

Green Organizational Culture, Knowledge Sharing, and Green Innovation in Chinese Manufacturing SMEs: An Enterprise Informatics Perspective

Hongxushan Wu, Norhafizah Abu Hasan

Faculty of Economics and Management, Universiti Kebangsaan Malaysia, Malaysia
p121649@siswa.ukm.edu.my (corresponding author); norhafizahl@ukm.edu.my

Abstract. This study examines the association between green organizational culture and green innovation in Chinese manufacturing small and medium-sized enterprises (SMEs). Drawing on the resource-based view and organizational culture theory, a mediation model with moderation is proposed in which green knowledge sharing serves as a mediating mechanism and digitalization level acts as a boundary condition. Survey data were collected from 326 managers and senior employees across manufacturing SMEs in China using a structured questionnaire. The data were analyzed using partial least squares structural equation modeling (PLS-SEM). The results indicate that green organizational culture is positively associated with green innovation. Green knowledge sharing partially mediates this relationship, suggesting that shared environmental values and norms facilitate the exchange of green-related information and experience across organizational units, which in turn is associated with innovation in green products, processes, and management practices. In addition, digitalization level positively moderates the relationship between green organizational culture and green knowledge sharing, such that the positive association between cultural values and knowledge-sharing behavior is stronger in firms with higher levels of digitalization. These findings contribute to enterprise informatics and knowledge management research by identifying green knowledge sharing as an informational mechanism linking organizational culture to green innovation outcomes in resource-constrained manufacturing SMEs. Practical suggestions for managers seeking to build green knowledge-sharing systems and use digital tools for environmental improvement are discussed.

Keywords: Green organizational culture; Green innovation; Green knowledge sharing; Enterprise informatics; Chinese manufacturing SMEs; Digitalization level

1. Introduction

Manufacturing firms worldwide face growing pressure to reduce their environmental impact while maintaining competitiveness. In China, environmental regulations and market expectations have made green innovation an important strategic objective for manufacturers across industries (Luo et al., 2023; Li et al., 2017). Small and medium-sized enterprises (SMEs), which account for a large share of China's manufacturing output, encounter particular difficulties in pursuing green innovation. Compared with large firms, manufacturing SMEs typically have fewer financial resources, less formalized environmental management systems, and uneven access to green technologies (Al-Hakimi et al., 2022; Chen et al., 2006). These constraints suggest that organizational-level factors, particularly those related to how environmental knowledge and information are managed within the firm, may play an important role in enabling green innovation in SMEs. Within the fields of enterprise informatics and knowledge management, green innovation can be understood as a process in which environmental values, organizational knowledge flows, and cross-functional information coordination are converted into new products, processes, and management practices (Abbas and Khan, 2023; Wang et al., 2022). A bibliometric review of government subsidies and corporate green innovation shows that Chinese research has moved from policy-effect evaluation toward mechanisms involving innovation strategy, commercialization, information asymmetry, and digital transformation (Chen and Masukujjaman, 2025). Panel evidence from Chinese logistics enterprises shows that supply chain collaboration improves green innovation performance and that organizational capabilities strengthen this collaborative effect (Ou et al., 2025). At the macro and regional levels, recent Chinese evidence also shows that green finance and digital service innovation can support low-carbon industrial transformation through green technology innovation, emissions reduction, and energy-structure optimization mechanisms (Ding et al., 2025; Wang and Kassim, 2025).

Green organizational culture refers to shared environmental values, behavioral norms, and management practices that shape how employees perceive and respond to environmental challenges (Al-Hakimi et al., 2022; Shahzad et al., 2023). It encompasses green values that provide a common standard for environmental decision-making, green norms that reduce uncertainty when employees collaborate on environmental tasks, and management leadership that supports resource allocation toward green objectives. In manufacturing SMEs, where formal environmental management systems may not be fully developed, organizational culture provides an informal but influential mechanism guiding employee behavior toward environmental goals. When green values are widely shared within the organization, employees are more likely to exchange environmental knowledge, propose green improvement ideas, and coordinate across functional boundaries to implement green innovations (Lin et al., 2024).

Previous research has established that green organizational culture is associated with environmental and innovation outcomes (Abbas and Khan, 2023; Lin et al., 2024; Shahzad et al., 2023). Several studies have examined green organizational culture as a moderator of other relationships, such as the link between green manufacturing practices and corporate sustainable performance (Al-Hakimi et al., 2022) or between green knowledge management and green innovation (Wang et al., 2022). However, the mechanism through which green organizational culture itself promotes green innovation has received less attention. In particular, few studies have examined green knowledge sharing as a mediating pathway from green culture to green innovation. Green knowledge sharing, defined as the exchange of environmental information, experience, and expertise among organizational members, represents an informational mechanism that could explain why firms with stronger green cultures tend to achieve better green innovation outcomes. Furthermore, existing research has not adequately considered how digitalization level influences the relationship between green culture and knowledge sharing. Digital tools may facilitate the recording, transmission, and utilization of green-related information, thereby strengthening the culture-knowledge sharing link (Lin et al., 2024).

This study investigates whether and how green organizational culture is associated with green innovation among Chinese manufacturing SMEs. Specifically, it examines the mediating role of green knowledge sharing and the moderating effect of digitalization level on the relationship between green organizational culture and green knowledge sharing. This study makes three contributions to the enterprise informatics and knowledge management literature. First, it extends the study of green organizational culture by showing that cultural values are linked to green innovation through a knowledge-sharing mechanism, framing culture as an information-enabling factor rather than only a contextual variable. Second, it provides empirical evidence from Chinese manufacturing SMEs on how green knowledge sharing serves as an informational channel connecting cultural values to innovation outcomes, addressing a gap in the understanding of knowledge management processes in environmentally oriented SMEs. Third, it identifies digitalization level as a boundary condition that shapes how effectively green organizational culture is translated into knowledge sharing, offering insights into the role of digital infrastructure in supporting environmental knowledge flows within SMEs.

