

The Digital Path to a Dual Win: How Entrepreneurial Leadership and Stakeholder Integration Drive Sustainable Performance

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Received: June 22, 2025 Accepted: January 17, 2026 Online Published: February 20, 2026

doi:10.5430/jbar.v15n1p1

URL: <https://doi.org/10.5430/jbar.v15n1p1>

Abstract

While digitalization is recognized as a driver of competitiveness, a critical question remains: how does it simultaneously advance environmental sustainability and profitability? The existing literature offers limited insight into the impact of digitalization on sustainable development. Grounded in the dynamic capabilities view, our study unpacks this relationship by testing a moderated mediation model. We theorize that digitalization enhances both environmental performance (EP) and financial performance (FP) through the mediating mechanism of stakeholder integration, and that this effect is moderated by entrepreneurial leadership (EL). An analysis of survey data from 294 Chinese firms confirms the validity of our framework. The findings show that digitalization has a direct and positive influence on both EP and FP. This effect is partially channeled through stakeholder integration. Significantly, the benefits of digitalization are amplified under high entrepreneurial leadership, which boosts the firm's capacity for effective stakeholder engagement. By defining a transparent mechanism and a critical contingency, our research provides novel insight into how firms can leverage digital transformation to achieve a "dual-win" for both the planet and profits. Thus, it contributes to the existing literature on innovation, strategy, and entrepreneurship.

Keywords: Digitalization, dynamic capabilities, entrepreneurial leadership, sustainability, stakeholder integration

1. Introduction

In today's increasingly uncertain and competitive global marketplace, digital transformation has emerged as a critical strategic imperative for businesses seeking to drive innovation, operational flexibility, and sustainable competitive advantage (Wen et al., 2022; Wu et al., 2022). The use of new technologies, such as artificial intelligence (AI), blockchain, the Internet of Things (IoT), and big data analytics, is revolutionizing traditional business practices and reshaping stakeholder interactions and internal operations (Ritter & Pedersen, 2020). Technological tools increase automation, improve decision-making accuracy, and ensure seamless communication across complex supply chains (Han & Trimi, 2022). As businesses navigate the new realities of the market, digitalization has emerged as a foundational element of strategic management—enhancing customer experience, fostering responsiveness, and enabling real-time decision-making (Talwar et al., 2023). Considering this transformational capability, scholars and practitioners are increasingly interested in the role of digital technologies in advancing sustainability objectives (Lu et al., 2024; Luo et al., 2023). Digitalization is now widely regarded as a driver of environmental balance and economic sustainability by promoting innovative behavior and optimal resource efficiency (Ardito, 2023; Broccardo et al., 2023). In line with the literature on sustainability, sustainable development (SD) in this research is defined as the strategic alignment of environmental stewardship and economic performance across key business operations to achieve the highest long-term organizational value (Kafetzopoulos & Gotzamani, 2022; Li, 2022; Rahi et al., 2023).

Despite growing appreciation of the importance of digitalization, its dual contribution to environmental performance (EP) and financial performance (FP) remains underexplored in the strategy and sustainability literature. Previous research has primarily focused on the distinct effects of individual technologies on specific areas, such as energy efficiency (Lange et al., 2020), servitization (Kohtamäki et al., 2020), green activities (Denicolai et al., 2021), and financial performance (Abou-Foul et al., 2021). Although digital technologies are frequently claimed to be cost-saving and efficiency-enhancing (Ciarli et al., 2021), their overall impact on companies' SD performance is rarely studied.

Based on the dynamic capabilities approach, digitalization enables firms to adapt their operations and assets to

reconfigure for sustainability, making it a core part of their business (Khurana et al., 2022; Xu et al., 2023). For example, digital technologies can increase resource productivity, reduce environmental footprint, and enable supply chain optimization (Yang et al., 2021), thereby enhancing environmental performance (EP). At the same time, they allow the establishment of new business models and revenue streams, thereby increasing financial performance (FP) through innovation and strategic agility (Neligan et al., 2023). Thus, the current research aims to analyze the extent to which digitalization supports the environment and finances of sustainable development. However, although digitalization appears to drive SD, the intra-firm mechanisms underlying this relationship remain poorly described. Previous studies offer limited explanations of how digital transformation produces sustainable outcomes (Talwar et al., 2023). To occupy this void, the existing literature proposes stakeholder integration as a potential mediating variable. Stakeholder integration is defined as a firm's ability to extend its reach to stakeholders—employees, customers, suppliers, and communities—and align its strategies with their expectations and interests (Hristov & Appolloni, 2022; Shi & Tsai, 2020).

Literature on corporate sustainability emphasizes that compliance with stakeholder demands is crucial in making sustainability initiatives meaningful and effective (Ahmed & Shafiq, 2022; Khaled et al., 2021). By actively engaging with stakeholder contributions in strategic decision-making, firms can address environmental concerns more effectively and enhance financial performance (Gupta et al., 2020). Digital technologies enable such alignment by allowing timely communication, data sharing, and cooperation (Hoblos et al., 2023). From a dynamic capability perspective, digitalization equips organizations with the necessary tools to respond in real-time to stakeholder pressure and enhance sustainability plans through feedback loops and analysis (Zheng et al., 2023; Broekhuizen et al., 2021). Therefore, the second aim of the current study is to explore how stakeholder integration mediates the impact of digitalization on sustainable development outcomes.

In addition to determining the mediating role of stakeholder integration, it is equally important to identify the contextual variables that would strengthen or weaken its efficacy. Although stakeholder participation increases the value of digital efforts, the leadership style is likely to determine the initiative's success. Entrepreneurial leadership (EL), characterized by vision, proactivity, and risk-taking, is highly relevant to guiding digital transformation projects toward sustainable outcomes (Ali et al., 2023). Entrepreneurial leaders generate innovation and set the stage for digital technologies to flourish (Nair, 2020). Given the inherent uncertainties and issues associated with digital programs (Hallin et al., 2022; Warner & Wäger, 2019), effective leadership is crucial for aligning digital programs with the broader needs of stakeholders and sustainability goals (Schaltegger & Wagner, 2011).

