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PRIMARY RESEARCH

Stakeholder pressure as a moderator in the relationship between digital technology, environmental collaboration, and sustainable performance: Evidence from Moroccan firms

Fatima Aarab[1]*, Malika Ait Nasser[2]
[1,2]Ibn Zohr University, Agadir, kingdom of Morocco

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Abstract
Drawing upon the Natural Recourse-Based View(NRBV), this study explores that digital technology adoption impact on sustainable performance, as well as the mediating role of internal and external environmental collaboration and the moderating effect of stakeholder pressure among manufacturing industries of Morocco. The data were collected from 390 managers and CEOs of manufacturing industries and the data were analyzed by PLS-SEM. The results indicates that direct effect of digital technology adoption on sustainable performance. Furthermore, internal and external environmental collaboration significantly and positively mediate the relationship between digital technology adoption and sustainable performance. Also, stakeholder pressure moderates the relationship among them. Theoretically, the research develops the NRBV by demonstrating that the value of digital and collaborative resources is dependent on external pressure. Practically, these insights call on managers to focus on internal collaboration and enforce strict digital governance when engaging external partners.

INTRODUCTION

Organizations' concerns about environmental regulations have grown because of current sustainability developments (Sun et al., 2025). To improve green environmental collaboration and the creation of new products, processes and services, organizations are attempting to adopt new forms of information sharing. People have witnessed a massive shift in technology over the past 20 years; smartphones and small devices are commonplace, leading to a variety of platforms for blogs as video sharing, photo sharing, and online communication (Mubarak et al., 2024). People are creating the majority of data and spending an increasing amount of time in front of screens. Microblogs, vlogs, social networking sites, collaborative websites, video platforms, and image-sharing apps are all included in digital technologies(Irum et al., 2025). Given that digital technology technologies are the most effective means of information dissemination, businesses are unavoidably looking to take advantage of them (Ur Rahman et al., 2020). Many green businesses might not be able to use digital technology adoption (DTA) to comprehend the green environment in the current situation. To stay competitive and inventive in their management, operations, and products, green businesses must effectively use digital technology (Huang et al., 2025).

Digital technology adoption does not require significant additional resources for companies that have internet access (Jin et al., 2024). Consequently, digital technology usage among companies is increasing at an exponential rate and is quickly emerging as a key phenomenon in corporate management (Al Doghan & Abd Razak, 2024). As a result, organizations are using a wider range of digital platforms. Businesses may be choosing digital technology more and more since it enables many-to-many communication rather than just private one-on-one exchanges (Mhlanga & Ndhlovu, 2023). Additionally, digital technology features offer reasonably priced alternatives for con-

*corresponding author:Fatima Aarab
†email: f.aarab@uiz.ac.ma

tent management, analytics, automatic publishing, conversion tracking, and customer targeting. Companies can advertise their goods, services, and brands on digital technologies (David et al., 2023).

According to Syed et al. (2024), social networking sites are consequently seen as an online marketplace where companies and consumers engage. Social media can reach markets beyond its immediate geographic area by using digital technology; a physical presence is not necessary (Mubarak et al., 2024). Because technology may render time, distance, and place meaningless, it appeals to owners. Digital technologies have made it a significant subject in the literature on business and entrepreneurship (Chavez et al., 2023). According to Khaw et al. (2022), as frequently lack the resources required for traditional forms of management, they can profit especially from utilizing alternative company management tools like digital technology.

The pressing demand for environmental sustainability and the quick development of digital technology are driving two major changes in the global corporate landscape (Skare & Soriano, 2021). The use of Industry 4.0 technologies is increasingly seen as a crucial enabler of this sustainable future, even though the shift to a circular economy and lower carbon footprints remains essential (Huang et al., 2025). Growing environmental concerns have made sustainable operations and performance even more important. In response to urgent environmental issues, companies that prioritize sustainable practices to lessen their ecological impact are becoming more and more acknowledged (Blichfeldt & Faullant, 2021). This highlights how crucial an organization's sustainable practices are to generating performance and guaranteeing long-term viability. Organizations and scholars have taken a keen interest in sustainable operational performance (Mhlanga & Ndhlovu, 2023) sustainable operational performance. Businesses now take a different approach to operations management. Nowadays, sustainable operations management is prioritized over old approaches. Enhancing sustainable operational performance is the primary objective.

Businesses are increasingly forming partnerships with external partners, such as suppliers, customers, universities, and even competing businesses, to facilitate the integration of their value co-creation processes (Adomako & Tran, 2022). The high failure rate of these partnerships reminds businesses of the difficulties in managing these relationships (Mishra et al., 2022). Researchers have not shed much light on the capabilities of firms to effectively create partnerships with external actors, a potentially clear source of the problem. Other sources of failure in collaborating with external firms may include inter-firm competition, governance issues, cultural clashes, coordination costs, unintended spillover of knowledge, differences in goals, the partners" "learning races," and organizational rigidity (Chavez et al., 2023; Syed et al., 2024). There has been little focus in research on whether all firms are equally capable of creating, developing, and profiting from external partnerships (Adomako & Tran, 2022).