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature and develops the research hypotheses. Section 3 describes the research methodology. Section 4 presents the results. Section 5 discusses the findings and their implications, and Section 6 concludes the study.

2. Literature Review

2.1 Green Organizational Culture in Manufacturing SMEs

Green organizational culture can be defined as the collection of shared values, beliefs, norms, and behavioral expectations within an organization that prioritize environmental responsibility (Shahzad et al., 2023; Al-Hakimi et al., 2022). It reflects the degree to which environmental concerns are integrated into the organization's daily operations, decision-making processes, and strategic orientation. Schein (2010) identified organizational culture as operating at multiple levels, including underlying assumptions, espoused values, and observable artifacts. Applied to the environmental context, green organizational culture includes green values that establish common environmental priorities, green norms that guide expected behavior in environmental matters, and management leadership that signals organizational commitment to environmental goals (Abbas and Khan, 2023).

In manufacturing SMEs, organizational culture is particularly influential because these firms typically rely more on informal coordination mechanisms than on formalized management systems. Large firms may implement environmental management systems such as ISO 14001 to structure their green activities, but many SMEs lack the resources to adopt such systems comprehensively (Al-Hakimi et al., 2022). In these settings, shared cultural values serve as a substitute for formal procedures, guiding how employees interpret environmental information, allocate attention to green issues, and coordinate their efforts across functions. From an enterprise informatics perspective, green organizational culture can be understood as an organizational condition that shapes how environmental information is perceived, processed, and acted upon within the firm. When green values are embedded in the organizational culture, employees are more likely to seek out environmental information, share it with colleagues, and apply it to their work (Wang et al., 2022; Abbas and Khan, 2023).

Resource-based view (RBV) theory suggests that organizational culture constitutes a valuable, rare, and difficult-to-imitate resource that can contribute to sustained competitive advantage (Barney, 1991; Wernerfelt, 1984). Green organizational culture, as an intangible resource, can support green innovation by creating an internal environment where environmental initiatives receive organizational support and where employees feel encouraged to contribute environmental knowledge and ideas. Unlike physical resources or formal policies, culture develops over time through social interactions and shared experiences, making it difficult for competitors to replicate (Schein, 2010). In the context

of Chinese manufacturing SMEs, where competitive pressures are high and resource constraints are common, green organizational culture may represent an accessible organizational capability that does not require large upfront investments but can meaningfully improve how firms approach environmental challenges. In resource-constrained SMEs, such cultural resources are especially relevant because they can support environmental coordination without requiring complex formal systems. This makes green organizational culture an important internal condition for explaining how SMEs mobilize knowledge and employee participation for green innovation.

2.2 Green Innovation

Green innovation refers to the development and implementation of new or improved products, processes, and management practices that reduce environmental impact (Chen et al., 2006; Xie et al., 2019). The literature commonly distinguishes among three dimensions of green innovation. Green product innovation involves designing products that use fewer resources, generate less waste, or have lower environmental impact during their lifecycle (Xie et al., 2019; Albort-Morant et al., 2016). Green process innovation refers to improvements in production methods that reduce energy consumption, minimize emissions, or decrease the use of hazardous materials (Luo et al., 2023). Green management innovation involves the adoption of new organizational practices, routines, or systems aimed at improving environmental performance, such as environmental auditing, green supply chain coordination, and environmental reporting (Luo et al., 2023; Al-Hakimi et al., 2022).

For manufacturing SMEs, green innovation often involves incremental improvements rather than radical changes. These firms may modify existing production processes to reduce waste, adjust product specifications to meet environmental standards, or introduce basic environmental management practices (Li et al., 2017). Such innovations require both environmental knowledge and cross-functional coordination, as green improvements in products or processes often depend on input from multiple departments including research and development, production, procurement, and quality management. The information-intensive nature of green innovation makes it relevant to enterprise informatics research, as the effectiveness of green innovation depends on how well environmental knowledge is generated, shared, and applied across the organization (Shehzad et al., 2023; Wang et al., 2022).

Prior studies have shown that green innovation is influenced by a range of organizational factors, including green human resource management practices (Shahzad et al., 2023; Renwick et al., 2013), environmental regulation (Luo et al., 2023), green intellectual capital (Shehzad et al., 2023), and artificial intelligence adoption (Lin et al., 2024). However, the role of organizational culture in directly promoting green innovation, and the informational mechanisms through which this effect operates, remain areas where further empirical evidence is needed. Research on supply chain partnerships further indicates that relationship attractiveness improves green innovation performance indirectly through relationship fairness and green innovation capability rather than through a strong direct effect (Zhan, 2025). Evidence from Vietnamese SMEs shows that leadership and digital transformation competency enhance green business performance, with business innovation acting as a key mediating mechanism (Khanh and Cuong, 2025).

2.3 Green Organizational Culture and Green Innovation

Several theoretical perspectives support the argument that green organizational culture promotes green innovation. From the RBV perspective, green organizational culture constitutes an organizational capability that enables firms to identify environmental opportunities, mobilize resources for green initiatives, and sustain innovation efforts over time (Barney, 1991; Al-Hakimi et al., 2022). Organizational culture theory further suggests that shared values and norms shape employee behavior by establishing expectations and reducing ambiguity in decision-making (Schein, 2010). When environmental values are central to the organizational culture, employees are more

likely to direct their creative efforts toward green objectives, propose environmentally friendly solutions, and support the implementation of green innovations (Damanpour, 1991).