Entrepreneurial leaders are better positioned to guide digital challenges strategically, thereby achieving sustainability goals through deliberate integration and effective change management. Hence, the third objective of this research is to examine entrepreneurial leadership as a moderator of the indirect relationship between digitalization and sustainable development through stakeholder integration. In summary, this study develops a moderated mediation model (see Fig. 1) to gain insight into the process by which digitalization promotes sustainable development. This research contributes threefold. First, it strengthens sustainability and strategic management research by empirically verifying the double impact of digitalization on the environment and profitability. Second, it reveals stakeholder integration as a crucial mechanism for transforming digital capabilities into sustainable results. Third, it identifies entrepreneurial leadership as a boundary condition that enables this. Together, the foregoing findings provide an overall view of the connection between digitalization and sustainability, enriching practice and theory within the strategy and entrepreneurship field (Talwar et al., 2023).

2. Theoretical Framework

2.1 Organizational Conceptualization of Digitalization

Digitalization refers to the strategic utilization of digital technologies to redefine how firms conduct business, create value, and engage with stakeholders (Broccardo et al., 2023). It encompasses a broad spectrum of initiatives, such as the adoption of technologies such as artificial intelligence (AI), cloud computing, big data analytics, and the Internet of Things (IoT), which are integrated into day-to-day operations to make things easier and produce better outcomes (Ritter & Pedersen, 2020). Such digital interventions enable firms to be more responsive, foster efficiency, and stimulate innovation by streamlining core operations, including communication, production processes, and customer relations (Ahmed et al., 2022). Digitalization also enhances organizational transparency by providing stakeholders with real-time access to information and detailed monitoring systems, thereby improving accountability and corporate governance structures (Aben et al., 2021). Additionally, by facilitating automation, sophisticated analytics, and the development of new products, digital technologies enable a competitive advantage in increasingly digitalized markets (Cheng et al., 2023).

2.2 Digitalization as a Dynamic Capability for Sustainable Development

Dynamic capabilities address a firm's ability to adjust systematically, combine, and recombine internal competencies and external assets in response to an ever-changing environment (Ghosh et al., 2022). According to the resource-based view, the theory emphasizes that competitive advantage does not only stem from owning valuable resources but from having the capability to mobilize and build them to a higher level of effectiveness under uncertainty and change (Do et al., 2022). Dynamic capabilities facilitate organizational learning, innovation, and strategic adaptability, enabling firms to respond to technological advancements, evolve in response to changing stakeholder expectations, and adapt to shifting market conditions (Knoppen & Knight, 2022). With such adaptive capacities, organizations can consistently reinvigorate their processes and strategies to ensure resilience, long-term applicability, and sustainability (Buzzao & Rizzi, 2021). Positioning digitalization as a dynamic capability underscores its strategic importance in enabling companies to respond to environmental and market changes, promote transparency, and enhance governance (Manita et al., 2020). With digital tools, organizations have access to advanced monitoring systems, enabling them to monitor performance more effectively, utilize resources more efficiently, and incorporate data-driven sustainability approaches (Nayal et al., 2022). For instance, big data analytics can provide a better understanding of consumption behaviors and emissions, helping ensure more precise energy management and waste minimization.

Furthermore, digitalization accelerates innovation towards more sustainable solutions, enabling organizations to quickly prototype and introduce sustainable products and services that align with evolving consumer values (Ghobakhloo et al., 2021). Thus, digital technologies are not only operational enhancers but also drivers of the adoption of social and environmental obligations in business models (Zheng et al., 2023). Despite growing awareness of the change-making potential of digitalization, its role in advancing sustainable development remains poorly explored. Scholarly research in this vein tends to limit its impacts to economic measures (Zeng et al., 2022), corporate social responsibility (Zheng & Zhang, 2023), energy consumption (Lange et al., 2020), or environmental innovation (Hao et al., 2023), but fails to offer a single framework that encapsulates its broader implications for sustainable development. Filling this gap, the present work argues that digitalization, as a dynamic capability, enables companies to make a substantial contribution to both environmental and financial performance. Through its ability to bring transparency, innovation, and leading responsible governance, digital technology serves as a strategic lever for embedding sustainability in business operations. This perspective underscores the vital importance of examining the integrative role of digitalization in achieving sustainable development, thereby laying the groundwork for developing and applying theory in strategic management for sustainability.

3. Hypothesis Development

3.1 Digitalization and Sustainable Development

We believe that digitalization has the potential to significantly enhance a company's environmental performance by making its processes more efficient and effective. Existing studies recognize that digital technologies enable organizations to optimize the use of available resources, thereby reducing waste and minimizing negative environmental impacts (Li et al., 2020). Digital technologies, such as artificial intelligence, the Internet of Things (IoT), and big data analytics, enable companies to monitor energy consumption and operational inefficiencies in real-time, empowering them to pursue data-driven sustainability measures (Ahmad et al., 2021). These technological capabilities encourage more sustainable business practices, including emissions reduction and material recycling, that fully enable environmental stewardship (Kunkel & Matthess, 2020). According to Ardito (2023), these technologies would allow companies to achieve operational excellence while balancing ecological goals.

Furthermore, digitalization accelerates the integration of green technology and supply chain optimization (Edwin Cheng et al., 2022), paving the way for improved sustainability outcomes. Digitalization also facilitates the development of sustainable innovations. It enables firms to utilize digital simulations and prototyping to develop and test environmentally friendly solutions more efficiently (Feng et al., 2022). Additionally, by facilitating enhanced transparency, digital tools allow firms to communicate their environmental performance more efficiently in line with regulatory requirements and stakeholder demands (Saldanha et al., 2022). Lastly, digitalization fosters a culture of green innovation and continuous improvement, which enhances firms' green image and competitiveness in environmentally conscious markets (Martínez-Caro et al., 2020; Rosamartina et al., 2022).

