital workers who receive assistance from entrepreneurial leaders become digitally oriented and engage in digital innovation. These findings suggest that entrepreneurial leaders who prioritize digital orientation among employees and the identification of opportunities in pursuit of evolving and future-focused organizational goals not only generate creative ideas to address business challenges but also guide the innovation and opportunity recognition processes by encouraging employees to take risks (Aparicio et al., 2023). Our study suggests that adopting a digital orientation encourages employees to prioritize the integration of digital technologies to meet the evolving digital requirements of businesses and consumers. This enables them to provide digital solutions with the potential to revolutionize business models and enhance consumer experience and firm performance. Therefore, implementing digital orientation can enhance the connection between entrepreneurial leadership and digital innovation.

The assertion that employee digital capabilities in the IT sector mediate the relationship between entrepreneurial leadership and digital innovation, as observed in both studies, is consistent with previous research conducted in non-IT settings (Bhardwaj et al., 2022; Khin & Ho, 2018; Malibari & Bajaba, 2022). The unique construct of employee digital capabilities distinguishes this study's findings from those of previous research, which demonstrate that employees' digital capabilities play a pivotal role in enabling companies to revolutionize their innovative business models and, in turn, their sustainability performance (Khin & Ho, 2018).

Additionally, this study contributes to the existing body of literature on sustainability and digital innovation by examining the impact of employees' digital capabilities on organizational digital innovation within the context of the Chinese IT industry. The successful execution of digital innovation necessitates acquiring digital technology and developing novel digital solutions, both of which require proficient expertise from skilled professionals. Drucker's productivity theory, which posits that digital workers require leadership support to enhance their digital capabilities, validates this hypothesis. The findings indicate that the continuous support and guidance provided by entrepreneurial leadership and employees' ability to recognize opportunities in a volatile, uncertain, complex, and ambiguous (VUCA) environment improve their digital skills to effectively navigate the evolving challenges of the contemporary digital landscape (Ochinanwata et al., 2023). Consequently, digital workers have an enhanced understanding of the potential benefits and limitations of digital technology. This enhanced understanding empowers knowledge workers to make well-informed and prudent decisions regarding digital innovation processes. The second study focused on the research questions. We provided an integrated overview of how firms address sustainability challenges through digital innovation. We incorporated an additional sustainability performance variable to assess the extent to which digital innovation can contribute to attaining sustainability performance in IT firms. Our sector selection was informed by the IT industry's critical role in providing the digital technologies required to devise forward-looking solutions in the existing digitized economy. Our findings confirmed the existence of a positive correlation between digital innovation and sustainability performance.

These findings are consistent with those of previous studies that were conducted in non-IT settings. Prior studies have demonstrated that innovation has a substantial influence on sustainability performance (Broccardo et al., 2023; Opland et al., 2022). This finding highlights the necessity of a holistic approach for directing organizational resources toward achieving sustainability goals. Our findings underscore the importance of cultivating employee capabilities through effective leadership practices to pave the way toward sustainability through digital innovation. This finding suggests that organizations demonstrating strong leadership commitment to adopting digital technologies (Aránega et al., 2023; Faridian, 2023) and enhancing their employees' ability to navigate these technologies effectively are more likely to generate innovative digital solutions to environmental and social challenges, ultimately leading to improved sustainability performance.

This study adopted a comprehensive approach that builds on previous research, emphasizing how entrepreneurial leadership facilitates autonomous decision-making and digital competency, which are critical determinants of employee-driven innovation (Felix et al., 2019; Huu, 2023). This approach further explores the role of entrepreneurial leadership in fostering innovation while acknowledging the necessity of digital capabilities to effectively translate autonomy into innovative outcomes (Huu, 2023). The interplay between entrepreneurial leadership and digital capabilities not only drives innovative work behavior but also aligns with sustainability goals by promoting autonomous, adaptive, and efficient practices. This perspective provides practical insights into leadership strategies in the IT industry, particularly in leveraging leadership capabilities to enhance sustainability performance in the sector (Straub et al., 2023).