Organizations face pressure from stakeholders to adopt sustainable practices (Singh et al., 2022). Organizations understand that they need to reduce their impact on the environment and improve their own environmental sustainability practices, and they are seeking ways to work with suppliers and customers in a collaborative manner to pursue the sustainability agenda together (Bello-Pintado et al., 2023). As such, environmental collaboration has gained attention recently from academics and practitioners. Appiah-Kubi (2024), dedication to environmental stewardship is important when discussing environmental collaboration. Specifically, environmental collaboration has the potential to help organizations start entering future markets and start creating first-mover advantages that can lead to a sustainable competitive advatntage and firm performance (Bello-Pintado et al., 2023; Singh et al., 2022). By working or collaborating with key stakeholders such as suppliers to address environmental issues, organizations can emerge with opportunities from pursuing sustainable environmental activities (Adomako & Tran, 2022). In fact, organizations that pursue environmental collaboration are likely to garner support from key stakeholders to lessen their products total environmental impact and achieve sustainable products and processes (Mishra et al., 2022).

The analysis fills in these empirical gaps in several ways. Sun et al. (2025) outline how adoption of digital technology affects long-term performance. Considering that this connection has not been specifically investigated in earlier research, this is a significant contribution. Second, little is known about the precise circumstances under which environmental cooperation promotes sustainable performance. Irum et al. (2025) demonstrates that stakeholder pressure influences how digital technology adoption affects sustainable performance, thereby adding to the body of literature. Third, although earlier research has demonstrated that environmental cooperation promotes sustainable performance, it is unclear how environmental cooperation predicts sustainable performance (Lau & Wong, 2024). Lastly, the separate items the new scale for assessing sustainable performance load well onto a single factor in this study, and it has a high Cronbach's alpha, demonstrating outstanding psychometric qualities. As a result, this study contributes to the body of research by developing a useful scale for assessing sustainable performance.

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LITERATURE REVIEW

Natural Recourse Based View

Elrayah and Keong (2023) expanded on the resource-based approach by creating the NRBV. In addition to extending the dynamic capability view by "helping to understand the genesis of new capabilities themselves," Al Doghan and Abd Razak (2024) content that organizations can use the NRBV to achieve sustainable development. Furthermore, according to Al Doghan and Abd Razak (2024), the NRBV offers the framework a solid theoretical foundation upon which to build environmental criteria. According to the NRBV, businesses gain unique resources and skills that make them more competitive when they engage in sustainability initiatives (Mishra et al., 2022). In response to stakeholder pressure and expectations, Mhlanga and Ndhlovu (2023) concluded that the adoption of sustainable practices enhanced sustainability outcomes. As a major factor in non-technological eco-innovation, Al Doghan and Abd Razak (2024) argue that environmental legislative instruments and norms drive organizations to innovate. To innovate and ensure a competitive advantage, managerial support is also necessary to develop capabilities that enhance innovative competitiveness in organizational change and marketing. Lastly, major innovations, including reshaping energy consumption, developing new future technologies in industry, embracing clean technological operational practices, and recycling practices are vital for clean technologies, and are deemed central to sustainability (Yavuz et al., 2023). Clean technology, environmental pressures, environmental regulations, employee contribution, and management participation are therefore identified as capable of being developed in organizations to leverage competitive advantage from NRBV. Digital technology usually causes enhanced transparency of information, which can reduce information asymmetry between the organization and its stakeholders, leading to better corporate governance and accountability (Appiah-Kubi, 2024). Cumulatively, DTA often tends to create more uniform Environmental, Social and Governance (ESG) ratings when used to improve visibility and internal controls, ultimately indicating better long-term viability and societal reliability to those outside the organization (Lau & Wong, 2024). Product innovation has two further important extensions in light of NRBV issues. It first addresses the effects on the environment, organizational-level results, and resources that are not fully under the organization's control. The research hypotheses for this study based on this theory.

Digital Technology Adoption and Sustainable Performance

Huang et al. (2025) noted that digital technology can be defined in a variety of ways, because various individuals have different understandings of what digital technology is and what it is appropriate to use digital technology for. Jin et al. (2024) definition is relied upon for the purpose of this study, as it is simple to understand but comprehensive. Al Doghan and Abd Razak (2024) assert that digital technology is a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of user generated content." Effectively using digital technology allows businesses to enrich a number of processes. David et al. (2023) examined the use of digital technology and its influence on sustainable performance in both developed and developing countries, although more studies have taken place in developed countries. It is important to note that extrapolating results from prior studies on digital technology usage in social media from developed countries to developing country context raises some issues. The reason is that social media in developed and developing countries differ significantly in terms of contextual conditions, as both organizational and environmental factors vary substantially (Chavez et al., 2023).