H1: *Digitalization has a positive effect on environmental performance.*

In addition to its environmental characteristics, we propose that digitalization is also a driving force for financial performance, facilitating operational efficiencies, cost reductions, and revenue growth. Automation and artificial intelligence-driven systems enhance processes, save time, and minimize errors, leading to increased productivity and reduced overhead (Mithas et al., 2022; Vlachos et al., 2023). Big data technologies and predictive analytics enable even more informed decision-making regarding inventory, prices, and demand forecasting, leading to optimal resource

utilization and higher margins (Mariani & Wamba, 2020; De Giovanni, 2021). These efficiencies manifest as improved bottom-line results and competitive strength (Xiong et al., 2022). Moreover, digital technology opens new opportunities for value creation. Digital channels and e-commerce sites make markets more accessible and enhance customer interactions, leading to increased revenue opportunities (Elia et al., 2021). Digital technology enables companies to innovate products more quickly, allowing them to respond to customer demand and resulting in improved conversion rates and customer loyalty (Mustak et al., 2024). Additionally, business model innovations, such as digital subscriptions and platform-based business models, generate recurring revenue and long-term profitability (Ancillai et al., 2023).

H2: *Digitalization enhances financial performance.*

3.2 The Mediating Role of Stakeholder Integration

Stakeholder integration involves the active engagement of stakeholders—such as customers, employees, suppliers, and communities—and the consideration of their interests in strategic and operational decision-making (Aksoy et al., 2022; Roscoe et al., 2020). This process is three-dimensional and involves grasping stakeholder needs, having ongoing interaction, and adjusting business strategies accordingly (Amankwah-Amoah et al., 2018; Plaza-Úbeda et al., 2010). Gaining insights from stakeholders helps businesses develop relevant sustainability strategies (Harrison et al., 2010), while ongoing interaction fosters trust and uniformity (Scandeliu & Cohen, 2016). Adaptive behavior ensures organizational responses are prompt and stakeholder-focused (Ortiz-Avram et al., 2024). Firms that use stakeholder perspectives in digitalization processes are likely to be in a better position to tackle environmental problems.

Digitalization, through dynamic capabilities, provides the channel through which stakeholder and environmental information can be gathered and processed in real-time (Chen et al., 2022), thereby enabling firms to link their sustainability ambitions with stakeholders' priorities (Brunetti et al., 2020). Transparent communication via digital platforms allows firms to receive feedback and adjust their ecological strategies accordingly (George & Schillebeeckx, 2022), thereby enhancing responsiveness and impact. Stakeholder collaboration also supports the co-creation of environmentally sustainable innovations. Supplier collaboration yields more sustainable technologies, whereas customer collaboration results in sustainable product design (Mishra et al., 2023). Such collaboration processes, supported by digital infrastructure, enable companies to reorganize their value chains in pursuit of environmental goals (Makhloufi et al., 2022).

H3: *Stakeholder integration mediates the relationship between digitalization and environmental performance.*

Similarly, stakeholder integration enhances the link between financial performance and digitalization. As much as digital investments facilitate operational efficiency and innovation (Saarikko et al., 2020), their full financial worth can only be attained when linked to stakeholder goals (Hoblos et al., 2023). By integrating stakeholders into digital strategy, businesses can easily identify profitable innovations and maximize their investment. Customer interaction enables firms to tailor their products to meet market requirements, thereby promoting sales and fostering customer loyalty (Varadarajan et al., 2022). Supplier collaboration enhances cost efficiency and responsiveness (Dong et al., 2020). Dynamically, firms with regular stakeholder participation can continually adapt to changing situations, thereby sustaining a competitive advantage and profitability (Hughes et al., 2022).

H4: *Stakeholder integration mediates the relationship between digitalization and financial performance.*

3.3 The Moderating Role of Entrepreneurial Leadership

Entrepreneurial leadership (EL) is characterized by inspiring innovation, identifying opportunities, and taking calculated risks aligned with strategy, particularly in high-risk environments (Ali et al., 2023). Such leaders foster a culture of creativity, experimentation, and agility, which is crucial in addressing the challenges of digital transformation (Simba & Thai, 2019; Akbari et al., 2020). We propose that the mediated impact of digitalization on environmental performance through stakeholder integration is enhanced by effective entrepreneurial leadership.

Entrepreneurial leaders are effective at combining digital instruments with environmental causes and empowering groups to engage positively with stakeholders (Dubey et al., 2020; Ritala et al., 2021). Their strategic vision ensures that digital initiatives not only become established but also optimized to deliver the most outstanding sustainability value. They foster stakeholder feedback loops, trigger innovation, and enable experimentation in environmental management (Yin & Yu, 2022). In contrast, entrepreneurial leadership in decline may adopt a risk-averse approach, limit the value-creation capabilities of digital tools, and reduce the effectiveness of stakeholder integration.

H5: *The indirect effect of digitalization on environmental performance via stakeholder integration is stronger in the presence of high entrepreneurial leadership.*

In the corporate sector, entrepreneurial leaders empower firms to leverage the power of digitalization through

facilitating strategic innovation and market sensitivity. Entrepreneurial risk-taking and awareness of opportunities drive business model innovation, process innovations, and stakeholder alignment (Miao et al., 2019; Xia et al., 2023). Entrepreneurial leaders also co-create financial value by engaging stakeholders in digital innovation practices, enhancing customer satisfaction, and fostering loyalty (Nor-Aishah et al., 2020). Without entrepreneurial leadership, digital investments may fail to achieve their full potential, and stakeholder involvement may lack strategic depth, thereby reducing the financial value of digitalization. We therefore posit that entrepreneurial leadership provides critical strength to the sought-after financial outcomes of digitalization when channeled through stakeholder integration.