Empirical evidence generally supports a positive relationship between green organizational culture and innovation outcomes, although the relationship has more commonly been examined in moderating rather than direct-effect roles. Wang et al. (2022) found that organizational green culture strengthens the relationship between green knowledge management and green innovation in manufacturing and service firms. Al-Hakimi et al. (2022) reported that green organizational culture moderates the effect of green manufacturing practices on green innovation in Saudi manufacturing SMEs. Lin et al. (2024) showed that green culture positively moderates the relationship between artificial intelligence use and green product innovation in Chinese agricultural firms. Abbas and Khan (2023) found that green culture strengthens the link between green knowledge management and organizational green innovation. Shahzad et al. (2023) showed that green culture mediates the relationship between green HRM practices and sustainable performance in Chinese manufacturing firms. These findings suggest that green organizational culture creates a supportive environment for green innovation, although the direct relationship between culture and innovation deserves more systematic examination, particularly in the context of manufacturing SMEs.

In manufacturing SMEs, the direct effect of green organizational culture on green innovation can be expected for several reasons. Shared green values increase the likelihood that employees will identify and pursue environmental improvement opportunities in their daily work. Green norms reduce the social and organizational costs associated with proposing and implementing green changes, as employees perceive such activities as consistent with organizational expectations. Management leadership on environmental issues increases the credibility of green innovation efforts and signals that the organization is willing to allocate resources toward environmental goals, even when short-term financial returns may be uncertain.

Based on the above discussion, this study proposes the following hypothesis:

H1: Green organizational culture has a significant positive effect on green innovation.

2.4 The Mediating Role of Green Knowledge Sharing

Green knowledge sharing refers to the exchange of environmental information, experience, expertise, and ideas among organizational members (Wang et al., 2022; Abbas and Khan, 2023). It includes both the sharing of explicit environmental knowledge, such as regulatory requirements, technical specifications, and environmental performance data, and the sharing of tacit knowledge, such as practical experience with green production methods and informal environmental problem-solving approaches (Nonaka and Takeuchi, 1995; Grant, 1996). From an enterprise informatics perspective, green knowledge sharing represents an information-flow mechanism that connects individual environmental awareness to collective organizational action (Donate and Sanchez de Pablo, 2015). This mechanism is central to the present study because green innovation depends on the circulation and application of environmental knowledge across functions.

Green organizational culture is expected to promote green knowledge sharing through several pathways. First, green values create a shared understanding of environmental priorities, which reduces the perceived cost and risk of sharing green knowledge. When employees believe that environmental knowledge is valued by the organization, they are more willing to share their expertise and experience with colleagues (Abbas and Khan, 2023). Second, green norms establish behavioral expectations that include knowledge-sharing behaviors. In organizations with strong green norms, sharing environmental information is considered part of expected job behavior rather than an optional or extra-role activity (Wang et al., 2022). Third, management leadership on environmental issues signals that green knowledge is important for organizational success, which motivates employees at all levels to engage in knowledge exchange. Managers who show commitment to environmental goals through

their own behavior send a message that environmental knowledge is organizationally valuable, encouraging employees to contribute their knowledge and experience (Shahzad et al., 2023).

Based on this reasoning, this study proposes:

H2: Green organizational culture has a significant positive effect on green knowledge sharing.

Green knowledge sharing, in turn, is expected to promote green innovation. Knowledge sharing has been widely recognized as a driver of organizational innovation in the knowledge management literature (Nonaka and Takeuchi, 1995; Donate and Sanchez de Pablo, 2015). When employees exchange environmental knowledge, they combine different perspectives and expertise, which can lead to new ideas for green products, processes, and management practices (Shehzad et al., 2023). Knowledge sharing also reduces information asymmetry across departments, enabling better coordination of green innovation activities. For instance, when production engineers share information about material waste with product designers, the designers can incorporate waste-reduction features into new product designs. Similarly, when environmental compliance specialists share regulatory knowledge with operations managers, the managers can implement process improvements that meet environmental standards more effectively (Song and Yu, 2018).

In the context of manufacturing SMEs, where formal knowledge management systems may be limited, interpersonal knowledge sharing plays a particularly important role in supporting innovation. Green knowledge sharing enables these firms to accumulate and use environmental knowledge without investing in complex information technology systems. As environmental knowledge flows more freely across the organization, employees can draw on a larger pool of environmental information and experience when developing green innovations (Abbas and Khan, 2023; Albort-Morant et al., 2016).

Based on this reasoning, this study proposes:

H3: Green knowledge sharing has a significant positive effect on green innovation.

Combining H2 and H3, green knowledge sharing is expected to mediate the relationship between green organizational culture and green innovation. Green organizational culture creates the conditions for knowledge sharing by establishing values and norms that encourage the exchange of environmental information. Knowledge sharing in turn enables the generation and implementation of green innovations by combining distributed environmental knowledge into actionable insights. Without adequate knowledge sharing, green cultural values may remain at the level of shared attitudes without translating into concrete innovation outcomes. The informational pathway from culture through knowledge sharing to innovation represents a mechanism through which intangible cultural resources are converted into tangible organizational outputs.

H4: Green knowledge sharing mediates the relationship between green organizational culture and green innovation.

2.5 The Moderating Role of Digitalization Level

Digitalization level refers to the extent to which an organization has adopted digital technologies and integrated them into its operations and management processes (Lin et al., 2024; El-Kassar and Singh, 2019). In manufacturing SMEs, digitalization may include the use of digital communication platforms, enterprise information systems, data analytics tools, and digital production monitoring systems. From an enterprise informatics perspective, digitalization level represents the technological infrastructure that supports information flows within the organization. Digital technology capability has been shown to improve enterprise innovation performance through network adaptation and network coordination, indicating that digital tools create innovation value when they reshape inter-organizational response mechanisms (Lu et al., 2025). A Vietnamese SME pilot study similarly finds that digital technology adoption is positively associated with competitiveness and that innovation capability partially

mediates this relationship (Thi et al., 2025). Related evidence from service and supply-chain contexts shows that digital transformation can promote sustainable growth through innovation, and that the effectiveness of digital maturity is strengthened when technological investment is accompanied by organizational capability development and cultural readiness (Khanh et al., 2025; Izunobi and Burinskiene, 2025).