By organizing structures optimization, routine activity automation, and enhancement of internal operational processes, digital technologies deliver cost reductions, shortened production cycles, and increased overall resource efficiency (Li, 2022). For example, real-time data monitoring enables rapid identification of bottlenecks or inefficiencies leading to enhanced labor productivity, firm agility, and other salient constructs for sustainable capital accumulation and competitive advantage (Khaw et al., 2022). Beyond economic influence, DTA shows a strong direct impact on sustainable performance. The working mechanism is largely based on its enhanced ability to monitor, measure, and control resource flows. Previous research supports the contention that digital technologies can improve resource allocation throughout the value chain, induce green manufacturing processes, and improve general environmental awareness (Blichfeldt & Faullant, 2021; Huang et al., 2025; Skare & Soriano, 2021). Modern IoT sensors and BDA, for instance, can track energy use and enable comprehensive predictive maintenance that can reduce unexpected waste, fossil fuel use, and pollutant emissions (Chavez et al., 2023). This direct impact tends to most commonly materialize in terms of process-based performance metrics, where digitalization unleashes precise control over production processes leading to a seamless alignment of operational efficiency and socio-ecological responsibility (Al Doghan & Abd Razak, 2024; Mhlanga & Ndhlovu, 2023).

H1: Digital technology adoption has direct impact on sustainable performance.

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Mediating Role of Environmental Collaboration

Scholars, decision-makers, business professionals, and other environmental stakeholders are becoming more interested in firms' cooperative efforts towards environmental sustainability (Syed et al., 2024). According to Chavez et al. (2023), environmental collaboration is the result of organizations and their stakeholders working together to develop methods to lessen their impact on the environment. This efforts can involve a variety of stakeholders, including suppliers, purchasers, and governments, and is regarded as a relational activity that transcends organizational borders. Researchers have investigated how firm collaboration may affect a firm's degree of sustainable innovation, since environmental collaboration that benefits the environment is a crucial component of environmentally sustainable business strategies (Adomako & Tran, 2022; Mishra et al., 2022). Businesses that integrate sustainability into their operations not only reduce their negative effects on the environment but also increase their operational and financial efficiency. By satisfying consumer demands for eco-friendly products and abiding by strict environmental rules, this focus on sustainable practices reduces resource consumption, waste generation, and emissions, giving businesses a competitive edge (Chavez et al., 2023). Additionally, it fosters long-term viability, innovation, and resilience in a dynamic market setting, supporting efforts to mitigate environmental degradation and achieve economic growth (Adomako & Tran, 2022). The importance of sustainable performance stems from both its concrete advantages for the longevity and success of an organization as well as from ethical and environmental considerations (Aftab et al., 2022; Ur Rahman et al., 2020).

While digital technologies provide the raw data and tools, IEC provides the organizational capacity for turning these digital resources into realized sustainable performance improvements (Adomako & Tran, 2022). The nature of digital technology adoption eases IEC by breaking down internal information silos improving cross-departmental information transfer and facilitating the integration of environmental objectives into production and management units (D'Souza et al., 2022). Employees and departments must first work together to transform BDA and IoT insights into actionable green policies, such as redesigning green products, or capturing resource use across complex processes (Bello-Pintado et al., 2023). EEC involves working together with stakeholders, including suppliers, customers, and regulators, to resolve environmental issues (Chavez et al., 2023). Digital technologies are vital for enabling this relationship. For example, applications such as platforms and shared databases (e.g., blockchain for traceability, and BDA for demand forecasting), enable supply chain transparency while also reducing the transaction costs of coordinating complex environmental initiatives with external stakeholders (Lau & Wong, 2024). DTA encourages collaboration by facilitating ease of data movement. This joint EEC, powered by DTA, positions the firm for environmental economies of scale while gaining access to green knowledge externally and joint innovation exercises, all contributing to an increased overall sustainable performance that occurs beyond the firm's boundaries (Khaw et al., 2022).

According to Alraja et al. (2022), one of the main concerns for firms operations is the improvement of inter-organizational collaboration procedures. Because it removes operational obstacles and promotes teamwork to satisfy customer needs rather than operating within the silos associated with traditional departmentalization, internal collaboration improves sustainable performance (Haleem et al., 2022). The idea that a company's departments and operating regions should cooperate with one another is known as internal environmental collaboration. It increases their mutual trust and guarantees that the data and resources needed to make sound judgements are promptly available. A producer may have a functional organizational structure, but to make the right decisions, information sharing is necessary at every level. For instance, if an order is delayed, customers would perceive this unfavorable even when they are not interested in learning the cause (Li, 2022).

While maintaining strategic distance from firms, organizations cultivate more cooperative, strategically important relationships with a select group of suppliers and consumers (Adomako & Tran, 2022). Businesses need to provide information about how they operate as well as the impact of risk and responsibility. According to Chavez et al. (2023), this requires cooperative strategies that incorporate information, technology, and skills from both internal and external sources. If implemented appropriately, green practices are thought to provide a competitive advantage (Syed et al., 2024). Additionally, environmental collaboration can enhance digital technology adoption and boost sustainable performance, leading to improved performance, including increased profit and cost reduction (Adomako & Tran, 2022). According to Elrayah and Keong (2023), integrating customers through environmental collaboration boosts returns and customer happiness while reducing environmental costs and waste. According to Piwowar-Sulej and Iqbal (2023), a company that collaborates on environmental issues can surpass a rival that was unable to identify the environmental problem. Overall, External Environmental Collaboration (EEC) can enhance productivity and efficiency while reducing operational costs and resource consumption (Chavez et al., 2023).

H2: Internal environmental collaboration has mediating impact among digital technology adoption and sustainable perfor-

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mance.

H3: External environmental collaboration has mediating impact among digital technology adoption and sustainable performance.

