

RESEARCH ON THE INFLUENCE MECHANISM OF DIGITAL LEADERSHIP ON GREEN INNOVATION OF MANUFACTURING ENTERPRISES

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ABSTRACT. *In recent years, promoting green and low-carbon development and achieving a comprehensive green transformation of economic and social development have become an important strategic deployment for China to promote high-quality economic and social development. To adapt to the ongoing transformations, leaders must evolve with the times, transitioning from traditional leadership to digital leadership to comprehensively promote corporate green innovation. Drawing on resource-based theory and dynamic capabilities theory, this study constructs an analytical framework linking digital leadership and green innovation. Furthermore, it conducts in-depth analyses based on enterprise ownership, lifecycle stages, and regional differences. By analyzing 564 matched questionnaire datasets, we find that digital leadership positively enhances green innovation by promoting green operation management, IT integration, and green information sharing. Additionally, pressure evaluation negatively moderates the indirect effects of digital leadership on green operation management and green information sharing. Through further analysis across ownership types, enterprise life cycles, and regions, we observe the following mechanisms: In state-owned enterprises, the mechanism follows the path “digital leadership – IT integration/green information sharing – green innovation”. In private enterprises and startups, the mechanism is characterized as “digital leadership – green operation management/green information sharing – green innovation”. For mature enterprises, the pathway is “digital leadership – green operation management/IT integration – green innovation”. In Eastern China, digital leadership influences green innovation primarily through green information sharing; In western China, digital leadership influences green innovation primarily through green operation management. This research elucidates how digital leadership empowers green innovation within manufacturing firms, identifies the underlying processes and limitations, and offers important insights for transforming traditional leadership paradigms and practices.*

Keywords: Digital leadership, Green transformation, Green innovation, Pressure evaluation, Manufacturing enterprises

1. Introduction. Digitalization and greening are crucial for achieving high-quality economic development in China. The National Informatization Plan for the 14th Five-Year Period emphasizes the need to “promote the coordinated development of digitalization and greening” and to “use digitalization to lead greening while leveraging greening to

advance digitalization". At the same time, the synergistic development of digitalization and greening has drawn increasing attention from scholars [8,9]. Manufacturing is a major source of waste and a key area for digitalization and green development. Facing pressure to upgrade, the industry can benefit from digital technologies and green innovation, which offer practical solutions for its transformation toward sustainability.

Digitalization can effectively facilitate enterprises' green transformation. Research based on case analysis by Cao et al. [10] shows that digital transformation in manufacturing firms promotes a green development trajectory evolving from structural greening to capability building, and finally to leveraging green advantages. Tian and Liu [11] further argue that not only does digitalization drive greening, but greening also stimulates digitalization; the two processes mutually reinforce each other and advance in coordination. Taking the new energy vehicle industry as an example, digitalization enhances firms' capabilities in green technological innovation, thereby promoting their green transformation. For instance, BYD has replaced traditional fuel vehicles with electric vehicles, demonstrating strong green innovation capabilities. During its green transformation, BYD's leadership leveraged data-driven insights to define green strategic directions and established a digital collaboration network to integrate internal and external resources, thereby driving technological innovation and end-to-end low-carbon management. This ability to make and carry out decisions that closely link digital technology with environmental goals is the key driver behind their successful transformation. In this process, digital leadership plays an important role. Another successful case of coordinated digital and green transformation is Xiaomi Auto. As a company inherently rooted in digital technologies, Xiaomi has embedded digital capabilities deeply into every stage of its green transformation, achieving simultaneous advancement in both dimensions. In contrast, traditional automakers such as China First Automobile Group, Shanghai Automotive Industry, Dongfeng Motor Corporation, and Changan Automobile have struggled to overcome path dependencies associated with conventional manufacturing due to insufficient digital leadership and have a vague understanding of the strategic priority of digital transformation, which hinders digital transformation.

Digital leadership has become one of the key driving forces enabling manufacturing firms to achieve green innovation and sustainable development in the digital era. Leadership influences both internal and external resources and environments of a firm, thereby promoting organizational innovation. The essence of digital leadership lies in integrating information technology with corporate strategy, fostering innovation through improved resource allocation and enhanced decision-making efficiency. Furthermore, digital leadership enables firms to maintain innovative vitality and competitive advantage in rapidly changing environments by facilitating the adoption of digital technologies, enhancing decision agility, promoting organizational learning and knowledge sharing, and improving responsiveness to external changes. Therefore, the effectiveness of digital leadership depends on a firm's capabilities in operations management, technology integration, and information sharing. Accordingly, this study examines the mediating roles of green operation management, IT technology integration, and green information sharing in the relationship between digital leadership and green innovation in manufacturing firms. Moreover, the institutional environment in which a firm operates also influences the enactment of digital leadership. Thus, this study thoroughly considers how enterprise ownership, firm life cycle stage, and regional location moderate the mechanisms through which digital leadership operates.

In summary, guided by the resource-based view and dynamic capabilities theory, this study investigates the role of digital leadership in promoting green innovation. First,

it explores how digital leadership influences green operation management, IT integration, and green information sharing, and systematically analyzes their mediating roles in the relationship between digital leadership and green innovation. Second, drawing on insights from organizational behavior research, this study incorporates pressure evaluation as an important boundary condition and systematically examines how organizations under different levels of pressure evaluation differ in their engagement in green operation management, IT technology integration, and green information sharing. Finally, the study conducts comparative analyses between state-owned and private enterprises, startups and mature firms, as well as enterprises located in eastern and western regions of China. Overall, by examining how digital leadership facilitates green innovation in Chinese manufacturing firms, this study develops and tests a localized conceptual model of digital leadership tailored to the context of China's manufacturing sector. The findings contribute novel theoretical insights and extend the existing body of research.

The remainder of this paper is organized as follows: Section 2 outlines the theoretical foundation and research hypotheses; Section 3 describes the research design; Section 4 presents the empirical results and analysis; Section 5 provides discussion and implications; and Section 6 draws conclusions, addresses limitations, and proposes directions for further developments.

2. Literature Review and Research Hypothesis.

2.1. Digital leadership and green innovation. Leadership is a fundamental and strategic element in any leadership system. It refers to a leader's ability to inspire and influence individuals or organizations, based on personal qualities and the specific situation. More importantly, it is a key force that drives continuous growth and long-term development of organizations. Digital leadership is the concrete presentation of leadership in the digital field, and different scholars have different views on digital leadership.