Theoretical contributions

This study makes four significant theoretical contributions. First, it incorporates organizational and employee factors, including entrepreneurial leadership, digital orientation, digital capabilities, and digital innovation, within a unified model to address an under-researched and critical element of organizational performance: sustainability performance. This model aimed to clarify how IT firms can improve employees' digital orientation and digital capabilities, thereby promoting digital innovation and attaining sustainability performance.

Second, this study focused on employee factors to explore the capabilities required to build a pathway from innovation to sustainability. Human resources are a crucial element of digital innovation in today's knowledge-dependent and future-focused economy; however, they are mostly neglected in the literature (Afshari et al., 2020; Farzaneh et al., 2022). This study extends the literature and incorporates employees' digital capabilities and digital orientation to provide an enriched understanding of the resources contributing to digital innovation and, ultimately, sustainability performance in organizations. We introduced a new construct, employee digital capabilities, to illuminate how effective leadership practices can orient knowledge workers' resources toward using digital technology and enhancing sustainability performance. This study contributes to the existing body of literature on leadership and organizational behavior by examining the direct effect of entrepreneurial leadership on employees' digital capabilities and orientation. Prior studies have exclusively focused on the digital capability of organizations in relation to leadership practices, neglecting its effect on employees' capabilities (Chaudhuri et al., 2022; Heredia et al., 2022; Nasiri et al., 2022).

Third, the findings indicate that entrepreneurial leadership is an essential antecedent of employees' digital orientation and digital capabilities, which are expressions of digital innovation at a deeper level. Thus, this study extends the entrepreneurship literature, which has primarily focused on demonstrating the link between entrepreneurial leadership and digital innovation and not on the mechanisms through which this link is established.

Fourth, this study focuses on sustainability performance, a critical element of organizations' evolving performance goals and an under-researched area in the literature. Only a few studies have examined capabilities that can be cultivated by leadership and that potentially affect sustainability performance. Those that have investigated the factors affecting sustainability only measured factors such as digital capabilities and orientation from an organizational perspective and ignored employee-focused perspectives (Heredia et al., 2022; Nasiri et al., 2022). Given the importance of sustainable development and digital behavior in the IT industry, this study demonstrated that entrepreneurial leadership practices can significantly improve sustainability performance by enhancing employees' digital orientation and capabilities. This finding highlights the role of employee-centered theories in enriching our understanding of sustainability performance.

Finally, this study applied Drucker's productivity theory (Drucker, 1999) to address the essential question of how and when entrepreneurial leadership improves employees' digital orientation and capability to achieve sustainability goals. To the best of our knowledge, this study is the first to use productivity theory (Drucker, 1999) to analyze the relationship between entrepreneurial leadership and IT employees' digital orientation and capabilities. It also examines how this relationship influences the digital innovation and sustainability performance of IT firms. Consequently, this study provides further evidence of the applicability of Drucker's productivity theory, which has been previously used to account for employees' actions in various settings (Sahibzada et al., 2023). Previous studies have utilized theories such as digital capability theory (Khin & Ho, 2018) and the resource-based view (Shan et al., 2019).

Implications for policy and practice

This study offers practical implications for IT industry managers and policymakers in addressing the challenges associated with digital innovation and sustainability performance. First, it emphasizes the importance of internal reorganization within firms to foster digital innovation and ensure high sustainability performance, which entails developing and applying novel digital capabilities (AlNuaimi et al., 2022), initiating cultural shifts to establish entrepreneurial leadership models, and implementing appropriate human resource management strategies to ensure digital innovation and sustainability performance. The empirical results show that entrepreneurial leadership is crucial for employees' digital orientation and capabilities, thereby enhancing digital innovation and sustainability performance in IT organizations. Moreover, IT firms that rely on digital innovation should embrace an entrepreneurial leadership style to foster innovation among employees. Entrepreneurial leadership motivates employees to recognize and seize entrepreneurial opportunities at work and act entrepreneurially (Bagheri et al., 2022). Consequently, those employees are well-prepared to address the social and environmental challenges associated with sustainability performance.