Moderating Role of Stakeholder Pressure

According to D'Souza et al. (2022), stakeholder pressure enhances the relationship between digital technology adoption and environmental collaboration to sustainable performance. First, as stakeholder green pressures and environmental values proliferate, more businesses will likely begin to act in ways consistent with environmental logics. Adomako and Tran (2022) suggests, in terms of the stakeholder approach to strategic management, that companies can deliberately activate pro-environmental behaviors as they meet stakeholder expectations by establishing and implementing behaviors that meet stakeholder expectations and interests. Hence, when companies see a higher degree of convergence in their stakeholder base, investing in responsible innovation behaviors can be a risk-mitigation strategy or an insurance-like hedge for a firm's relationship-based intangible assets (Haleem et al., 2022). Not only primary stakeholders like government, shareholders, and the media expect businesses to act on their environmental concern, stakeholders like non-governmental organizations, local communities, and tribal leaders are also increasingly aligned with environmental logic and are concerned about the damaging effects of business activities on the environment and expect businesses to act on their environmental need by providing better environmental protections (Singh et al., 2022). As such, organizational actors engaging in sustainable performance will be encouraged to operate in a social environment where pressures to adopt environmental actions are being placed on them from all significant stakeholders (Bello-Pintado et al., 2023). In general, this will increase the positive impacts of environmental collaboration on sustainable performance.

Stakeholder pressure considers that organizations can achieve their financial performance goals by managing the interests of a variety of stakeholders which, in turn, helps an organization develop its reputation and engender greater trust from stakeholders and, ultimately, better economic returns (Appiah-Kubi, 2024). Previous stakeholder research may have examined closely related environmental practices and corporate social responsibility, where motivations for firm behavior are relevant, which may also have played a role in the divergence (Jin et al., 2024). However, in other circumstances, financial or moral motivations can coexist in a mutually beneficial and reciprocal manner rather than mutually exclusive (D'Souza et al., 2022). Thus, the importance of stakeholders in this research is understood as a broad amalgamation of multiple configurations. Digital technologies increase entities' interconnectedness, which fosters innovation and growth. Although cooperation and collaboration are frequently employed in organizational behavior, there hasn't been much effort to distinguish between the two. It does not, however, have the interpreted meanings and necessary conditions that collaboration requires (Sun et al., 2025). IEC is essential to a business because it facilitates information absorption, permits the sharing of data acquired from many sources, and supports more intricate and sensible decision-making. To ensure that a business stays environmentally innovative, IEC is also largely responsible for coordinating environmental infrastructures to make information flow more dynamic and focused (Singh et al., 2022). This enables more effective transmission of crucial operational information across various roles.

Furthermore, DTA fosters successful information exchange between businesses, permits collaborative knowledge, sharing and stimulates competitive ideas, all of which improve company collaboration (Khaw et al., 2022). The main goal of environmental collaboration, according to theory that supports improving business performance, is to use ecological information to generate new concepts and advance GI activities. Digital technology, which is drastically changing how people produce, communicate, cooperate, and consume, is highlighting the importance of digital business tactics (Mhlanga & Ndhlovu, 2023). Additionally, digital technology has altered how businesses interact with the public and market, presenting both opportunities and difficulties in a variety of fields, including marketing, logistics, finance, and human resource management (Al Doghan & Abd Razak, 2024; Jin et al., 2024).

These stakeholders leverage their considerable resources, power, and legitimacy, or a combination thereof, to create pressure (D'Souza et al., 2022). Thus, companies may contend with stakeholder expectations, requests, and duties, all of which should be considered for effective management. Primary stakeholders increasingly have greater power to sway organizations' demands for digitalization, whether explicitly or inadvertently, in this digital era. Haleem et al. (2022) suggested that companies need to adapt to the disruptions of digitalization for survival in the long run, which could entail pressure. Consequently, stakeholder pressure for digitalization is the focus of our research. Furthermore, stakeholders may mobilize collectively to diffuse and amplify the salience of environmental management efforts, when they rally collectively around an emerging logic, in this case, a concern for responsible innovation. Stakeholders may further demand behavioral changes to mitigate negative repercussions on sustainable performance (Appiah-Kubi, 2024; Bello-Pintado et al., 2023; Sun et al., 2025). Therefore, it is

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proposed that:

H4: Stakeholder pressure has moderating impact on digital technology adoption and sustainable performance.

H5: Stakeholder pressure has moderating impact on internal environmental collaboration and sustainable performance.

H6: Stakeholder pressure has moderating impact on external environmental collaboration and sustainable performance.

Conceptual Framework

Therefore, the objective of this research is to examine how stakeholder pressure simultaneously affects the connection between adopting digital technologies and sustainable performance. Therefore, the objective of this research is to explore how internal and external environmental collaboration mediates the relationship between adopting digital technologies and sustainable performance. Figure 1 shows the conceptual framework of this research, which will serve as the basis for the hypotheses discussed in this section.