This study proposes that digitalization level moderates the relationship between green organizational culture and green knowledge sharing. Digital tools and platforms provide channels through which environmental knowledge can be recorded, stored, and transmitted more efficiently (El-Kassar and Singh, 2019; Zhang et al., 2020). In firms with higher digitalization levels, employees can share environmental information across departments using digital systems, reducing the time and effort required for knowledge exchange. Digital platforms can also make environmental information more visible to all organizational members, enabling broader participation in green knowledge-sharing activities.

When green organizational culture is strong, employees are motivated to share environmental knowledge. However, the extent to which this motivation translates into actual knowledge-sharing behavior depends partly on the available infrastructure for knowledge exchange. In firms with higher digitalization levels, the infrastructure supports more frequent and more effective knowledge sharing, amplifying the effect of cultural values on knowledge-sharing behavior. In contrast, in firms with lower digitalization levels, environmental knowledge may remain localized within individual departments even when employees hold shared green values, because the channels for cross-functional information exchange are limited (Zhang et al., 2020).

Based on this reasoning, this study proposes:

H5: Digitalization level positively moderates the relationship between green organizational culture and green knowledge sharing, such that the positive effect is stronger when digitalization level is higher.

Figure 1 presents the conceptual framework of this study.

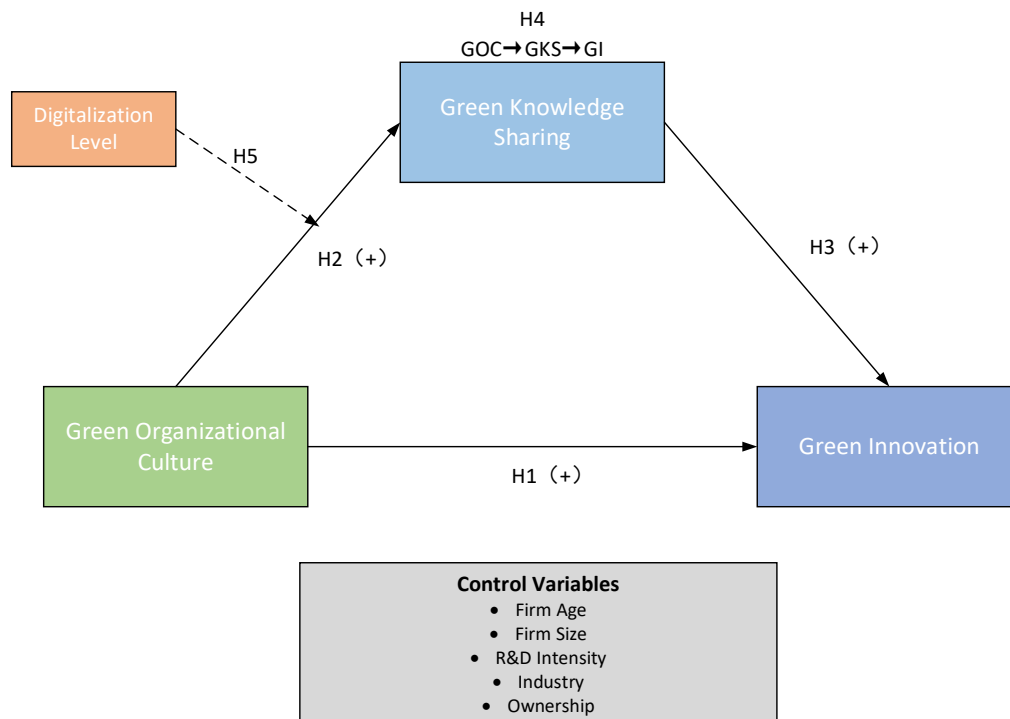


Fig.1: Conceptual Framework

3. Research Methods

3.1 Research Design

This study employs a quantitative research design based on survey data from Chinese manufacturing SMEs. A cross-sectional questionnaire was used to collect information on green organizational culture, green knowledge sharing, green innovation, digitalization level, and firm characteristics. Partial least squares structural equation modeling (PLS-SEM) was selected as the primary analytical method for several reasons. First, PLS-SEM is suitable for testing complex structural relationships involving mediation and moderation effects (Hair et al., 2022). Second, PLS-SEM performs well with smaller sample sizes relative to the number of model parameters, making it appropriate for SME research where obtaining very large samples can be difficult. Third, PLS-SEM does not require multivariate normality assumptions, which is an advantage when working with survey data from diverse organizational contexts.

3.2 Sample and Data Collection

The target population was managers and senior employees in Chinese manufacturing SMEs who were knowledgeable about their firms' environmental practices and innovation activities. Manufacturing SMEs were defined as firms with fewer than 500 employees operating in manufacturing industries, following the classification criteria used by China's Ministry of Industry and Information Technology.

Data were collected between June and December 2025 using a structured online questionnaire. The questionnaire was distributed through industry associations, industrial park management offices, and professional networks, covering manufacturing SMEs in eastern, central, and western regions of China. To be eligible, respondents needed to hold a managerial or senior professional position and have at least two years of work experience at their current firm. A total of 500 questionnaires were distributed, and 362 responses were received, yielding a response rate of 72.4%. After removing incomplete responses and those failing attention-check items, 326 valid responses remained, representing a valid response rate of 90.1%.