Avolio et al. [1] initially defined digital leadership as "a process of transformation and influence experienced by leaders in terms of cognition, emotion, and behavior, triggered by information technology". This definition has gained broad recognition in academic circles; however, its applicability and guidance in empirical research remain limited. Since Avolio et al. introduced the concept of e-leadership, scholars have not reached a consensus on its conceptual boundaries. Through continuous refinement, Avolio et al. [2] later redefined digital leadership as "a social influence process embedded within proximal and distal contexts, enabled by information and communication technology (ICT), that leads to changes in individuals', and organizations' attitudes, emotions, thinking, behaviors, and performance". Roman et al. [3] further described digital leadership as "a series of technology-mediated social influence processes aimed at changing attitudes, emotions, thinking, behaviors, and performance. This process relies on the leader's ability to communicate clearly and appropriately, facilitate sufficient social interaction, motivate and manage change, build and maintain responsible teams, articulate ICT-related knowledge, and foster trust in virtual environments", emphasizing the importance of effective communication skills. Benitez et al. [6] argue that digital leadership refers to a leader's capability to utilize a combination of digital skills to lead and manage personnel, and to digitally transform organizations, highlighting the role of digital competencies in leadership.

Although China's traditional manufacturing sector has established a clear strategic direction for digital transformation, several challenges remain, including outdated industrial models, suboptimal product structures, insufficient digital management capabilities, and difficulties in accessing funding. A key underlying cause is that traditional managers often rely solely on experience without actively acquiring new knowledge or developing digital

leadership skills. Therefore, it is essential to explore the structural dimensions of digital leadership, as well as the specific indicators under each dimension. From a theoretical perspective, Roman et al. [3] proposed the SEC model of digital leadership, which categorizes digital leadership into six dimensions: e-communication (digital communication), e-social (digital social interaction), e-change (digital change management), e-team (digital team leadership), e-tech (digital technology proficiency), and e-trust (digital trust building). Li and Miao [12], drawing on the SEC model proposed by Van Wart et al. [13], conducted a qualitative study using grounded theory with a sample of 58 Chinese entrepreneurs. They designed a context-specific structural framework and measurement scale for digital leadership in China, identifying five dimensions: digital strategic thinking, digital environmental control, digital organizational transformation, digital talent development, and digital communication/social interaction. Each measurement item was subjected to confirmatory analysis, yielding strong reliability and validity.

Based on the above review of the current development of corporate digital leadership and in alignment with the research focus of this study – the relationship between digital leadership and green innovation – this study adopts the definition proposed by Benitez et al. [6], which conceptualizes digital leadership as the integration of digital technologies with leadership practices. It reflects a leader's proactive embrace of change, ability to inspire innovation, and capacity to rapidly reconfigure organizational structures and processes in response to dynamic digital environments. Furthermore, this study draws upon the measurement scale for digital leadership in the Chinese context developed by Li and Miao [12] to assess the construct of digital leadership.

The resource-based theory posits that a firm's innovative capability is influenced by its resources, and digitalization represents a critical information and knowledge resource for modern enterprises. However, current literature on digital leadership and digital transformation remains limited. Dynamic capabilities theory originates from the seminal work "Dynamic Capabilities and Strategic Management" by Teece et al. [14]. Its central argument is that dynamic capabilities enable firms to gain innovative competitive advantages in rapidly changing business environments. Teece [15] defines dynamic capabilities as the ability of a firm to integrate, build, and reconfigure internal and external resources as needed to rapidly respond to market dynamics, identify environmental changes, and seize technological opportunities. As an extension of resource-based theory, dynamic capabilities theory moves beyond the static analysis of competitive advantage under the traditional resource-based view. Dynamic capabilities are unique in that they allow firms to sense complex and turbulent market conditions, initiate competitive actions, and quickly adapt to new circumstances. This dynamic alignment with the external environment serves as the foundation for achieving sustainable competitive advantage. Among others, digital leadership plays a crucial role in enabling firms to effectively address the challenges of digital transformation. In the context of leadership, scholars such as Mihardjo et al. [16] emphasize organizational resource capabilities as the first theoretical basis of dynamic capabilities. They argue that organizations must create, expand, and modify their resources to align with environmental changes and that they achieve this through integrating, building, and reconfiguring capabilities to detect changes, exploit opportunities, and transform the organization [14]. Research shows that digital leadership has a significant direct and indirect impact on innovation. Importantly, this effect is accelerated when leaders adopt a market-oriented focus.

Against the strategic backdrop of the "carbon peaking and carbon neutrality" goals and the broader push for green development, corporate green innovation has emerged as a critical pathway to achieving the "dual carbon" targets and sustainable development. It represents not only a major national priority but also a key research agenda for the

academic community. Green innovation is a systematic effort to reduce energy use, lower pollution, and improve the environment, with the main goal of supporting ecological progress. Its core value lies in helping shift economic growth from reliance on resources to being driven by innovation. It is a key support and main driving force for high-quality development. Based on the above, the following hypothesis is proposed:

H1: Digital leadership has a positive impact on green innovation.

2.2. The mediating role of green operation management, IT technology integration, and green information sharing. With the widespread adoption and deepening application of digital technologies, firms are continuously creating new products and services by building digital capabilities. Leadership exerts influence over both internal and external organizational resources and environments, thereby promoting innovation. Today, a suite of digital technologies – such as cloud computing, big data, and artificial intelligence – form a technological “ecosystem” that is transforming nearly every industry. The effective enactment of digital leadership depends on organizational capabilities in operations management, technology integration, and information sharing. Given that this study’s dependent variable is green innovation, we contextualize the aforementioned capabilities within the framework of sustainable development, redefining them as green operation management, IT technology integration, and green information sharing, respectively, to better align with the research context of green innovation. First, digital leaders establish a clear digital vision that motivates organizational members to apply digital technologies toward energy conservation and emissions reduction, thereby enhancing green operation management. Second, through continuous learning of digital theories and the application of digital tools, digital leaders can integrate IT technologies effectively. Third, digital leadership shapes employees’ perceptions of organizational digital transformation and environmental issues, facilitating green information sharing and, consequently, fostering organizational green innovation.

Based on the above reasoning, this study posits that green operation management, IT technology integration, and green information sharing serve as mediating mechanisms between digital leadership and green innovation. Therefore, the following hypotheses are proposed:

H2a: Green operation management plays an intermediary role between digital leadership and green innovation;

H2b: IT technology integration plays an intermediary role between digital leadership and green innovation;

H2c: Green information sharing plays an intermediary role between digital leadership and green innovation.

2.3. The moderating effect of pressure evaluation. Under the “innovation and change” style of the Internet factory, due to policy changes, business competition, etc., the moderating and change of employees are more frequent than in other industries. Employees around 35 years old are often the first to be abandoned by enterprises due to the decline of energy and the rise of costs. In the reality of the industry, there are not many survivors aged 35 in the Internet factory. “How to escape the trap of being 35 years old” is a problem that needs to be considered early. According to the BOSS (corporate name) survey data, 56.8% of the users clearly stated that the workplace was not friendly to the 35-year-old population. Nearly 60% of the respondents had not received promotions and salary increases in the past two years, while 75.9% believed that they had encountered ceilings in the workplace. This means that the people left behind are not easy.