H6: The indirect impact of digitalization on financial performance, channeled through stakeholder integration, is greater in high-entrepreneurial leadership.

4. Research Methodology

4.1 Study Setting and Data Generation

China is one of the world's leading economies and a major emitter of greenhouse gases, facing significant environmental challenges (Ali et al., 2023a). According to the World Health Organization, more than 2 million deaths are attributed to pollution worldwide each year. In response, the Chinese government has imposed stringent environmental regulations to mitigate environmental harm from intensified industrialization, for instance, by closing highly polluting activities (Nace, 2017). This is while China is a global leader in digital innovation, spearheading a digital revolution in its industrial economy. This simultaneous intersection of sustainability needs and digital advancement positions China within an interesting scenario for studying how digitalization can support sustainable performance. Information for this study was gathered using structured questionnaires. The initial questionnaire was designed in English, utilized established scales, and expert interviews. A forward-backward translation was employed to ensure both linguistic equivalence and cultural suitability.

The survey was translated from English into Chinese by two strategic management experts and two distinct academics, then translated back into English to verify the accuracy (Berry, 1980). A pilot test involving 30 CEOs from 10 local firms was conducted to refine the instrument before the full application. To ensure geographic representativeness, firms were selected from multiple provinces using industrial directories provided by local Chambers of Commerce. A total of 1,700 firms were sampled, with 600 from each of the three principal regions. After initial contact via telephone and e-mail, 345 firms agreed to be interviewed in person. These were conducted by trained researchers in collaboration with senior management, typically lasting one hour, thereby ensuring high-quality responses and minimizing missing data.

To minimize common method bias, data were collected from two respondents per firm: CEOs or presiding officers, who provided information on digitalization and entrepreneurial leadership. At the same time, top managers completed stakeholder integration and sustainability outcomes items. In addition to missing questionnaires, we received responses from 296 firms in large manufacturing industries, including information technology, chemicals, energy, and machinery, resulting in 589 practical answers, for an effective response rate of 19.6%.

Table 1. Description of the firm (N = 296).

Sample characteristics	Frequency	%	Sample characteristics	Frequency	%
Firm age	Firm size			87	29.59
0-10	92	31.300-100		48	16.33
11-20	121	41.15100-200		35	11.90
21-30			48	83	28.22
36-40	16.33	200-350		41	13.95
36-50				131	44.44
Above 50				86	29.24
Revenues (in million				75	25.51
RMB)				26	8.85
0-20				42	14.29
11-40				68	23.12
31-60				115	39.10

51-80				25	8.50
51-100					
Above 100					
Ownership					
State-owned					
Private					
Others	24	8.16	Agriculture	18	6.12

4.2 Nonresponse Bias

To assess nonresponse bias, we also compared early and late respondents on significant firm variables, such as size, age, ownership, and geographical region, using one-way ANOVA (Armstrong & Overton, 1977). Results indicated that there were no significant differences in firm age ($F = 1.107, p > 0.05$), size ($F = 1.063, p > 0.01$), ownership ($F = 0.764, p > 0.10$), or region ($F = 1.264, p > 0.05$), which suggests nonresponse bias is not a severe threat to the validity of our results.

4.3 Measurement of Variables All the measurement items were adopted from established scales and adjusted for contextual fit. All the constructs utilized a seven-point Likert scale (1 = strongly disagree, 7 = strongly agree). Exemplary items are presented in Appendix A.

4.3.1 Entrepreneurial Leadership

Entrepreneurial leadership was measured using eight items adapted from Renko et al. (2015) and Ali et al. (2023), which capture a leader's inclination toward innovation, strategic risk-taking, vision, and empowering behavior. The items gauged leaders' ability to inspire change, stimulate creativity, and disrupt current practices.

4.3.2 Digitalization

Digitalization was measured using four items, as described by Nasiri et al. (2020) and Li (2022), which assess the degree to which a company has integrated digital technologies into its operational activities, information exchange, data utilization, and cross-functional networking.

4.3.3 Stakeholder Integration

Stakeholder integration, as measured by Danso et al. (2020) and Plaza-Úbeda et al. (2010), is a multidimensional construct comprising stakeholder knowledge (4 items), interaction (4 items), and adaptive behavior (5 items). These dimensions reflect the firm's sensitivity to stakeholder expectations, the level of involvement, and the flexibility in corresponding changes in strategy.

4.3.4 Environmental Performance

Environmental performance was measured using four items adapted from Han and Huo (2020) and Wang et al. (2015), focusing on emissions reduction, hazardous material management, incident rate, and energy efficiency.

4.3.5 Financial Performance

Financial performance was measured using four items from Vickery et al. (2003) and Lee and Roh (2023), which focused on profitability, return on sales, and return on investment relative to industry competitors.

4.3.6 Control Variables

Control variables included firm age (log), firm size (employees, log), ownership structure (SOE = 1, non-SOE = 0), industry competition (1 = low, 4 = high), and CEO education level (categorical dummy: 1 = high school to 5 = doctoral degree).

4.4 Construct Validity

Cronbach's alpha was 0.812 to 0.901, indicating high reliability. Confirmatory factor analysis in AMOS 22 yielded a good model fit: $\chi^2/df = 2.180$ ($p < 0.001$), CFI = 0.914, GFI = 0.972, NNFI = 0.932, SRMR = 0.051, and RMSEA = 0.064. All factor loadings were greater than 0.70, AVE values were greater than 0.50, and composite reliabilities were greater than 0.70 (Hair et al., 2014). Discriminant validity was established using chi-square difference tests (Anderson & Gerbing, 1988), and all were statistically significant. Additionally, the square root of every construct's AVE was higher than its correlations with other constructs. Multicollinearity was also not an issue, as all VIF values ranged from 0.92 to 2.23, with an average of 1.16.