Table 1. Sample Characteristics

Characteristic	Category	Frequency	Percentage (%)
Industry	Machinery and equipment	72	22.1
	Electronics	58	17.8
	Chemicals	48	14.7
	Textiles	40	12.3
	Automotive parts	32	9.8
	Light manufacturing	29	8.9
	Others	47	14.4
	20-50	92	28.2
Firm size (employees)	51-100	110	33.7
	101-300	84	25.8
	301-500	40	12.3
	< 5	39	12.0
Firm age (years)	5-10	90	27.6
	11-20	125	38.3
	> 20	72	22.1
	Senior manager	59	18.1
Respondent position	Middle manager	146	44.8
	R&D manager	73	22.4
	Operations manager	48	14.7
Region	Eastern China	170	52.1

Central China	91	27.9
Western China	65	20.0

Note: N = 326.

3.3 Measurement

All constructs were measured using multi-item scales adapted from previously validated instruments. Items were measured on five-point Likert scales ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire was originally developed in English and then translated into Chinese following a back-translation procedure. Two bilingual researchers independently translated the English version into Chinese, and a third researcher translated the Chinese version back into English. Discrepancies between the original and back-translated versions were discussed and resolved. Before the main survey, a pilot test was conducted with 35 managers from manufacturing SMEs to assess item clarity and comprehensibility.

Green organizational culture was measured using 12 items adapted from Shahzad et al. (2023) and Al-Hakimi et al. (2022). The items captured three aspects of green culture: green values (4 items), green norms (4 items), and management environmental leadership (4 items). A sample item is "Our organization considers environmental protection as an important organizational value."

Green knowledge sharing was measured using 8 items adapted from Abbas and Khan (2023) and Wang et al. (2022). The items assessed the extent to which employees share environmental information, experience, and expertise with colleagues across functional areas. A sample item is "Employees in our organization frequently share their knowledge about environmental practices with colleagues."

Green innovation was measured as a higher-order construct with three dimensions: green product innovation (4 items), green process innovation (4 items), and green management innovation (4 items), totaling 12 items. The items were adapted from Xie et al. (2019) and Luo et al. (2023). A sample item for green product innovation is "Our organization has introduced products with reduced environmental impact over the past three years." A sample item for green process innovation is "Our organization has adopted cleaner production processes to reduce waste and emissions." A sample item for green management innovation is "Our organization has implemented new environmental management practices or routines."

Digitalization level was measured using 6 items adapted from Lin et al. (2024) and Zhang et al. (2020). The items assessed the extent to which the firm has adopted digital technologies in its operations and management. A sample item is "Our organization uses digital tools to manage and share operational information across departments."

Control variables included firm age (number of years since establishment), firm size (natural logarithm of the number of employees), industry type (classified as high-pollution or low-pollution based on the Ministry of Ecology and Environment classification), ownership type (state-owned, private, or foreign-invested), and R&D intensity (R&D expenditure as a percentage of annual revenue). Industry type and ownership type were included as categorical control variables in the structural model; they are not reported in the correlation matrix because they were entered as dummy-coded variables rather than continuous Likert-scale constructs.

3.4 Data Analysis Method

Data analysis followed a two-stage procedure recommended for PLS-SEM (Hair et al., 2022). In the first stage, the measurement model was evaluated by examining indicator reliability, internal consistency reliability (Cronbach's alpha and composite reliability), convergent validity (average variance extracted), and discriminant validity (Fornell-Larcker criterion and heterotrait-monotrait ratio). In the second stage, the structural model was evaluated by examining the significance and

magnitude of path coefficients, the explained variance (R-squared), and the predictive relevance (Q-squared).

Mediation was tested using the bootstrap procedure with 5,000 resamples to construct bias-corrected confidence intervals for the indirect effect (Preacher and Hayes, 2008). Moderation was tested by including the interaction term between green organizational culture and digitalization level in the structural model, with both variables mean-centered before forming the product term. All analyses were performed using SmartPLS 4.0.

3.5 Common Method Bias

Because all variables were collected from the same respondents at the same time, common method bias (CMB) was a potential concern. Several procedural and statistical measures were taken to address this issue. Procedurally, the questionnaire ensured respondent anonymity, items for different constructs were mixed rather than grouped by construct, and different response anchors were used where appropriate (Podsakoff et al., 2003). Statistically, Harman's single-factor test was conducted by entering all measurement items into an exploratory factor analysis. The analysis yielded multiple factors, and the first unrotated factor accounted for 28.6% of the total variance, which is below the 50% threshold. In addition, full collinearity VIFs for all constructs were below 3.3, providing further evidence that CMB was unlikely to be a serious concern (Kock, 2015).

4. Results

4.1 Descriptive Statistics and Correlations

Table 2 presents the descriptive statistics and correlation matrix for the main variables. The means of the Likert-scale variables ranged from 3.31 (digitalization level) to 3.72 (green organizational culture), indicating moderate to moderately high levels across all constructs. Green organizational culture was positively correlated with green knowledge sharing ($r = .52$), green innovation ($r = .46$), and digitalization level ($r = .34$). Green knowledge sharing was positively correlated with green innovation ($r = .49$). Among the control variables, R&D intensity showed a positive correlation with green innovation ($r = .27$).

Table 2. Descriptive Statistics and Correlation Matrix

Variable	Mean	SD	1	2	3	4	5	6	7
1. Green organizational culture	3.72	0.81	—						
2. Green knowledge sharing	3.58	0.84	.52	—					
3. Green innovation	3.45	0.79	.46	.49	—				
4. Digitalization level	3.31	0.92	.34	.38	.31	—			
5. Firm age	12.35	7.28	.08	.06	.05	.11	—		
6. Firm size (ln)	4.52	1.13	.15	.12	.14	.21	.36	—	
7. R&D intensity	3.86	2.41	.22	.19	.27	.25	-.04	.18	—

Note: N = 326. Correlations above .11 are significant at $p < .05$; correlations above .14 are significant at $p < .01$.