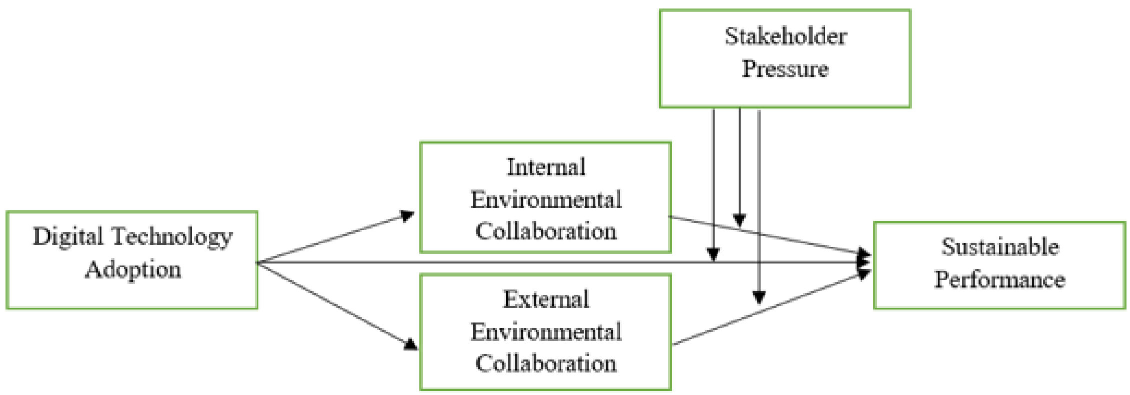

FIGURE 1. Conceptual framework

METHODS

Data Collection and Participants

Data for this study were obtained from manufacturing companies located in Morocco via an online questionnaire distributed through platforms such as i WhatsApp and Google Forms. The f data collection period coincided with the global impacts of COVID-19, which lengthened the process and required several follow-up reminders to respondents to secure the desired participation rate. This method of data collection through the use of online surveys is consistent with recent trends in research. This method was also used in light of the benefits of cost-effectively providing information, simplifying the process, and accelerating the data collection period, as well as allowing instructions and assistance to be provided when requested.

The survey was first sent to 422 potential respondents, where email invitations explained the research and provided a hyperlink to the questionnaire. The target respondents were owner-managers or CEOs of the firms, who the researchers believed would have the best knowledge of the overall firm environment and sustainable performance, which has been characterized in previous studies (Huang et al., 2025). In spite of the combined follow-up efforts, which consisted of follow-up telephone calls and follow-up e-mails to increase the return rate, the process produced a sample of 422 initial responses. After screening, 32 questionnaires were eliminated due to missing observations, duplicate observations, or errors in completion, leaving a usable sample of 390 responses from six different industries.

The researchers expected the low response rate to occur and deemed it to be adequate for analysis based on the scant literature in similar studies conducted in the region. Additionally, to investigate non-response bias, a typical approach was followed to determine if the final sample was representative of the target population, systematically assessing differences between early and late respondents. The types of firms among the final 390 responses, firm size, firm age, and the demographic characteristics of the respondents can be seen in Table 1.

Measurements

The validity of the study is guaranteed because the constructs' items were taken from the body of recognised literature. A questionnaire with a five-point Likert scale was used to measure each construct. The origins of the constructs and items employed in this investigation are shown in Table 2. Huang et al. (2025) provided the metrics for measuring the adoption of digital technologies. The IEC and EEC measurement items were taken from Syed et al. (2024). Items for measuring sustain-

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able performance were taken from earlier research Mubarak et al. (2024). Additionally, this study used stakeholder pressure as a moderating variable, which was borrowed from Sun et al. (2025).

TABLE 1. Profile of manufactured industry employees

Characteristics	Categories	Frequencies	Percentage %
Gender	Male	245	62.82%
	Female	145	37.17%
Manufacturing Industries	Textiles and Clothing	100	25.64%
	Food Processing	80	20.51%
	Chemical and Pharmaceutical	60	15.38%
	Automotive Parts and Assembly	50	12.82%
	Plastics and Rubber	50	12.82%
	Metal Fabrication	50	12.82%
Firm Size	Small (50-100)	120	30.77%
	Medium (110-250)	180	46.15%
	Large (280+)	90	23.08%
Firm Age	Less than 3 Years	50	12.82%
	4-9 Years	150	38.46%
	More than 10 Years	190	48.72%
Employees Designations	Owner/CEO	290	74.36%
	Senior Managers	100	25.64%

TABLE 2. Variables measurement and source

Constructs	Items	Source
Digital Technology Adoption	9	(Huang et al., 2025)
Internal Environmental Collaboration	5	(Syed et al., 2024)
External Environmental Collaboration	4	(Syed et al., 2024)
Stakeholder Pressure	6	(Sun et al., 2025)
Sustainable Performance	11	(Mubarak et al., 2024)

RESULTS

To examine the link between the constructs, this study used the partial least squares-structural equation modelling technique. When exploratory results are needed and heterogeneity is detected, PLS-SEM is regarded as a suitable technique. It can identify hidden heterogeneities within the sample, which aids in confirming the validity of the findings. Because PLS-SEM is robust and produces dependable findings for extremely complicated models, it is used (Hair et al., 2024). Consequently, this study used PLS-SEM in two stages. In the initial stage, the PLS-Algorithm approach was used to assess the validity and reliability of the constructs. It offers the following examination to validate a study: factor loadings (or item loadings), Composite Reliability (CR), Average Variance Extracted (AVE), Fornell–Larcker (FL), Heterotrait-Monotrait ratio (HTMT), crtoss-loading, and Variance Inflation Factor (VIF) for all constructs (Fornell & Larcker, 1981). In the second stage, the bootstrapping procedures was employed to evaluated the direct and indirect path effects.