4.5 Common Method Bias

Multiple techniques were employed to control for common method bias (CMB). First, data were gathered from various respondents across each company. Second, Harman’s single-factor test via CFA revealed four factors, which explained 68.21% of the variance, with the most significant factor accounting for 29.29% of the variance. Third, a marker variable (respondent marital status) was included; its relationship ($r = 0.001$) did not skew the results. Once controlled for, all significant relationships remained, alleviating concerns about CMB.

4.6 Analytical Strategy

We estimated our moderated mediation model using PROCESS (Preacher et al., 2007), with mediation analysis (Baron & Kenny, 1986) for H3 and H4 and moderated mediation analysis (Edwards & Lambert, 2007) for H5 and H6. Bootstrapping with 5,000 resamples generated Monte Carlo confidence intervals.

5. Results

5.1 Direct Effects

Descriptive statistics and correlations are shown in Table 2. Model 5 and Model 8 in Table 3 indicate that digitalization has a positive effect on environmental performance ($\beta = 0.230, p < 0.001$) and financial performance ($\beta = 0.268, p < 0.001$), confirming H1 and H2.

Table 2. Correlation matrix and discriminant validity

Variables	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11
1. Firm age e	1.320	0.79	-										
2. Firm size e	2.902	0.894	0.004	-									
3. Firm ownership	1.591	0.810	-0.005	-0.08	-								
4. Industrial competition	3.041	0.793	-0.007	0.020	0.07	-							
5. CEO age e	5.849	0.821	-0.008	0.007	-0.110*	-0.008	-						
6. CEO education	2.653	0.641	0.041	0.006	0.001	0.000	0.040	-					
7. Entrepreneurial leadership	4.925	0.792	0.080	0.020	-0.080	0.100*	0.020	0.040	0.791				
8. Digitalization	5.375	0.810	-0.006	-0.090	0.030	0.130*	0.010	0.120*	0.290*	0.811			
9. Stakeholder integration	4.854	0.714	0.040	0.070	0.030	0.010	0.050	-0.080	0.410**	0.360**	0.819		
10. Environmental performance	5.341	0.922	-0.060	-0.090	0.030	0.102*	-0.050	0.130*	0.251*	0.420**	0.270**	0.862	
11. Financial performance	4.642	6.361	0.104*	0.110*	-0.080	0.100*	0.004	0.090	0.380**	0.350**	0.310**	0.300**	0.849

Diagonal elements (in bold) are the square roots of the AVE values;

* $p < 0.05$, ** $p < 0.01$; 2-tailed; N = 294;

e Natural logarithm taken.

Table 3. Regression results

<i>Control variables</i>	Stakeholder integration			Environmental performance			Financial performance		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Firm age							0.062	0.064	0.0683
Firm size							(0.025)	(0.023)	(0.034)
Firm ownership	- (0.31)	- (0.31)	- (0.30)	- (0.20)	0.02 (0.22)	0.026 (0.24)	0.021*	0.113*	0.125*
Industrial competition	- (0.29)	- (0.28)	- (0.29)	0.02 (0.12)	0.04 (0.13)	0.03 (0.14)	(0.047)	(0.034)	(0.012)
CEO age	0.01 (0.20)	0.01 (0.21)	0.01 (0.27)	- (0.20)	- (0.12)	- (0.20)	0.044 (0.311)	0.058 (0.310)	0.0397 (0.272)
CEO education	0.03 (0.19)	0.03 (0.18)	0.03 (0.25)	0.04 (0.10)	0.04 (0.20)	0.03 (0.36)	0.037 (0.154)	0.050 (0.232)	0.042 (0.263)
Main effects	- (0.12)	- (0.16)	0.02 (0.15)	- (0.23)	- (0.24)	- (0.30)	0.008	0.007	0.019
Digitalization	0.03 (0.08)	0.08 (0.04)	0.09 (0.10)	0.04 (0.10)	0.06 (0.07)	0.08 (0.03)	(0.256)	(0.231)	(0.251)
Entrepreneurial leadership		0.17* (0.01)	0.17** (0.01)		0.23** (0.00)	0.18* (0.01)	(0.253)	(0.205)	(0.221)
Mediating effect			0.14* (0.01)					0.268*** (0.000)	0.180* (0.021)
Stakeholder integration					0.29** (0.00)				0.340*** (0.000)
Moderating effect of									
Digitalization × entrepreneurial leadership	0.196** (0.020)								
Model summary		0.293							
R ²	0.125		0.321	0.243	0.327	0.341	0.158	0.208	0.314
Adjusted R ²	0.210	0.237	0.293	0.201	0.242	0.230	0.220	0.242	0.311
ΔR ²		0.168***	0.028***			0.084***	0.014***	0.050***	0.106***
F value	7.495***	8.754***	8.781***	8.475***	10.242***	13.964***	8.764***	9.890***	15.352***

*p < 0.05; **p < 0.01; ***p < 0.001; 2-tailed; N = 296.