Employees of Internet companies have to face these pressures. Can they stay in the company after the age of 35? Will their path to promotion go smoothly? Pressure eva-

uation, on the other hand, is the process by which employees judge the demands of their situation and their own ability to cope with those demands. Individuals will tend to evaluate high situational requirements as obstacles. At present, the new generation of post-90s and post-00s employees has gradually become the mainstream of the workplace. Studies have shown that compared with the older generation of employees, the new generation of employees is quite different from them in many aspects (such as values, pressure resistance, work, and lifestyle), which has an impact on their behavioral cognition and psychological state. Based on this, this study attempts to use pressure evaluation as a moderating variable to explore its moderating effect on the digital leadership of leaders on green operation management, IT technology integration, and green information sharing. Therefore, the following hypotheses are proposed:

H3a: Pressure evaluation negatively moderates the impact of digital leadership on green operation management;

H3b: Pressure evaluation negatively moderates the impact of digital leadership on IT technology integration;

H3c: Pressure evaluation negatively moderates the impact of digital leadership on green information sharing.

Based on the above theoretical analysis and hypothesis deduction, the conceptual model constructed in this study is shown in Figure 1.

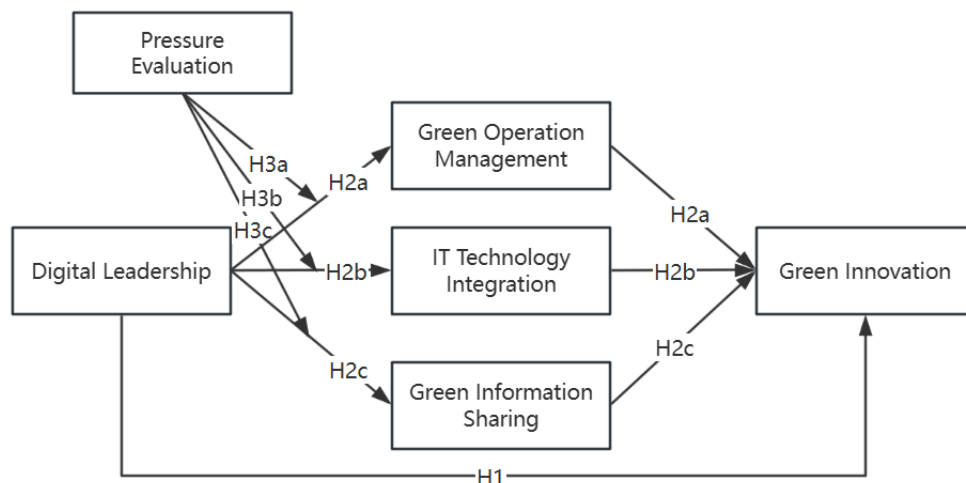


FIGURE 1. Conceptual model

3. Materials and Methods.

3.1. Study design. This study uses the maturity scale in the field for variable measurement. The specific selection criteria include 1) the measurement method is widely recognized and cited by the academic community; 2) the reference scale has high reliability and validity; 3) the measurement items are suitable for the context of this study and can accurately express the meaning of the concept in this paper. Then, through the pre-survey stage, the respondents' feedback on the content of the initial questionnaire was collected, and the industry experts and field scholars were consulted to obtain their opinions on the content of the scale. Finally, according to the collected feedback, the content of the questionnaire and the expression of the wording are modified to determine the content of the scale. In addition to the control variables, the scales involved in this study used a Likert Scale (1 represents completely inconsistent, 5 means entirely consistent, and so on). The specific scale selection results are as follows:

TABLE 1. Variable measurement standards

Variable	Item	Cronbach's α	Source of scale
Digital leadership	12	0.932	Using the measurement scale developed by Li and Miao [12], referring to Zhang and Zheng's [24] question method for the items of the digital leadership scale.
Green operation management	4	0.821	Different scholars have different ways of expressing green operation management. This paper summarizes it in the same way of expression, including technology, talents, publicity, and economic input.
IT technology integration	4	0.832	Many scholars use questionnaires to measure the ability of technology integration. Combined with the research content of this paper, they mainly consider whether the IT technology integration of enterprises can adapt to the green transformation.
Green information sharing	6	0.878	The Wood and Menezes [25] scale used in the employee engagement scale in Nazir et al.'s [26] study was the Wood and Menezes [25] scale.
Green innovation	8	0.944	Following the research paradigm of Dong et al. [27], the number of green patent authorizations is used as the basic measurement index of green innovation.
Pressure evaluation	6	0.890	One-dimensional scale developed by LePine et al. [28].

In addition, existing research indicates that demographic variables such as gender, age, firm size, years since establishment, job position, and organizational ownership are significantly associated with employees' innovative behaviors. To account for the potential influence of these background factors, this study includes the aforementioned demographic variables as control variables in the subsequent data analysis. Furthermore, given that this study focuses on green innovation in manufacturing firms, we introduce "Corporate Green Technology Capability" as an additional control variable to account for potential effects stemming from differences in firms' baseline green technological capacities. This variable is assessed based on the six sub-dimensions under the "Green Enterprise" category of the Green Manufacturing Standards System, that is, the standards for the creation of green enterprises, the standards for resource structure, the standards for energy structure, the standards for product structure, the standards for output efficiency and the standards for environmental responsibility, ensuring scientific rigor and operational feasibility in its measurement.

3.2. Data collection. This exploratory study adopted a quantitative research method, and data on key indicators were collected through questionnaires distributed via Wenjuanxing (an online survey platform). A total of 800 questionnaires were collected, and after collection, some invalid ones needed to be excluded. The criteria for screening out invalid questionnaires were as follows: 1) excluding questionnaires completed in an excessively short time; 2) excluding questionnaires filled out carelessly or in a mechanical, patterned manner; 3) excluding questionnaires where responses to reverse-worded items

were completely contradictory to those of other items. After selection and sorting according to the above criteria, 564 valid questionnaires were finally obtained, with an effective response rate of 70.5%.

In the final effective samples, the proportion of male employees in the gender part is 65.4%, and the proportion of female employees is 34.6%. The gender ratio distribution is relatively average, so the impact of gender on the data results can be reduced. The proportion of ordinary employees in the job position is 28.4%, the proportion of grass-roots managers is 28.9%, the proportion of middle managers is 20.9%, and the proportion of senior managers is 21.8%. The proportion of jobs is more balanced, which can reduce the impact of job positions on the overall data results. Based on the research of manufacturing enterprises, 30.8% of the enterprises have been established for 10 years or more, and the company has been established for a long and stable period, which provides a guarantee for the credibility of the sample selection. The high-tech industry is 43.1%, which is in line with the background of this study and provides support for our survey of digital leadership. In summary, the research conclusions based on the final screened data can provide more effective practical guidance for organizations.