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Assessment of Measurement Model

The SmartPLS 3.0 application was utilized in this investigation. Internal consistency reliability was demonstrated by the composite reliability values and coefficient alpha. According to Hair et al. (2024), constructs reliability is confirmed by Cronbach's alpha and Composite Reliability (CR), both of which are greater than 0.70. All the constructs' AVE values are greater than 0.50, indicating that the values fall within the acceptable range.

TABLE 3. Results of measurement model

Variables	Items	Loadings	Alpha	CR	AVE
Digital Technology Adoption	DTA1	0.812	0.926	0.938	0.629
	DTA2	0.787			
	DTA3	0.742			
	DTA4	0.783			
	DTA5	0.785			
	DTA6	0.81			
	DTA7	0.831			
	DTA8	0.721			
	DTA9	0.857			
Internal Environmental Collaboration	IEC1	0.789	0.892	0.921	0.699
	IEC2	0.877			
	IEC3	0.89			
	IEC4	0.801			
	IEC5	0.82			
External Environmental Collaboration	EEC1	0.829	0.789	0.864	0.614
	EEC2	0.719			
	EEC3	0.754			
	EEC4	0.828			
Stakeholder Pressure	STP1	0.802	0.879	0.909	0.625
	STP2	0.857			
	STP3	0.845			
	STP4	0.772			
	STP5	0.718			
	STP6	0.738			
Sustainable Performance	SP1	0.715	0.913	0.927	0.537
	SP10	0.719			
	SP11	0.758			
	SP2	0.776			
	SP3	0.718			
	SP4	0.762			
	SP5	0.735			
	SP6	0.8			
	SP7	0.805			
	SP8	0.785			
	SP9	0.758			

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The Fornell–Larcker (FL) criterion values were evaluated in detail for discriminant validity. The FL values, after taking the square root, are compared to the inner correlations of the constructs (Fornell & Larcker, 1981). Discriminant validity is established when the inter-construct correlations are lower than the square root of the AVE values. Table 4 shows that none of the correlations between the variables were greater than the square root of the AVE values.

TABLE 4. Discriminant validity values

Constructs	1	2	3	4	5
Digital Technology Adoption	0.793				
External Environmental Collaboration	0.505	0.784			
Internal Environmental Collaboration	0.694	0.543	0.836		
Sustainable Performance	0.730	0.677	0.720	0.833	
Stakeholder Pressure	0.705	0.614	0.809	0.710	0.790

In particular, the R-squared values for the variance in sustainable performance of (88.4%), the variance in internal environmental collaboration of (63.1%), and the variance in external environmental collaboration of (25.5%) can be interpreted as representing moderate levels of variance.

TABLE 5. R^2 values

Constructs	*R* Square
External Environmental Collaboration	0.255
Internal Environmental Collaboration	0.631
Sustainable Performance	0.844

Assessment of Structural Model

The suggested associations between the variables have been tested using PLS-SEM. A total of 5000 sub-samples have been used for bootstrapping. The findings of the hypothesis testing are displayed in table 4 below. The bootstrapping method with bias corrected confidence estimates and a 95% confidence interval for indirect effects was then employed to examine the mediation and moderation effects of the structural model (Hair et al., 2024). The direct effect of digital technology adoption significantly and negatively impacts on sustainable performance (β = -0.264, p = 0.002). Furthermore, internal environmental collaboration significantly and positively mediates the relationship between digital technology adoption and sustainable performance (β = 0.156, p = 0.007). Also, external environmental collaboration significantly and negatively mediates the relationship among digital technology adoption and sustainable performance (β = -0.097, p = 0.000). However, stakeholder pressure moderates on digital technology adoption and sustainable performance (β = -0.121, p = 0.047), internal environmental collaboration and sustainable performance (β = -0.180, p = 0.017) and external environmental collaboration and sustainable performance (β = -0.141, p = 0.005).

TABLE 6. Hypothesis testing

Paths	β	Mean	SD	*T* Values	*p* Values
H1: DTA -> SP	-0.264	-0.263	0.083	3.177	0.002
H2: DTA -> IEC -> SP	0.156	0.158	0.082	2.909	0.007
H3: DTA -> EEC -> SP	-0.097	-0.096	0.025	3.851	0.000
H4: STP * DTA -> SP	-0.121	-0.127	0.061	1.987	0.047
H5: STP * IEC -> SP	-0.180	-0.176	0.075	2.400	0.017
H6: STP * EEC -> SP	-0.141	-0.147	0.090	3.833	0.005

Discussion and Conclusion

The present study drawing on the natural recourse - based view, investigated the impact of digital technology adoption on sustainable performance. Furthermore, internal and external environmental collaboration mediate the relationship between digital technology

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adoption and sustainable performance. However, stakeholder pressure moderates the relationship between digital technology adoption, internal and external environmental collaboration with sustainable performance among manufacturing industries of Morocco.