5.2 Mediation Analysis

To test Hypotheses 3 and 4, we applied Baron and Kenny’s (1986) four-step mediation procedure. In this approach, one must show that (1) the independent variable (digitalization) significantly affects the mediator (stakeholder integration), (2) the independent variable significantly affects the dependent variable, (3) the mediator significantly affects the dependent variable when the independent variable is controlled, and (4) the effect of the independent variable on the dependent variable is reduced (for partial mediation) or eliminated (for full mediation) when the mediator is included

In the estimation of H3, digitalization was a significant predictor of stakeholder integration ($\beta = 0.177, p < 0.01$), which in turn significantly predicted environmental performance ($\beta = 0.298, p < 0.001$). The direct effect of digitalization on

environmental performance dropped ($\beta = 0.111, p < 0.05$) after controlling for stakeholder integration, corroborating the partial mediation. Sobel test ($z = 2.670, p < 0.01$) and the Monte Carlo Method (CI = 0.083–0.252) also validated this effect. The findings are comprehensively stated in Table 3. For H3 (stakeholder integration mediates the effect of digitalization on environmental performance, EP), all four conditions were satisfied: Digitalization \rightarrow Stakeholder Integration: Digitalization has a significant positive effect on stakeholder integration ($\beta = 0.177, p < 0.01$). Digitalization \rightarrow EP: Digitalization also directly increases EP ($\beta = 0.230, p < 0.001$). Stakeholder Integration \rightarrow EP: Stakeholder integration significantly predicts EP when controlling for digitalization ($\beta = 0.298, p < 0.001$). Direct Effect Reduction: Adding stakeholder integration to the model substantially reduces the direct effect of digitalization on EP (the coefficient drops to $\beta = 0.111, p < 0.05$).

Similarly, H4 was supported because stakeholder integration mediated the effect of digitalization on financial performance. Digitalization had a significant impact on stakeholder integration ($\beta = 0.177, p < 0.01$) and financial performance ($\beta = 0.268, p < 0.001$). Stakeholder integration also significantly predicted financial performance ($\beta = 0.340, p < 0.001$). Including stakeholder integration reduced the impact of digitalization on financial performance ($\beta = 0.180, p < 0.05$). Both the Sobel test ($z = 3.471, p < 0.01$) and the Monte Carlo Method (CI = 0.053–0.314) confirmed partial mediation.

5.3 Moderated Mediation Analysis

Hypothesis 5 examines whether entrepreneurial leadership moderates the indirect effect of digitalization on environmental performance through stakeholder integration. To test this proposition, we employed the MODMED procedure developed by Preacher et al. (2007). As reported in Table 4, the analysis was based on 5,000 bootstrap resamples, yielding 95% confidence intervals. The results indicate that the direct effect of digitalization on environmental performance remains significant ($\beta = 0.111, p < 0.05$). More importantly, the magnitude of the indirect effect varies markedly across different levels of entrepreneurial leadership. Specifically, when entrepreneurial leadership is high, the indirect effect of digitalization on environmental performance via stakeholder integration is positive and statistically significant ($\beta = 0.268, 95\% \text{ CI} = [0.081, 0.266]$). In contrast, under low levels of entrepreneurial leadership, the corresponding indirect effect is weak and not statistically significant ($\beta = 0.031, 95\% \text{ CI} = [-0.015, 0.102]$). These findings indicate that entrepreneurial leadership strengthens the mediating role of stakeholder integration in the digitalization–environmental performance relationship, thereby supporting Hypothesis 5. That is, H5 was estimated using PROCESS with 5,000 bootstraps. The indirect effect of digitalization on environmental performance via stakeholder integration was stronger at high levels of entrepreneurial leadership ($\beta = 0.268, 95\% \text{ CI} = [0.081, 0.266]$) than at low levels ($\beta = 0.031, 95\% \text{ CI} = [-0.015, 0.102]$), in support of H5.

Table 4. Conditional indirect effect of digitalization on environmental performance in the presence of entrepreneurial leadership

Mediating effect	<i>B</i>	<i>SE</i>	95% bias-corrected <i>CI</i>
Direct effect of digitalization on sustainable performance			
Digitalization - environmental performance			
Conditional indirect effect across entrepreneurial leadership	0.111	0.037	[0.041, 0.231]
Low – 1SD	0.031	0.020	[-0.015, 0.102]
Medium	0.093	0.033	[0.064, 0.157]
High + 1SD	0.268	0.042	[0.081, 0.266]

Note. SE: standard error, CI: confident interval. Original size = 294, bootstrapping size = 5,000.

H6 was also supported. The indirect impact of digitalization on financial performance through stakeholder integration was considerably more positive at high levels of entrepreneurial leadership ($\beta = 0.290, 95\% \text{ CI} = [0.064, 0.216]$) than at low levels ($\beta = 0.052, 95\% \text{ CI} = [-0.019, 0.123]$).

Table 5. Conditional indirect effect of digitalization on financial performance under the presence of entrepreneurial leadership

Mediating effect	<i>B</i>	<i>SE</i>	95% bias-corrected <i>CI</i>
Direct effect of digitalization on financial performance			
Digitalization - financial performance	0.180	0.042	[0.046, 0.303]
Conditional indirect effect across entrepreneurial leadership			
Low - 1SD	0.052	0.026	[-0.019, 0.117]
Medium	0.123	0.043	[0.042, 0.139]
High + 1SD	0.290	0.058	[0.064, 0.210]

Simple slope analysis (Aiken & West, 1991) confirmed the interaction effects. With entrepreneurial leadership at a +1 standard deviation, the relationship between digitalization and stakeholder integration was much more positive, as shown in Figure 1. As depicted in Figure 1, the interaction between digitalization and stakeholder integration is more pronounced at high EL levels than at low levels.