3.3. Data extraction and analysis. In this study, the reliability and validity of the scale were evaluated by the reliability coefficient Cronbach's α , composite reliability (CR), average variance extraction (AVE), factor loading, and confirmatory factor analysis. As shown in Table 2, Cronbach's α and CR values were more significant than the recommended standard of 0.7, and KMO values were more significant than 0.7, which indicated that the scale used in this study had good reliability. In terms of convergence validity, all factor loads are more important than 0.6, and the AVE values of each variable exceed the recommended threshold of 0.5, indicating that the convergence validity of each variable is good. In addition, the six-factor model (see Table 3) indicates good discriminant validity among these six variables, with IFI = 0.908, TLI = 0.900, CFI = 0.907, and RMSEA = 0.057.

TABLE 2. Measurement index, reliability, and convergence validity test of the scale

Variable	Number of items	Factor load range (minimum~maximum)	Cronbach's α	KMO	AVE	CR
DL	12	0.696~0.841	0.932	0.952	0.537	0.933
GOM	4	0.689~0.883	0.821	0.734	0.570	0.840
IT	4	0.704~0.865	0.832	0.765	0.575	0.843
GIS	6	0.698~0.785	0.878	0.888	0.547	0.878
PE	6	0.710~0.828	0.890	0.883	0.576	0.890
GI	8	0.807~0.856	0.944	0.896	0.681	0.945

Considering that the questionnaire is self-reported by employees, there may be homologous variance (CMV) problems. In terms of statistical techniques, the Harman single-factor test was used to evaluate potential CMV problems. The results show that all factors with eigenvalues greater than 1 explain 63.3% of the total variance, and the first factor explains 15.6% of the total variance, which is lower than the recommended threshold of 40%. This shows that the CMV problem with the questionnaire data is not serious and is unlikely to affect the reliability of the research results. As a supplement, this study further uses the potential error variable control method to test CMV. This test method adds a common method factor to the baseline model and then performs confirmatory factor analysis. As shown in the confirmatory factor analysis results in Table 3, after adding

TABLE 3. Confirmatory factor analysis results

	χ^2	df	χ^2/df	IFI	TLI	CFI	RMSEA	SRMR
One-Factor Model (DL + GOM + IT + GIS + PE + GI)	8631.745	740	11.665	0.456	0.425	0.455	0.138	0.140
Two-Factor Model (DL + GOM + IT + GIS + PE, GI)	6657.893	739	9.009	0.592	0.568	0.591	0.119	0.126
Three-Factor Model (DL + GOM + IT + GIS, PE, GI)	4988.346	737	6.768	0.707	0.689	0.706	0.101	0.103
Four-Factor Model (DL + GOM + IT, GIS, PE, GI)	3884.380	734	5.292	0.783	0.769	0.782	0.087	0.098
Five-Factor Model (DL + GOM, IT, GIS, PE, GI)	3069.192	730	4.204	0.839	0.827	0.838	0.087	0.088
Six-Factor Model (DL, GOM, IT, GIS, PE, GI)	2066.509	725	2.850	0.908	0.900	0.907	0.057	0.043
Seven-Factor Model (DL, GOM, IT, GIS, PE, GI, CMV)	1892.459	685	2.763	0.917	0.905	0.917	0.056	0.037

Note: 1) CMV represents the standard method variation factor. 2) “+” means the combination of two factors into one factor.

the method factor, the main fitting indexes of the new model (seven-factor model) in the model fitting results show no significant change compared with the six-factor model. Therefore, there is no serious CMV problem in this study.

4. Results.

4.1. Correlation analysis. Correlation analysis is shown in Table 4, including mean, standard deviation, and correlation coefficient. The results showed that digital leadership was positively correlated with green operation management ($r = 0.413$, $p < 0.01$), IT technology integration ($r = 0.388$, $p < 0.01$), and green information sharing ($r = 0.324$, $p < 0.01$). The above results provide preliminary support for subsequent hypothesis testing. The square roots of the core variable AVE on the diagonal are more significant than the non-diagonal elements, which offers additional support for the discriminant validity of the variable measurement. The correlation coefficient of each variable is lower than 0.7, which is a low-to-medium correlation, indicating that multicollinearity is not serious.

4.2. Hypothesis testing.

4.2.1. Main effect test. In this paper, the results of hierarchical regression analysis of sample data are summarized in Table 5. In this table, Job represents the job position, E-age represents the establishment time of the company, E-size represents the size of the company, E-pro represents the province of the company, and E-Nature represents the nature of the company. Model 7 takes green innovation as the dependent variable and analyzes the influence of multiple control variables at the individual level and the enterprise level. Based on this, Model 8 uses digital leadership as an independent variable

TABLE 4. Mean, standard deviation, and correlation coefficient table

	1	2	3	4	5	6
1. DL	(0.733)					
2. GOM	0.413**	(0.755)				
3. IT	0.388**	0.703**	(0.758)			
4. GIS	0.324**	0.631**	0.581**	(0.740)		
5. PE	0.078	-0.111**	-0.153**	-0.059	(0.760)	
6. GI	0.413**	0.478**	0.461**	0.472**	0.077	(0.825)
Mean	3.261	2.719	2.812	2.496	3.171	2.260
SD	0.750	0.743	0.745	0.805	0.774	0.907

Note: 1) $N = 564$. 2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. 3) The square root of the core variable AVE is presented in the diagonal brackets of the matrix.

TABLE 5. Hierarchical regression results

Variable	GOM		IT		GIS		GI					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Sex	0.024	0.025	0.052	0.045	-0.009	-0.008	0.078	0.062	0.053	0.044	0.065	0.054
Age	0.004	0.012	-0.041	-0.029	0.076	0.083*	-0.041	-0.048	-0.049	-0.033	-0.077*	-0.061
Job	0.066	0.061	0.059	0.060	0.071	0.067	0.039	0.019	-0.005	-0.001	-0.008	-0.014
E-age	-0.072	-0.076	0.052	0.036	-0.020	-0.024	-0.054	-0.035	-0.009	-0.053	-0.027	-0.027
E-size	0.065	0.057	0.040	0.026	0.069	0.063	0.025	0.015	-0.009	0.002	-0.011	-0.015
E-pro	0.161***	0.141***	0.137***	0.114**	0.003	-0.013	0.084	0.081*	0.022	0.034	0.080*	0.041
E-Nature	0.098*	0.076	-0.038	-0.058	-0.066	-0.084	0.003	-0.034	-0.070	-0.021	-0.009	-0.027
Green technology	0.055	0.057	0.045	0.042	0.069	0.071	0.063	0.090*	0.070	0.074*	0.063	0.060
DL	0.405***	0.409***	0.388***	0.400***	0.327***	0.331***		0.420***	0.272***	0.287***	0.295***	0.237***
GOM									0.365***			0.135**
IT										0.343***		0.127**
GIS											0.380***	0.239***
PE		-0.122**		-0.168***		-0.095**						
DLxPE		-0.136***		-0.058		-0.103**						
R ²	0.210	0.243	0.180	0.210	0.132	0.152	0.022	0.196	0.302	0.292	0.322	0.350
ΔR^2	0.162	0.033	0.148	0.030	0.106	0.020	0.022	0.174	0.106	0.292	0.322	0.350
F	16.319	16.097	13.539	13.379	9.359	8.967	1.589	15.011	23.876	22.833	26.213	24.693

Note: 1) $N = 564$. 2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. 3) The results reported in the table are standardized coefficients.

to test the main effect. The results show that digital leadership positively affects green innovation ($\beta = 0.420$, $p < 0.001$), so Hypothesis 1 is verified.