The study findings indicate that digital technology adoption significantly impacts on sustainable performance. The results obtained are comparable to those of (Al Doghan & Abd Razak, 2024; Huang et al., 2025; Mubarak et al., 2024). The rationale is that increased usage of digital tools like Facebook, LinkedIn, Twitter, and others has enhanced communication. These tools are used by organizations to communicate with their supply chain and commercial partners (Mhlanga & Ndhlovu, 2023). Consequently, it has been discovered that DTA helps organizations improve their sustainable performance and enhance coordination. The mechanism is based on the special characteristics associated with digital technologies. When systems like IoT, big data analytics, and AI are utilized in a manufacturing firm, they provide a new level of visibility into operations, allowing for optimal resource utilization and automation of process observations, while significantly improving energy efficiency. This digital optimization contributes to lowering unanticipated outputs, reducing waste creation, and lowering pollution, leading to better environmental performance. In addition, an enhancement of information flow and operational flexibility as evidenced by studies on strategic emerging industries results in value creation and innovative activities that contribute positively to the economic and social sustainability dimensions (Elrayah & Keong, 2023). Therefore, digital technology adoption is justified not just as an operational improvement, but as a fundamental strategic tool for companies in enhancing their approach to continuous and sustainable development.

Furthermore, the study validates that internal environmental collaboration has a significantly positive mediating effect on the relationship between digital technology adoption and sustainable performance. DTA mainly acts as an enabler of sustainability when there is a relatively strong internal environment where there is coordination and shared purpose. Digital technologies serve as an enabler to break down the traditional siloes of the organization, allowing for environmental data sharing and tacit green knowledge sharing at real-time across departments. Such capabilities are critical components of effective intra-organizational collaboration (Chavez et al., 2023; Syed et al., 2024). In short, improved internal coherence enables the firm to quickly integrate sustainability goals into key processes, such as R & D and manufacturing. As an example, digitally enabled collaboration between R & D and production teams can accelerate both the design and implementation of green innovations that improve resource reconfiguration in terms of sustainability, and ultimately enhance sustainable performance. This is also consistent with the NRBV, which posits that an internal capability, which in this case is collaboration that is supported by technology, is necessary to convert external technology into a sustained competitive advantage and environmental advantage (Adomako & Tran, 2022).

The findings indicate that external environmental collaboration has a significant negative mediating effect on the relationship between digital technology adoption and sustainable performance. This result is paradoxical, as the complexity, risks and demands for resources to digitally relate to external stakeholders for these manufacturing firms currently exceed any benefits from the process. Digital technology adoption provides the means for the external organization to seamlessly exchange data, however, utilizing this technology for EEC requires managing partner systems across various platforms, negotiating terms for protecting intellectual property and deterring opportunistic behavior (Chavez et al., 2023). The considerable amount of time and financial resources expended by management in standardizing and managing these complex external digital collaborations results in a crowding-out effect, diverting available resources away from direct sustainability implementation strategies, and therebyt diminishing the net positive impact of digital technology adoption on sustainable performance. This outcome reinforces the point that as critical as the technology is a successful sustainability outcome, is the relational capital and governance structures employed to manage external collaborations.

The important finding identifies that stakeholder pressure significantly moderates the relationship between digital technology adoption and sustainable performance. This indicates that DTA may not be effective on its own - rather, it is highly contingent on the external context. Specifically, if manufacturing firms are under heightened scrutiny from external stakeholders, they will be forced to strategically direct their resources towards digital investments that support observable sustainability benefits. This external pressure converts the dormant capability of digital technology into actual sustainable performance. This finding reinforces the research literature that advocates the key role of external institutional pressure as a significant catalyst for pushing organizations to move beyond just voluntary compliance and fully integrate sustainability into their strategic fabric (Appiah-Kubi, 2024; Jin et al., 2024). Therefore, stakeholder pressure is a key magnifying glass for determining the extent to which the DTA contributes to genuine organizational sustainability gains.

Furthermore, it has been shown that stakeholder pressure also significantly moderates the relation between internal environmental

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collaboration and sustainable performance. This indicates that while internal environmental collaboration has inherent benefits, its practical benefits and features are increased dramatically when firms are operating in response to observable accountability and obligations from stakeholders who are external to their organization. When institutional and market pressure is high, the relatively flexible and voluntary nature of internal collaboration is transformed into externally focused, institutionalized organizational practices. This underscores that those organizational habits will help constrain the process by which cross-functional environmental knowledge is generated and applied to meet external standards and reporting requirements, making collaborative work efforts more efficient and effective in delivering tangible sustainable performance benefits (Adomako & Tran, 2022). Put simply, the leverage of the pressures stemming from external stakeholders supports the discipline of processes occurring inside the firm, thereby ensuring that firm resources and collaborative practices are subsequently oriented toward better accountable performance outcomes.

Moreover, stakeholder pressure significantly moderates the relationship between external environmental collaboration and sustainable performance. This important boundary condition clarifies the previously discussed, seemingly contradictory negative mediation of EEC (Bello-Pintado et al., 2023). In other words, when external environmental collaboration occurs with high levels of external scrutiny and demand, manufacturing firms must confront the complex coordination challenges and risks of digitally engaging partners. Because of the need to achieve compliance with regulations in addition to public transparency, the commitment to actually leverage shared data and joint environmental initiatives must be upheld. Pressure thus creates an incentive for external environmental collaboration to be less a resource-draining activity and instead focused, responsible driver of sustainable performance, as it helps ensure that external collaboration to result in growing concerns for regulatory and transparency issues for competitive advantage.