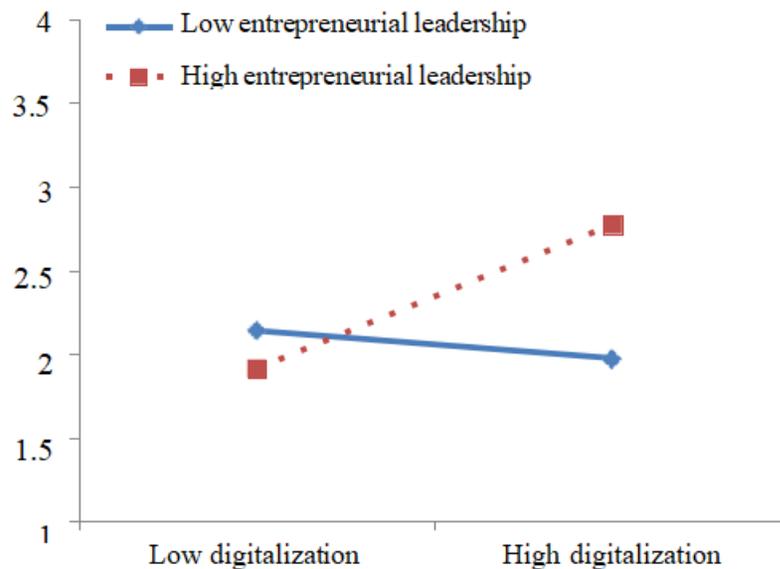


Figure 1. The relationship between digitalization and stakeholder integration

6. Discussion

Drawing on the dynamic capabilities approach, this study examined how digitalization sustains both environmental and financial development performance and the extent to which this interaction is shaped by stakeholder integration and entrepreneurial leadership. Drawing on empirical data from Chinese manufacturing firms, the study confirms that digitalization significantly influences firms’ environmental and financial performance.

Moreover, stakeholder integration is the key mediating factor that translates digital transformation activities into tangible sustainability gains. Interestingly, this mediating effect is further amplified in firms with high-level entrepreneurial leadership. This research contributes new insights to business strategy and sustainability literature by uncovering the mechanisms and boundary conditions through which digitalization facilitates sustainable development.

6.1 Key Findings

We present strong empirical evidence for the hypotheses we anticipated. Second, digitalization impacts environmental performance and financial performance in both direct and indirect ways. The signals indicate that digital technologies help firms simplify processes, reduce waste, and decrease environmental impact (Martínez-Caro et al., 2020) while concomitantly improving profitability through increased efficiency and cost savings (Chen & Zhang, 2024).

These results align with previous research highlighting the value of digital technology in achieving both environmental (Bendig et al., 2023) and economic (Yang & Yee, 2022) benefits. More generally, the result affirms the strategic value of digital transformation as a twin-edged promoter of sustainability. Second, the study finds that stakeholder integration is a determinant of the link between digitalization and sustainable performance. While digital technology offers operational advantages, its impact is significantly enhanced when organizations actively engage stakeholders in the design and implementation of their digital strategy. By aligning technological efforts with stakeholder requirements, organizations can make their sustainability efforts pertinent, participative, and results-focused. This outcome demonstrates that stakeholder integration enhances the effectiveness of digitalization, resulting in broader improvements in both environmental performance and profitability.

Third, the results emphasize the strong moderating influence of entrepreneurial leadership. The indirect effect of digitalization on sustainable performance through stakeholder integration is much stronger for firms with high entrepreneurial leadership. Visionary and opportunity-oriented leaders actively initiate innovation and propel stakeholder engagement in digital transformation. This type of leadership fosters alignment between digital and sustainability strategies, thereby amplifying their impact on both environmental and financial performance. Thus, cultivating entrepreneurial leadership within organizations is essential to realizing the sustainability value of digital transformation.

6.2 Theoretical Contributions

This research makes theoretical contributions to the current body of literature in several significant aspects. Firstly, it contributes to strategic management and sustainability literature by envisioning digitalization as a key driver of both economic and environmental performance. While previous studies have primarily investigated the isolated impact of specific technologies—i.e., AI or blockchain—on operational performance like energy consumption (Lange et al., 2020), servitization (Kohtamäki et al., 2020), or CSR (Denicolai et al., 2021), this research provides a more integrated perspective regarding conceptualizing digitalization as a dynamic capability. It demonstrates how digitalization enables businesses to handle complex and dynamic situations and integrate mainstream sustainability into their core strategic pursuits. This mutual influence challenges the historical assumption that environmental and economic objectives are in opposition and demonstrates instead that digital technologies can serve both functions simultaneously. Third, this study contributes to the growing body of work on digitalization and sustainability performance by identifying stakeholder integration as a crucial mediating process. While the causal relationship between digitalization and sustainable outcomes has been rigorously explored (Talwar et al., 2023; Guo et al., 2023), existing literature has given insufficient attention to the underlying relational mechanisms. Our findings indicate that stakeholder integration is a critical driver in transforming technological potential into tangible sustainability outcomes.

This underscores the need for a more engagement-driven, interaction-based approach to digital transformation—one that values the advantages of external input in framing internal initiatives and strategy. Through stakeholder participation in digitalization, corporations can enhance innovation, increase legitimacy, and deliver sustainable value creation. Ultimately, the research underscores the pivotal role of entrepreneurial leadership as a moderating factor in improving the relationship between digitalization, stakeholder integration, and sustainable development. Following research by Ali et al. (2023) and Zhang et al. (2021), which emphasizes the importance of leadership in green innovation, our study confirms that entrepreneurial leaders drive innovation and increase the strategic fit of sustainability initiatives. Entrepreneurial leaders establish a culture of experimentation, cross-functional teamwork, and stakeholder responsiveness—environments that are essential to unlocking the sustainability returns of digital technology. Moreover, the inclusion of both mediation and moderation in our conceptual model provides an integrated image of the relationship between leadership and stakeholder participation in the digitalization–sustainability connection. This contribution thereby addresses a clear research gap in the literature and offers meaningful implications for researchers and practitioners seeking to leverage digital transformation toward sustainable donations.

Overall, this study positions entrepreneurial leadership at the forefront of empowering firms to release the full potential of digitalization. Through stakeholder integration and coordination of digital capabilities, entrepreneurial leaders are pivotal in guiding environmentally friendly and financially sound business models in the digital era.

6.3 Managerial Implications

This study provides actionable guidance for managers on applying digitalization, stakeholder integration, and entrepreneurial leadership to achieve sustainable development. First, the results confirm that digitalization has a substantial impact on both environmental and financial performance. Managers should, therefore, view digital technologies as strategic enablers rather than operational instruments.