4.2.2. Mediation effect test. According to Model 1 in Table 5, digital leadership has a significant positive impact on green operation management ($\beta = 0.405$, $p < 0.001$). When digital leadership and green operation management are put into Model 9, the influence coefficient of digital leadership on green innovation is reduced, and significant ($\beta = 0.272$, $p < 0.001$), and green operation management has a considerable positive impact on green innovation ($\beta = 0.365$, $p < 0.001$). At the same time, as shown in Table 6, the results of the mediating effect test using the Bootstrap method show that the indirect effect value of green operation management between digital leadership and green innovation is 0.0565, the standard error is 0.0257, and the confidence interval is [0.0064, 0.1080], excluding 0. The indirect effect of green operation management is significant. Therefore, it is assumed that H2a is supported.

According to Model 12 in Table 5, when the three variables of green operation management, IT technology integration, and green information sharing are put into Model 8 at the same time, the impact of green operation management on green innovation is

significant ($\beta = 0.135$, $p < 0.01$), IT technology integration has a significant effect on green innovation ($\beta = 0.127$, $p < 0.01$), and the impact of green information sharing on green innovation is also substantial ($\beta = 0.239$, $p < 0.001$). At the same time, as shown in Table 6, the indirect impact of IT technology integration between digital leadership and green innovation is 0.0509, the standard error is 0.0232, the confidence interval is [0.0082, 0.0986], excluding 0, and the indirect effect of IT technology integration is significant. The indirect effect value of green information sharing between digital leadership and green innovation is 0.0808, the standard error is 0.0191, the confidence interval is [0.0449, 0.1189], excluding 0, and the indirect effect of green information sharing is significant.

TABLE 6. Indirect effect test of mediating effect

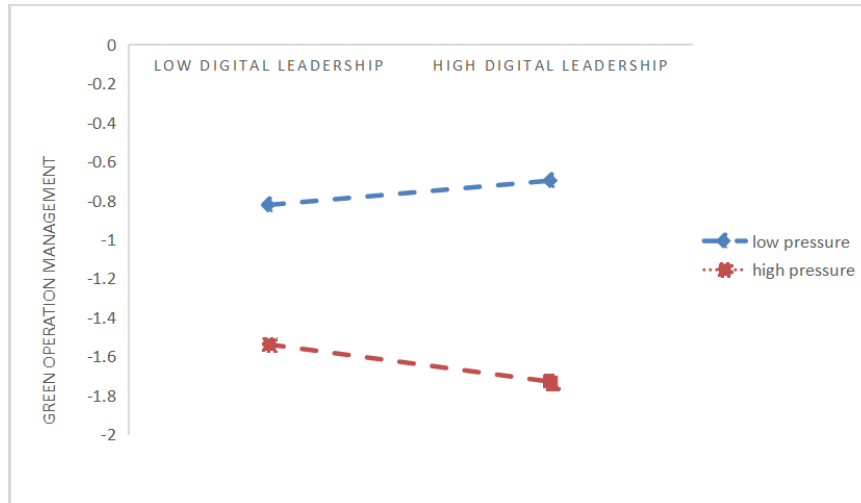
	Effect	SE	LLCI	ULCI
Total effect	0.4331	0.0396	0.3553	0.5108
Direct effect	0.2449	0.0397	0.1669	0.3230
Indirect of GOM	0.0565	0.0257	0.0064	0.1080
Indirect of IT	0.0509	0.0232	0.0082	0.0986
Indirect of GIS	0.0808	0.0191	0.0449	0.1189

The total indirect effect value of green operation management, IT technology integration, and green information sharing between digital leadership and green innovation is 0.4331, the standard error is 0.0396, the confidence interval is [0.3553, 0.5108], excluding 0. This shows that the mechanism of digital leadership affecting green innovation, green operation management, IT technology integration, and green information sharing plays multiple mediating roles, which further verifies Hypotheses H2a, H2b, and H2c.

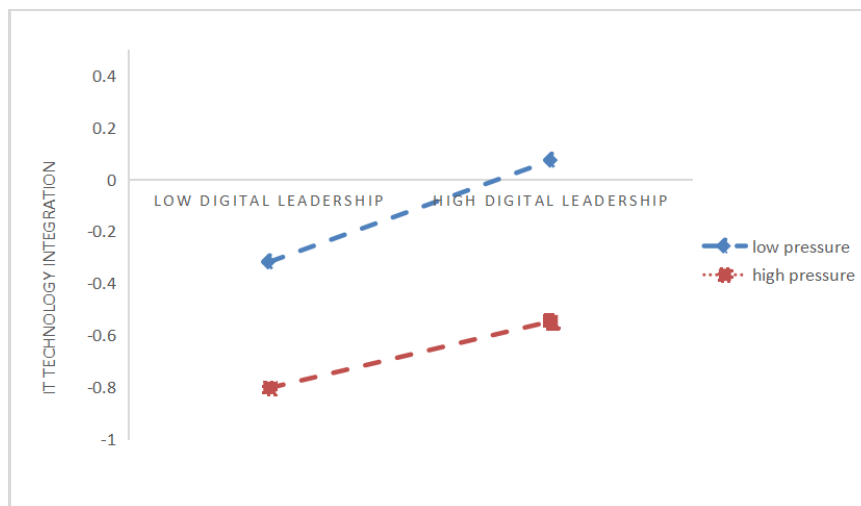
4.2.3. Moderating effect test. To test the moderating effect of pressure evaluation between digital leadership and green operation management, this study centralizes the two variables of digital leadership and pressure evaluation to construct product terms and then carries out a hierarchical regression analysis. The results are shown in Table 5. According to Model 2 in Table 5, the product of digital leadership and pressure evaluation has a significant negative impact on green operation management ($\beta = -0.136$, $p < 0.001$). In this study, samples with a standard deviation higher than the score of pressure evaluation were further divided into the high-pressure group, and samples with a standard deviation lower than the score of pressure evaluation were divided into the low-pressure group, which denotes ‘high degree of pressure evaluation’ and ‘low degree of pressure evaluation’, respectively. The moderating effect diagram is drawn by calculating the simple slope, as shown in Figure 2(a). From Figure 2(a), it can be seen that when the degree of pressure evaluation is low, the positive impact of digital leadership on green operation management is strengthened; when the degree of pressure evaluation is high, this positive effect is weakened. Thus, it is assumed that H3a is supported.