Implications of Study

Theoretical implications

The current research makes several important theoretical contributions to the acclaimed conceptualization of digital strategy, environmental collaboration, and institutional forces under the Natural Resource-Based View (NRBV) lens - which is understudied in the context of the Moroccan manufacturing industries.

First, this study extends the NRBV core argument by clarifying the mechanistic chain through which digital resources create environmental advantage (Al Doghan & Abd Razak, 2024). While previous research has shown that digital technology adoption is a dynamic capability that leads to sustainable performance, our research indicates that this relationship is actually operationalized through internal environmental collaboration and external environmental collaboration. These findings show that DTA not directly associated with Sustainable Performance (SP) but is instead mediated by organizational relational capabilities for raw digital capacity to be transformed into waste reduction and resource optimization. This role of the intermediary has contributed to the understanding of how resources are converted within the NRBV by stressing collaboration as an important factor for digital technology adoption (Elrayah & Keong, 2023). While collaboration theory is often discussed within the NRBV on external collaboration literature, this evidence shows that with no appropriate external governance, associated costs (coordination, complexity, resource leakage) of digitally enabled EEC can outweigh benefits to a net negative impact on sustainable performance. This caveat to the collaborative resource perspective of NRBV is relevance for developing market contexts of our study and the weak data points overall of external, digitally enabled integration is a cautionary tale. The multi-level moderation suggests that strategic alignment and the resource allocation and commitment to convert DTA and collaborative abilities to measurable sustainability outcomes is not simply a management choice of internal organizational capacity have far more on the presence and the strength associated with normative pressures. The convergence of these theories helps advance theory by establishing external conditions of imperative digital green strategies from elective avenues for organizations as high-impact drivers of sustainable performance.

Practical implications

The research reports several tangible and actionable implications for owner-managers and CEOs of Moroccan manufacturing firms who are working towards sustainable development goals with digitalization.

The first implication for managers is to appreciate that digital technology adoption is a strategic investment in sustainability rather than a cost of doing business. Companies need to prioritize the adoption of Industry 4.0 technologies for more than just operational efficiency and cost reduction. DTA should explicitly support real-time environmental monitoring and compliance functions (Yavuz et al., 2023). By utilizing DTA to track emissions, energy consumption, and waste streams, firms can ensure that their foundational

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digital capabilities are supporting their sustainability mandates. Managers must actively intervene to dismantle departmental silos by establishing cross-functional green teams that utilize digital technology to share environmental data (e.g., leveraging shared dashboards) and tacit knowledge. This will facilitate the timely translation of new environmental information generated by DTA into actionable green innovations across R&D, production, and supply chain management departments. With a negative moderating role, firms should only start a deep level of digital collaboration with external firms after strong digital governance and trust protocols are developed. The goal should be to open up limited, transparent, and secure data sharing until relational capital is strong enough to weather risks largely stemming from coordination costs and potential intellectual property leakage. An adverse outcome of premature broad rollouts of EEC can lead to a decline in sustainable performance. Instead of merely reacting to external pressure, manager should actively use stakeholder pressure to stimulate change internally. Regulatory obligations (coercive pressure) and market demand for green goods (normative pressure) should be applied internally to justify and create funds for DTA, IEC, and selective EEC initiatives. The findings in this study indicate that DTA, IEC, and selective EEC are most effective when there is high scrutiny from the external environment. Managers should rely on public reporting and transparency to help direct this external force into accountable and high sustainable performance outcomes.

Limitations and Future Research

The research presented in this paper delivers significant empirical evidence related to the digital and collaborative antecedents of sustainable performance, but there are several limitations that open further research avenues.

First, a significant limitation is the cross-sectional research design, which captures data in a single point in time. While our theory posits clearly directional relationships (causality), the design does not allow us to determine the dynamic evolution and/or causality between digital technology adoption, collaboration, and sustainable performance. Future researchers may want to use longitudinal studies to track these areas overtime, which would allow for a more rigorous analysis of how digital capabilities and collaborative practices progress and improve performance over time, thus providing more robust causal inferences for the Natural Resource-Based View (NRBV).

Secondly, the generalizability of the study is limited by its distinctive research setting: Manufacturing firms in Morocco, a developing economy. The context may bring through certain cultural, institutional and regulatory biases that affect the relationship observed within this study, particularly the negative mediation of internal and external environmental collaboration. Future research should consider repeating this integrated model in a wider array of cultural settings (e.g., developed economies, different industrial sectors) to investigate the robustness and generalizability of these findings, specifically regarding how the costs and benefits of EEC differ across institutional settings.

Lastly, to further the theoretical contribution to digitalization in sustainability, future research could consider variations in the granularity of the constructs. Researchers could examine DTA as different isolated technologies (e.g., comparing AI against blockchain) or analyze components of stakeholder pressure (e.g., isolate regulatory pressure from community pressure) in order to provide managers with more detailed insights into which specific tools and external pressures deliver the stronger sustainable performance outcomes.

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