4.2 Measurement Model

The measurement model was evaluated for reliability and validity. Table 3 presents the results. All indicator loadings ranged from .68 to .89, exceeding the recommended threshold of .60. Cronbach's alpha values ranged from .84 to .91, and composite reliability (CR) values ranged from .89 to .93, indicating satisfactory internal consistency (Hair et al., 2022). Average variance extracted (AVE) values ranged from .58 to .71, exceeding the .50 threshold and confirming convergent validity (Fornell and Larcker, 1981).

Table 3. Measurement Model Results

Construct	Items	Cronbach's alpha	CR	AVE	Loading range
Green organizational culture	12	.89	.91	.63	.72-.87
Green knowledge sharing	8	.87	.90	.60	.71-.86
Green innovation (higher-order)	12	.91	.93	.58	.68-.89
— Green product innovation	4	.85	.90	.69	.78-.87
— Green process innovation	4	.84	.89	.67	.76-.86
— Green management innovation	4	.86	.91	.71	.80-.89
Digitalization level	6	.85	.89	.62	.73-.84

Note: CR = composite reliability; AVE = average variance extracted. All loadings are significant at $p < .001$.

Discriminant validity was assessed using the heterotrait-monotrait (HTMT) ratio (Henseler et al., 2015). All HTMT values were below .85, confirming satisfactory discriminant validity. The Fornell-Larcker criterion was also met, as the square root of each construct's AVE exceeded its correlations with all other constructs.

Table 4. Discriminant Validity (HTMT)

Construct	GOC	GKS	GI	DL
Green organizational culture (GOC)	—			
Green knowledge sharing (GKS)	.58	—		
Green innovation (GI)	.51	.55	—	
Digitalization level (DL)	.38	.43	.35	—

Note: All HTMT values are below the .85 threshold.

For the higher-order construct of green innovation, the three first-order dimensions loaded significantly onto the higher-order factor, with path weights of .86 (green product innovation), .83 (green process innovation), and .88 (green management innovation), all significant at $p < .001$.

4.3 Structural Model and Hypothesis Testing

Table 5 reports the structural model results. The model explained 31.2% of the variance in green knowledge sharing ($R^2 = .312$) and 38.4% of the variance in green innovation ($R^2 = .384$). The Stone-Geisser Q^2 values for green knowledge sharing (.182) and green

innovation (.224) were above zero, indicating satisfactory predictive relevance. The standardized root mean square residual (SRMR) was .058, below the recommended threshold of .08.

Table 5. Structural Model Results

Hypothesis	Path	beta	SE	t	p	Result
H1	GOC → GI	0.24	0.06	4.00	.001	Supported
H2	GOC → GKS	0.46	0.05	9.20	< .001	Supported
H3	GKS → GI	0.35	0.06	5.83	< .001	Supported
H5	GOC x DL → GKS	0.14	0.05	2.80	.005	Supported
Control	Firm age → GI	-0.03	0.05	0.60	.549	Not significant
Control	Firm size → GI	0.08	0.05	1.60	.110	Not significant
Control	R&D intensity → GI	0.12	0.05	2.40	.016	Significant
Control	Industry type → GI	0.06	0.05	1.20	.230	Not significant
Control	Ownership type → GI	0.04	0.05	0.80	.424	Not significant

Note: N = 326. GOC = green organizational culture; GKS = green knowledge sharing; GI = green innovation; DL = digitalization level. R-squared (GKS) = .312; R-squared (GI) = .384; Q-squared (GKS) = .182; Q-squared (GI) = .224; SRMR = .058. Industry type and ownership type were dummy-coded control variables.

H1 proposed that green organizational culture has a positive effect on green innovation. The results show a positive and significant direct effect (beta = 0.24, SE = 0.06, t = 4.00, p = .001), supporting H1. H2 proposed that green organizational culture has a positive effect on green knowledge sharing. The results indicate a positive and significant effect (beta = 0.46, SE = 0.05, t = 9.20, p < .001), supporting H2. H3 proposed that green knowledge sharing has a positive effect on green innovation. The results show a positive and significant effect (beta = 0.35, SE = 0.06, t = 5.83, p < .001), supporting H3.

Among the control variables, R&D intensity had a positive and significant effect on green innovation (beta = 0.12, SE = 0.05, t = 2.40, p = .016). Firm age, firm size, industry type, and ownership type were not significantly associated with green innovation.

4.4 Mediation Analysis

Table 6 reports the mediation analysis results based on 5,000 bootstrap resamples.

Table 6. Mediation Analysis Results

Effect	beta	SE	95% CI lower	95% CI upper
Indirect effect (GOC → GKS → GI)	0.16	0.04	0.09	0.24
Direct effect (GOC → GI)	0.24	0.06	0.12	0.36
Total effect (GOC → GI)	0.40	0.06	0.28	0.52

Note: N = 326. Bootstrap resamples = 5,000. CI = bias-corrected confidence interval. VAF = 40.0%.

The indirect effect of green organizational culture on green innovation through green knowledge sharing was positive and significant (beta = 0.16, SE = 0.04, 95% CI [0.09, 0.24]). The confidence interval does not include zero, confirming the significance of the mediation effect. Because the direct effect remained significant (beta = 0.24, p = .001), the results indicate partial mediation. The variance

accounted for (VAF) by the indirect effect was 40.0%, suggesting that green knowledge sharing explains a substantial portion of the total effect. H4 is supported.

4.5 Moderation Analysis

H5 proposed that digitalization level positively moderates the relationship between green organizational culture and green knowledge sharing. The interaction term had a positive and significant effect on green knowledge sharing ($\beta = 0.14$, $SE = 0.05$, $t = 2.80$, $p = .005$), supporting H5.