As shown in Model 4 of Table 5, the product term of digital leadership and pressure evaluation has no significant negative impact on IT technology integration ($\beta = -0.058$, $p > 0.05$). Similarly, the moderating effect diagram is drawn by calculating the simple slope, as shown in Figure 2(b). It can be seen that the slopes of the two lines are very close, showing a nearly parallel state, so it is not consistent with the previously expected assumptions. Thus, it is assumed that H3b is not supported.

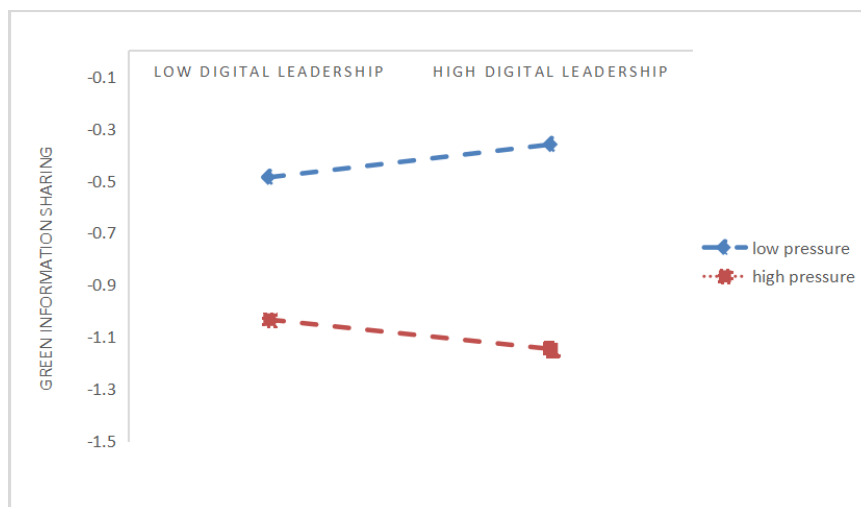
To test the moderating effect of pressure evaluation between digital leadership and green information sharing, the results are shown in Model 6 of Table 5. The product term of digital leadership and pressure evaluation has a significant negative impact on green



(a) The moderating effect of pressure evaluation on *digital leadership – green operation management*



(b) The moderating effect of pressure evaluation on *digital leadership – IT technology integration*



(c) The moderating effect of pressure evaluation on *digital leadership – green information sharing*

FIGURE 2. The moderating effect of pressure evaluation on ‘DL – GOM/IT/GIS’

information sharing ($\beta = -0.103$, $p < 0.01$). Similarly, the moderating effect diagram is drawn by calculating the simple slope, as shown in Figure 2(c). From Figure 2(c), it can be seen that when the degree of pressure evaluation is low, the positive impact of digital leadership on green information sharing is strengthened; when the degree of pressure evaluation is high, this positive effect is weakened. Thus, it is assumed that H3c is supported.

Based on the above empirical findings, we can conclude that digital leadership exerts multiple effects on green innovation through the mediating roles of green operation management, IT technology integration, and green information sharing. Moreover, pressure evaluation negatively moderates the relationships between digital leadership and both green operation management and green information sharing, thereby also influencing the mediating roles these factors play in the relationship between digital leadership and green innovation. However, pressure evaluation does not exhibit a significant negative moderating effect on the relationship between digital leadership and IT technology integration. Drawing upon current national policies and the development context of China's manufacturing industry, this phenomenon can be explained by the following reasons.

1) Policy-Driven Development

The "Made in China 2025" initiative explicitly emphasizes promoting intelligent and green manufacturing, providing firms with clear developmental directions and strong policy support. As a result, corporate managers tend to perceive policy-induced pressure as opportunities for transformation and upgrading. Under such a policy environment, even when facing substantial pressure, managers are unlikely to reduce their investment in IT technology integration based on pressure evaluation. Instead, they may intensify efforts toward digital transformation to meet policy requirements and capture policy-related benefits, thus weakening the negative moderating effect of pressure evaluation.

2) Strategic Urgency of IT Technology Integration

With increasing market competition and accelerating technological innovation, Chinese manufacturing firms have come to recognize the strategic importance of IT technology integration in enhancing core competitiveness. Firms seek to improve supply chain coordination efficiency, reduce costs, and strengthen their positions within the industrial chain through IT integration. The urgency surrounding IT technology integration leads firms to maintain it as a strategic priority even under pressure, which weakens the negative impact of pressure evaluation.

3) Organizational Culture and Atmosphere Supporting Digital Transformation

Some leading Chinese manufacturing firms have cultivated a strong internal culture and atmosphere conducive to digital transformation. Employees in these firms generally demonstrate high acceptance and engagement with digital initiatives. Consequently, even under pressure, organizational culture and atmosphere encourage employees to continue supporting digital transformation rather than retreating due to pressure evaluation. This positive organizational culture mitigates the negative moderating influence of pressure evaluation on the relationship between digital leadership and IT technology integration.

4.2.4. Model test – Comparative group analysis.

1) State-owned enterprises and private enterprises.

In this paper, according to the nature of the enterprise, '1' is a state-owned enterprise, and 200 valid samples are obtained. Firstly, according to the analysis of process Model 4, as shown in Table 7, it can be seen that the indirect effect of IT technology integration on digital leadership and green innovation is significant (the indirect effect is 0.0733, the standard error is 0.0392, and the 95% confidence interval is [0.0140, 0.1656], excluding 0). Green information sharing has a significant indirect effect on digital leadership and

TABLE 7. Indirect effect test of mediating effect – ‘State-owned enterprises and private enterprises’

		Effect	SE	LLCI	ULCI
State-owned enterprises	Total effect	0.2278	0.0416	0.1523	0.3192
	Direct effect	0.2428	0.0633	0.1180	0.3676
	Indirect of GOM	0.0344	0.0385	-0.0383	0.1138
	Indirect of IT	0.0733	0.0392	0.0140	0.1656
	Indirect of GIS	0.1201	0.0383	0.0452	0.1966
Private enterprises	Total effect	0.1625	0.0359	0.0959	0.2362
	Direct effect	0.1971	0.0594	0.0800	0.3142
	Indirect of GOM	0.0763	0.0362	0.0063	0.1483
	Indirect of IT	0.0175	0.0266	-0.0342	0.0724
	Indirect of GIS	0.0687	0.0303	0.0171	0.1351