Second, this study makes practical contributions to IT firms and policymakers by emphasizing the importance of cultivating a digitally oriented culture and enhancing employees' digital capabilities. These allow employees to effectively manage digital technologies and provide innovative digital solutions to meet the challenges posed by sustainability issues. It is imperative to develop and execute targeted training programs to strengthen employees' digital capabilities. This includes providing comprehensive training ranging from foundational to advanced levels in digital tools, promoting digital literacy, and ensuring easy access to relevant resources. IT organizations can enhance their digital compatibility by honing digital skills, allowing employees to integrate new technologies effectively within their workflows. Enhancing digital skills is critical for fostering digital compatibility within an organization (Hashim et al., 2024). By equipping employees with the necessary skills, they can effectively integrate and adapt to new technologies, thereby ensuring smoother transitions and improved operational efficiency. This proactive approach empowers the workforce and drives innovation and competitiveness in the increasingly digital landscape. A critical component of establishing a connection between digital orientation and innovation is the promotion of collaborative digital platforms. IT professionals are essential for implementing user-friendly systems that facilitate knowledge sharing and collaborative project development. This process enhances employees' digital orientation and capability by providing channels for teamwork and exchanging ideas, ultimately leading to a more robust alignment between leadership vision and innovation outcomes. Moreover, IT professionals should prioritize the alignment of digital systems and tools with employees' existing workflows and capabilities. By conducting regular digital compatibility evaluations, IT professionals can identify discrepancies and implement systems that are better suited to the digital skills of the workforce. This approach will facilitate the smoother adoption and integration of digital innovations.

Finally, firms must be aware of the direct impact of digital innovation on sustainability performance. IT professionals must prioritize resource-saving digital solutions to enhance sustainability. Leveraging cloud computing, virtualization, and energy-efficient data centers can significantly reduce energy consumption and carbon footprints. With powerful analytical tools, these professionals can monitor real-time resource utilization, waste management, and environmental impacts. By identifying inefficiencies, analytics help inform and optimize sustainable operations (Agu et al., 2024). Promoting digital collaboration platforms, such as video conferencing and project management tools, can minimize business energy and travel emissions. These platforms are tailored for remote work, improving overall sustainability performance, while supporting a flexible work environment. Moreover, IT professionals can establish automated systems to monitor sustainability metrics and generate compliance reports. This approach ensures timely and precise reporting on sustainability performance, enhances transparency, and aligns with regulatory standards regarding environmental sustainability.

Limitations and future opportunities for scholars

This study has certain limitations that require further research. First, the sample was limited to Chinese IT enterprises, which restricts the study's generalizability. This study setting may not capture organizational trends in other sectors or nations. Cultural, legislative, and operational variation across sectors and geographies can affect the connection between entrepreneurial leadership and digital innovation. Second, while a time-lagged methodology provides insights into this connection over time, it is correlational and cannot establish causation like an experimental design. Offering alternative explanations for reported relationships without experimental controls remains challenging. Experimental or quasi-experimental studies could better identify and analyze the causative processes of the association between entrepreneurial leadership and digital innovation. Finally, regression analysis may overlook complex, asymmetric patterns in the interactions between entrepreneurial leadership and digital innovation due to its focus on linear connections. By incorporating multilevel and nonlinear linkages, hierarchical linear modeling and fuzzy-set qualitative comparative analysis may enhance our understanding of organizational contexts. These methods could reveal subtle variable correlations, revealing the setups or situations of the association between entrepreneurial leadership and digital innovation.

Conclusions

This study adopts an integrated approach to addressing the pressing need to foster sustainability performance in the IT sector. It provides insights into the pathways from leadership toward enhanced sustainability performance, focusing on employee-centered factors. Using time-lagged data from two studies, this study illuminates the mechanisms that align organizations' human resources with digital innovation and, ultimately, enhanced sustainability performance. The findings of this study support Drucker's productivity theory, which states that entrepreneurial leadership enhances IT firms' sustainability performance through digital innovation by developing employees' digital capabilities and orientation.

CRediT authorship contribution statement

Umar Farooq Sahibzada: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Nadia Aslam Janjua:** Methodology, Investigation, Formal analysis, Conceptualization. **Leila Afshari:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Muhammad Shakil:** Supervision, Investigation.

Declaration of competing interest

none

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