By incorporating digital solutions into their core business practices, companies can optimize resource utilization, reduce waste, and decrease their environmental footprint—while also lowering costs and enhancing profitability. Thus, incorporating digital transformation into long-term strategic planning is central to achieving sustainability goals. Second, the mediating effect of stakeholder integration suggests that digitalization's ability to enhance sustainability is primarily determined by the extent to which companies connect with their stakeholders. Managers are required to prioritize open communication and cooperation with key stakeholder groups, including employees, customers, suppliers, and communities. Inclusive feedback mechanisms ensure digital initiatives align with stakeholder expectations, thereby enhancing legitimacy and trust. Such a stakeholder approach not only increases the effectiveness of sustainability activities but also enhances these relations, which are core to long-term organizational resilience and innovation.

Third, the moderating function of entrepreneurial leadership highlights its value in maximizing the sustainability benefits of digitalization. Such leaders, who are vision-oriented, adaptable, and change-oriented, are more likely to connect digital strategies with stakeholders' interests and sustainability goals. Therefore, firms need to foster an entrepreneurial culture through initiatives that encourage risk-taking, innovation, and support, empowering employees to take the initiative. Investing in entrepreneurship-focused leadership development initiatives can further help ensure that digital transformation activities are implemented to maximize environmental and financial performance.

6.4 Limitations and Future Research Directions

While the present study offers valuable contributions, several limitations provide opportunities for future research. Initially, digitalization was theorized as a broad concept that encompasses a range of technologies. Follow-up studies should disaggregate this variable and examine the individual contributions of specific technologies, such as artificial intelligence (Di Vaio et al., 2020), blockchain (Paul et al., 2021), or the Internet of Things (IoT), to environmental and financial performance. A more advanced understanding of the differential effects of each technology would enable firms to make more informed investment decisions. Second, this study focused on the economic and environmental aspects of sustainable development, omitting the social facet. Future research should incorporate social performance measures, such as employee well-being, local community involvement, and equity, to gain a more holistic view of sustainability (Chavez et al., 2024). A grasp of how digitalization influences social outcomes is crucial to determining the comprehensive scope of business sustainability initiatives. Third, while this study has focused on the moderating role of entrepreneurial leadership and the mediating role of stakeholder integration, other organizational factors may also influence the relationship between digitalization and sustainability. Future research could explore the moderating role of organizational learning capabilities (Altinay et al., 2016) or the mediating role of process efficiency and innovation performance (Roy & Khastagir, 2016). These factors can provide further insights into how internal competencies engage with digital tools to create sustainable results.

Finally, the geographical boundaries of this study were limited to Chinese manufacturing firms. Although China is a relevant and dynamic setting due to its rapid digital growth and environmental concerns, the findings may not be generalizable to other parts of the world with dissimilar institutional, cultural, or regulatory environments. Future research should replicate this study in different national settings or conduct comparative studies to ascertain how country-specific factors shape the relationship between digitalization, stakeholder engagement, and sustainability. By overcoming these limitations, subsequent research can provide deeper insights into how companies can strategically align digital transformation, leadership, and stakeholder participation to advance global sustainability agendas.

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Appendix A

Full Thematic Matrix (28 Articles × 12 Themes)

A full thematic matrix was constructed linking all 28 articles to the final twelve themes. The matrix does not rank studies or judge their quality; it simply indicates whether a given article contributed to a particular thematic interpretation

Author-Year	Spiritual Legitimacy	Board Composition	Governance Competence	Accountability Mechanisms	Financial Practices	Stakeholder Accountability	External Regulation	Mission & Values	Ethical Leadership	Participation	Hybrid Governance	Contextual Factors
Jeavons (1998)	✓			✓		✓		✓	✓		✓	
Najam (1996)			✓	✓		✓	✓					✓
Miller-Millesen (2003)		✓	✓								✓	
Herman & Renz (2008)			✓	✓	✓	✓			✓	✓		
Cordery et al. (2019)			✓	✓	✓	✓	✓					✓
Sider & Unruh (2004)	✓	✓				✓		✓	✓	✓	✓	
Smith & Sosin (2001)	✓	✓				✓		✓	✓		✓	
Bielefeld & Cleveland (2013)	✓	✓		✓		✓		✓	✓	✓	✓	✓
Clarke (2006)	✓			✓			✓	✓	✓	✓	✓	✓
Christensen & Ebrahim (2006)			✓	✓	✓	✓	✓					✓
O'Dwyer & Unerman (2008)			✓	✓	✓	✓	✓		✓		✓	✓
Darus et al. (2014)			✓	✓	✓		✓	✓	✓			✓
Roslan et al. (2017)	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓

Omar et al. (2016)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Carolei (2022)		✓	✓	✓	✓	✓		✓	✓		✓	✓
Ang & Wickramasinghe (2023)		✓	✓	✓	✓		✓	✓	✓		✓	✓
Jacinto et al. (2023)	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Nawawi et al. (2024)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Albarracín et al. (2024)			✓	✓	✓	✓	✓		✓			✓
Steiner (2012)	✓			✓		✓		✓	✓	✓	✓	✓
Fredericksen & London (2000)		✓	✓	✓	✓	✓	✓					✓
Brown (2005)		✓	✓			✓			✓			
O'Dwyer (2010)			✓	✓	✓	✓			✓		✓	✓
Ebrahim (2003)			✓	✓		✓	✓			✓		✓
Noor Masdar (2015)	✓			✓		✓		✓	✓	✓		✓
Kugel & Mercado (2024)		✓	✓	✓	✓	✓	✓		✓			✓
Sider & Unruh (2004)*	✓	✓				✓		✓	✓	✓	✓	
Jeavons (2012)	✓			✓		✓		✓	✓		✓	✓

(✓ = represented in the study)

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