TABLE 8. Test of moderated mediation effect

Group	Mediator variable	Model	Effect	SE	95% confidence interval (CI)	
					Minimum	Maximum
State-owned enterprises	IT technology integration	DL	0.3096	0.0492	0.2124	0.4067
		PE	0.0351	0.0548	-0.0730	0.1432
		DL*PE	0.0033	0.0528	-0.1009	0.1074
	Green information sharing	DL	0.3096	0.0492	0.2124	0.4067
		PE	0.0351	0.0548	-0.0730	0.1432
		DL*PE	0.0033	0.0528	-0.1009	0.1074
Private enterprises	Green operation management	DL	0.3898	0.0591	0.2733	0.5062
		PE	-0.1688	0.0594	-0.2840	-0.0497
		DL*PE	-0.1283	0.0549	-0.2366	-0.0201
	Green information sharing	DL	0.3626	0.0668	0.2309	0.4944
		PE	-0.2494	0.0672	-0.3819	-0.1169
		DL*PE	-0.1516	0.0621	-0.2740	-0.0291

green innovation (indirect effect is 0.1201, standard error is 0.0383, 95% confidence interval is [0.0452, 0.1966], excluding 0). Then, according to the analysis of process Model 7, as shown in Table 8, it is found that the confidence interval of pressure evaluation in the path of ‘digital leadership – IT technology integration/green information sharing – green innovation’ contains 0, so pressure evaluation does not play a moderating role in this path. In summary, it can be seen that the impact mechanism of state-owned enterprises is ‘digital leadership – IT technology integration/green information sharing – green innovation’, and because state-owned enterprises are not sensitive to pressure, pressure evaluation does not play a moderating role in this path.

In this paper, according to the nature of the enterprise, ‘2’ is a private enterprise, and 225 valid samples are obtained. Firstly, according to the analysis of process Model 4, as shown in Table 7, the indirect effect of green operation management on digital leadership and green innovation is significant (indirect effect is 0.0763, standard error is 0.0362, 95% confidence interval is [0.0063, 0.1483], excluding 0); the indirect effect of green information sharing on digital leadership and green innovation is significant (indirect effect is 0.0687, standard error is 0.0303, 95% confidence interval is [0.0171, 0.1351], excluding 0). Then, according to the analysis of process Model 7, as shown in Table 8, it is found that the

indirect effect of pressure evaluation is significant in the path of ‘digital leadership – green operation management – green innovation’ (the indirect effect is -0.1283 , the standard error is 0.0549 , and the 95% confidence interval is $[-0.2366, -0.0201]$, excluding 0). The indirect effect of pressure evaluation on the path of ‘digital leadership – green information sharing – green innovation’ is significant (indirect effect is -0.1516 , the standard error is 0.0621 , 95% confidence interval is $[-0.2740, -0.0291]$, excluding 0). In summary, it can be seen that the impact mechanism of private enterprises is ‘digital leadership – green operation management/green information sharing – green innovation’, and pressure evaluation plays a negative moderating role in the path of ‘digital leadership – green operation management/green information sharing – green innovation’.

2) Startup enterprises and mature enterprises.

This paper divides the enterprises with a founding time of less than 6 years into start-up enterprises and obtains 235 valid samples. Firstly, according to the analysis of process Model 4, as shown in Table 9, green operation management has a significant indirect effect on digital leadership and green innovation (indirect effect is 0.0959 , standard error is 0.0453 , 95% confidence interval is $[0.0078, 0.1847]$, excluding 0); green information sharing has a significant indirect effect on digital leadership and green innovation (indirect effect is 0.0861 , standard error is 0.0304 , 95% confidence interval is $[0.0314, 0.1510]$, excluding 0). Then, according to the analysis of process Model 7, as shown in Table 10, it is found that the confidence interval of pressure evaluation in the path of ‘digital leadership – green operation management/green information sharing – green innovation’ contains 0, so pressure evaluation does not play a moderating role in this path. In summary, it can be seen that the impact mechanism of start-up enterprises is ‘digital leadership – green operation management/green information sharing – green innovation’, and pressure evaluation does not play a moderating role in the impact mechanism.

TABLE 9. Indirect effect test of mediating effect – ‘Startup enterprises and mature enterprises’

		Effect	SE	LLCI	ULCI
Startup enterprises	Total effect	0.2114	0.0372	0.1464	0.2920
	Direct effect	0.2168	0.0648	0.0891	0.3444
	Indirect of GOM	0.0959	0.0453	0.0078	0.1847
	Indirect of IT	0.0294	0.0377	-0.0361	0.1127
	Indirect of GIS	0.0861	0.0304	0.0314	0.1510
Mature enterprises	Total effect	0.1395	0.0354	0.0709	0.2101
	Direct effect	0.2799	0.0602	0.1615	0.3984
	Indirect of GOM	0.1011	0.0322	0.0401	0.1659
	Indirect of IT	0.0806	0.0348	0.0166	0.1533
	Indirect of GIS	-0.0422	0.0322	-0.1106	0.0161

In this paper, enterprises established for 10 years and above are divided into mature enterprises, and 303 valid samples are obtained. Firstly, according to the process Model 4, as shown in Table 9, green operation management has a significant indirect effect on digital leadership and green innovation (indirect effect is 0.1011 , standard error is 0.0322 , 95% confidence interval is $[0.0401, 0.1659]$, excluding 0); IT technology integration has a significant indirect effect on digital leadership and green innovation (indirect effect is 0.0806 , standard error is 0.0348 , 95% confidence interval is $[0.0166, 0.1533]$, excluding 0). Then, according to the analysis of process Model 7, as shown in Table 10, it is found that the indirect effect of pressure evaluation is significant in the path of ‘digital leadership

– green operation management – green innovation’ (the indirect effect is -0.1956 , the standard error is 0.0544 , and the 95% confidence interval is $[-0.3027, -0.0884]$, excluding 0). It is found that the confidence interval of pressure evaluation in the path of ‘digital leadership – IT technology integration’ contains 0, so pressure evaluation does not play a moderating role in this path. In summary, it can be seen that the impact mechanism of mature enterprises is ‘digital leadership – green operation management/IT technology integration’, and pressure evaluation plays a negative moderating role in the path of ‘digital leadership – green operation management – green innovation’.

TABLE 10. Test of moderated mediation effect

Group	Mediator variable	Model	Effect	SE	95% confidence interval (CI)	
					Minimum	Maximum
Startup enterprises	Green operation management	DL	0.3645	0.0554	0.2553	0.4737
		PE	-0.1286	0.0575	-0.2419	-0.0152
		DL*PE	-0.1051	0.0560	-0.2155	0.0052
	Green information sharing	DL	0.3014	0.0535	0.1960	0.4067
		PE	-0.0215	0.0555	-0.1308	0.0878
		DL*PE	-0.0239	0.0540	-0.1304	0.0825
Mature enterprises	Green operation management	DL	0.4168	0.0520	0.3144	0.5192
		PE	-0.1514	0.0523	-0.2544	-0.0484
		DL*PE	-0.1389	0.0473	-0.2320	-0.0458
	IT technology integration	DL	0.4302	0.0541	0.3237	0.5367
		PE	-0.1956	0.0544	-0.3027	-0.0884
		DL*PE	-0.0887	0.0492	-0.1856	0.0081

3) Enterprises in the eastern and western regions.