To illustrate the moderation effect, simple slope analysis was conducted at one standard deviation above and below the mean of digitalization level.

Table 7. Simple Slope Analysis for Moderation

Digitalization level	Effect of GOC on GKS (beta)	SE	t	p
High (+1 SD)	0.58	0.06	9.67	< .001
Mean	0.46	0.05	9.20	< .001
Low (-1 SD)	0.34	0.07	4.86	< .001

Note: N = 326. High = mean + 1 SD; Low = mean - 1 SD.

The effect of green organizational culture on green knowledge sharing was positive and significant at all levels of digitalization, but the effect was notably stronger at high digitalization levels ($\beta = 0.58$) compared with low digitalization levels ($\beta = 0.34$). This pattern indicates that digital infrastructure amplifies the effectiveness of green organizational culture in promoting knowledge-sharing behavior among employees.

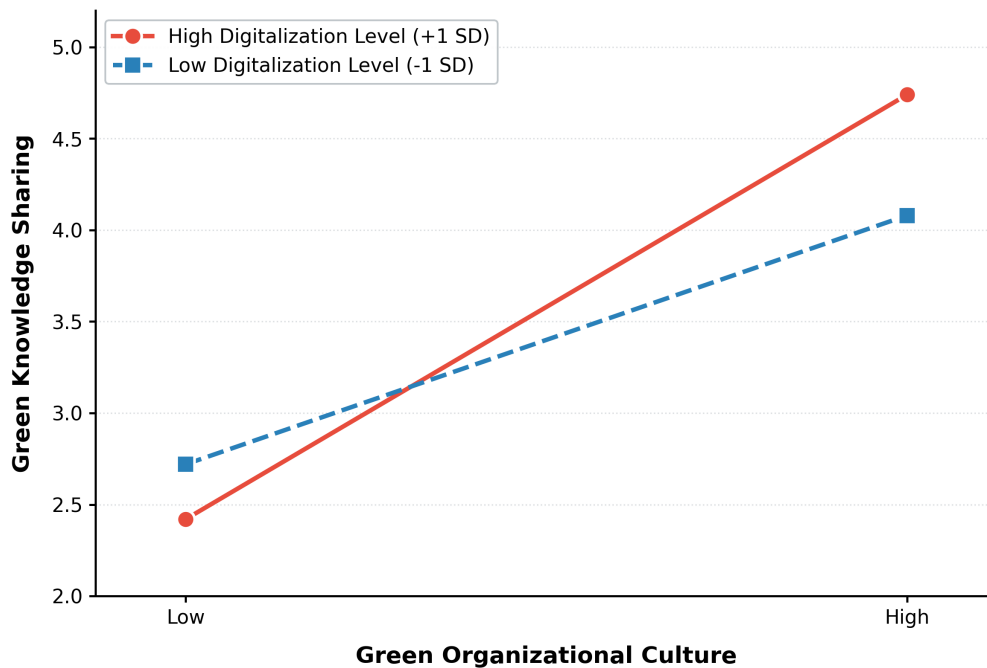


Fig.2: Interaction Plot: Moderating Effect of Digitalization Level on the Relationship between Green Organizational Culture and Green Knowledge Sharing

Table 8. Summary of Hypothesis Testing Results

Hypothesis	Statement	Result
H1	Green organizational culture has a significant positive effect on green innovation.	Supported
H2	Green organizational culture has a significant positive effect on green knowledge sharing.	Supported
H3	Green knowledge sharing has a significant positive effect on green innovation.	Supported
H4	Green knowledge sharing mediates the relationship between green organizational culture and green innovation.	Supported (partial mediation)
H5	Digitalization level positively moderates the relationship between green organizational culture and green knowledge sharing.	Supported

5. Discussion

This study examined how green organizational culture is associated with green innovation in Chinese manufacturing SMEs, with attention to the mediating role of green knowledge sharing and the moderating role of digitalization level. All five hypotheses were supported. The findings and their implications are discussed below.

5.1 Green Organizational Culture and Green Innovation

The results show that green organizational culture is positively associated with green innovation (H1 supported). This finding is consistent with previous research suggesting that organizational culture supportive of environmental goals is related to green innovation outcomes (Al-Hakimi et al., 2022; Wang et al., 2022; Lin et al., 2024). In the context of manufacturing SMEs, this result suggests that shared environmental values, norms, and management leadership are associated with an internal environment where green innovation is encouraged and supported. When employees and managers share a common understanding of the importance of environmental improvement, the organization is more likely to allocate resources toward green product development, process modifications, and management practice improvements.

This finding has particular relevance for SMEs that may lack formal environmental management systems. In these firms, organizational culture provides an informal mechanism that guides employee behavior and resource allocation in the absence of codified environmental procedures. The result suggests that building shared environmental values and norms can be an effective strategy for SMEs seeking to improve their green innovation without necessarily investing in complex formal systems. This is an important distinction from previous research that has primarily examined green organizational culture as a moderator of other relationships (Al-Hakimi et al., 2022; Wang et al., 2022), as it shows that green culture also has an independent positive effect on green innovation.

5.2 The Mediating Role of Green Knowledge Sharing

The findings indicate that green knowledge sharing partially mediates the relationship between green organizational culture and green innovation (H4 supported). This result suggests that green organizational culture is related to green innovation not only directly but also through the informational mechanism of green knowledge sharing. When employees share environmental information, experience, and expertise across departments and functions, they combine different types

of knowledge that can generate new ideas for improving products, processes, and management practices.

The partial mediation result is informative. Green knowledge sharing accounts for approximately 40% of the total effect of green organizational culture on green innovation, indicating that knowledge sharing is a substantial pathway through which cultural values are translated into innovation outcomes. The remaining direct effect suggests that green culture also promotes green innovation through other channels not examined in this study, such as increased environmental motivation, stronger commitment to organizational environmental goals, or greater willingness to pursue uncertain green initiatives. Future research could investigate these additional mechanisms to build a more comprehensive understanding of how green organizational culture supports green innovation.

From an enterprise informatics perspective, the mediating role of green knowledge sharing indicates that the effectiveness of green organizational culture depends partly on how well environmental information flows within the organization. Cultural values set the direction for environmental action, but knowledge sharing provides the informational infrastructure through which values are converted into innovation activities. This finding contributes to the knowledge management literature by showing that organizational culture and knowledge sharing function as complementary forces in promoting green innovation, rather than as independent or substitutable factors.

5.3 The Moderating Role of Digitalization Level

The results show that digitalization level positively moderates the relationship between green organizational culture and green knowledge sharing (H5 supported). The positive effect of green organizational culture on green knowledge sharing is stronger in firms with higher levels of digitalization. This finding suggests that digital tools and platforms facilitate the translation of cultural values into knowledge-sharing behaviors by providing efficient channels for information exchange.

In firms with higher digitalization levels, environmental information can be recorded, stored, and transmitted using digital systems, making knowledge sharing less dependent on face-to-face interaction and more accessible across organizational boundaries. Digital communication platforms, shared databases, and enterprise information systems reduce the effort required for knowledge exchange and increase the visibility of environmental information to all organizational members. In contrast, in firms with lower digitalization levels, environmental knowledge may remain within individual departments or personal networks even when employees share green values, because the channels for cross-functional information exchange are limited.

This finding is relevant for manufacturing SMEs at different stages of digital adoption. It suggests that investing in digital infrastructure can enhance the effectiveness of green organizational culture by enabling more frequent and broader environmental knowledge sharing. For SMEs with limited resources, even basic digital tools such as internal communication applications and shared document platforms may improve the flow of green knowledge within the organization and strengthen the connection between environmental values and knowledge-sharing practices.

5.4 Theoretical Contributions

This study contributes to the enterprise informatics and knowledge management literature in three ways. First, it shows that green organizational culture is linked to green innovation through green knowledge sharing, identifying an informational mechanism that connects cultural values to innovation outcomes. This extends the understanding of green organizational culture, which has largely been examined as a moderating variable in previous studies (Al-Hakimi et al., 2022; Wang et al., 2022), by providing evidence for its direct and indirect relationships with green innovation. Second, the finding that digitalization level moderates the culture-knowledge sharing relationship contributes to research on how digital infrastructure supports knowledge management processes in

organizations. It shows that the relationship between organizational culture and knowledge sharing is not uniform but depends on the technological context in which knowledge exchange takes place. Third, the focus on Chinese manufacturing SMEs provides empirical evidence from a context where green innovation faces particular organizational constraints, contributing to the limited research on green innovation processes in resource-constrained firms.

5.5 Practical Implications

The findings offer several practical suggestions for manufacturing SME managers. First, managers should invest in building a green organizational culture by communicating environmental values, establishing green behavioral norms, and leading by example on environmental issues. Specific actions include formulating and communicating a green vision statement, incorporating environmental objectives into departmental goals, and recognizing employees who contribute to environmental improvement. The results suggest that such cultural investments can have meaningful effects on green innovation outcomes.

Second, managers should create conditions that support green knowledge sharing among employees. This may involve organizing regular cross-functional meetings to discuss environmental challenges and solutions, establishing internal platforms for sharing environmental best practices, and encouraging employees to document their experiences with green production methods and management approaches. The mediating role of knowledge sharing suggests that cultural values alone may not be sufficient to generate green innovation; active knowledge-sharing practices are needed to connect values to concrete innovation activities.

Third, managers should consider how digital tools can support green knowledge sharing. The moderating effect of digitalization level suggests that investments in digital communication tools, shared information platforms, and environmental data management systems can strengthen the link between green culture and knowledge sharing. For SMEs with limited budgets, prioritizing affordable digital tools that enable cross-departmental information exchange may yield meaningful improvements in how environmental knowledge is shared and used within the organization.

6. Conclusions

This study examined the relationship between green organizational culture and green innovation in Chinese manufacturing SMEs, with attention to the mediating role of green knowledge sharing and the moderating role of digitalization level. The findings show that green organizational culture is positively associated with green innovation, and that this relationship is partially mediated by green knowledge sharing. Digitalization level strengthens the positive relationship between green organizational culture and green knowledge sharing. These results suggest that manufacturing SMEs seeking to improve their green innovation performance should build shared environmental values and norms, encourage cross-functional knowledge exchange on environmental issues, and invest in digital tools that support information sharing.

This study has several limitations that point to directions for future research. First, the cross-sectional research design limits the ability to establish causal relationships among the variables. Future studies could employ longitudinal designs to examine how green organizational culture, knowledge sharing, and green innovation develop and interact over time. Second, data were collected from single respondents within each firm, which may introduce common method bias despite the procedural and statistical measures taken to address this concern. Future research could use multi-source data collection designs to reduce this risk. Third, the sample was drawn from Chinese manufacturing SMEs, and the generalizability of the findings to other national or industrial contexts remains to be tested. Replication studies in different countries or in service-sector SMEs would be valuable. Fourth, this study examined green knowledge sharing as the mediating mechanism, while

other pathways through which green organizational culture promotes green innovation, such as environmental motivation or organizational commitment, remain to be investigated.

From the perspective of enterprise informatics and knowledge management, future research could examine how specific types of digital systems, such as environmental information platforms, green supply chain coordination tools, or digital environmental reporting systems, influence green knowledge sharing and green innovation in manufacturing SMEs. Research examining green innovation dynamics in logistics and service-system contexts would also contribute to a broader understanding of how organizational culture and knowledge management interact to support environmental innovation across different types of organizations.

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