This paper categorizes firms located in Beijing, Tianjin, Shanghai, Hebei, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan as enterprises in the eastern region and 207 valid samples are obtained. Firstly, based on the analysis of process Model 4, as shown in Table 11, green information sharing has a significant indirect effect on digital leadership and green innovation (indirect effect is 0.1301 , standard error is 0.0371 , 95% confidence interval is $[0.0639, 0.2114]$, excluding 0). Then, according to the process Model 7, as shown in Table 12, it is found that the confidence interval of pressure evaluation in the path of ‘digital leadership – green information sharing – green innovation’ contains 0, so pressure evaluation does not play a moderating role in this path. In summary, it can be seen that the impact mechanism of enterprises in the eastern region is ‘digital leadership – green information sharing – green innovation’, and pressure evaluation does not play a moderating role in the impact mechanism.

This paper categorizes firms located in Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Inner Mongolia, Guangxi, Tibet, Ningxia, and Xinjiang as enterprises in the western region and 211 valid samples are obtained. Firstly, based on the analysis of process Model 4, as shown in Table 11, the indirect effect of green operation management on digital leadership and green innovation is significant (the indirect effect is 0.0871 , the standard error is 0.0394 , the 95% confidence interval is $[0.0164, 0.1710]$, excluding 0). Then, according to the analysis of process Model 7, as shown in Table 12, it is found that the indirect effect of pressure evaluation is significant in the path of ‘digital leadership – green operation management – green innovation’ (the indirect effect is -0.0615 , the standard error is 0.0609 , and the 95% confidence interval is $[-0.1817, -0.0586]$, excluding

TABLE 11. Indirect effect test of mediating effect – ‘Eastern and western enterprises’

		Effect	SE	LLCI	ULCI
Eastern enterprises	Total effect	0.2062	0.0403	0.1281	0.2885
	Direct effect	0.2764	0.0575	0.1629	0.3898
	Indirect of GOM	−0.0055	0.0367	−0.0826	0.0606
	Indirect of IT	0.0816	0.0433	−0.0021	0.1675
	Indirect of GIS	0.1301	0.0371	0.0639	0.2114
	Total effect	0.1659	0.0398	0.0971	0.2540
Western enterprises	Direct effect	0.2433	0.0724	0.1005	0.3860
	Indirect of GOM	0.0871	0.0394	0.0164	0.1710
	Indirect of IT	0.0416	0.0320	−0.0123	0.1144
	Indirect of GIS	0.0371	0.0218	−0.0021	0.0825

TABLE 12. Test of moderated mediation effect

Group	Mediator variable	Model	Effect	SE	95% confidence interval (CI)	
					Minimum	Maximum
Eastern enterprises	Green information sharing	DL	0.3215	0.0549	0.2133	0.4297
		PE	−0.0742	0.0592	−0.1910	0.0426
		DL*PE	−0.0852	0.0485	−0.1809	0.0105
Western enterprises	Green operation management	DL	0.3672	0.0627	0.2435	0.4910
		PE	−0.2043	0.0641	−0.3307	−0.0779
		DL*PE	−0.0615	0.0609	−0.1817	−0.0586

0). In summary, it can be seen that the impact mechanism of mature enterprises is ‘digital leadership – green operation management’, and pressure evaluation plays a negative moderating role in the path of ‘digital leadership – green operation management – green innovation’.

5. Discussion and Implications. Firstly, from the perspective of the overall model, digital leadership can promote green innovation through green operation management, IT technology integration, and green information sharing. Therefore, leaders should enhance their digital competencies to facilitate these three mechanisms – green operation management, IT technology integration, and green information sharing – to drive green innovation within manufacturing firms. Notably, green information sharing demonstrates the highest level of mediating significance. Managers should thus place particular emphasis on improving internal information exchange and fostering communication between different hierarchical levels within the organization. This can effectively stimulate resource integration and enable process innovation across business operations.

Secondly, it is essential to dialectically understand the role of pressure evaluation and appropriately leverage its moderating effects in the context of digital leadership, promoting green innovation within manufacturing enterprises. Given the high complexity and uncertainty of both internal and external organizational environments, as well as the challenges posed by the influx of a new generation of employees into the workplace, managers must recognize the significant impact of pressure evaluation on this demographic.

Finally, within the Chinese context, enterprises of different types and regions should adopt distinct pathways for green innovation. Specifically:

1) State-Owned Enterprises (SOEs): Given their inherent administrative nature and consistent government support, SOEs can leverage digital leadership to foster a harmonious working environment. By enhancing IT integration and promoting green information sharing, digital leaders within these organizations can further stimulate green innovation.

2) Private Enterprises (PEs): In contrast, managers of PEs must address the negative impact of pressure on subordinates' emotions. Publicly praising employees and mitigating the adverse effects of pressure on digital leadership, green operation management, and green information sharing are crucial. This approach can help maintain employee morale and productivity.

3) Startups: Startups typically possess innovative ideas and advanced technologies. Digital leaders in these firms can promote green innovation by fostering green operation management and enhancing green information sharing within teams, thereby capitalizing on their inherent agility and adaptability.

4) Mature Enterprises: As mature enterprises near the saturation point of industry production capacity, they should focus on differentiation strategies. Managers need to be vigilant regarding employee pressure levels, as this can negatively impact green operation management within the organization. Addressing employee pressure is essential for maintaining practical green innovation efforts.

5) Eastern Region: Due to its geographical advantages, the eastern region should give priority to green information sharing through digital leadership. Information circulation is the key to green innovation.

6) Western Region: Many enterprises in the western region are still in the exploration stage. Therefore, greater emphasis should be placed on internal operations and management practices to foster an environment conducive to green innovation.

By recognizing the unique characteristics and challenges faced by each type of enterprise and regional context, tailored strategies can be developed to effectively promote green innovation in line with China's broader sustainability goals.

6. Conclusions, Limitations, and Further Developments. Based on China's manufacturing industry context, this study employs dynamic capability theory and resource-based theory to comprehensively examine the impact mechanisms of digital leadership on green innovation within manufacturing enterprises. Specifically, it delves into how these mechanisms differ among state-owned versus private enterprises, startups versus mature enterprises, and enterprises in the eastern versus western regions. The following research conclusions are drawn:

1) Overall Impact Mechanism:

a) In the overall model, digital leadership enhances internal green operation management, IT technology integration, and green information sharing, thereby fostering a robust team innovation process that positively influences corporate green innovation.

b) Pressure evaluation exerts a negative moderating effect on both the relationship between digital leadership and green operation management, as well as between digital leadership and green information sharing.

2) Ownership Differences in Influence Mechanisms:

a) State-Owned Enterprises (SOEs): Digital leadership further promotes green innovation by improving IT technology integration and green information sharing. Given SOEs' access to national policies and resource support, pressure evaluation does not play a significant moderating role.

b) Private Enterprises (PEs): Digital leadership promotes green innovation through two mediating pathways – green operation management and green information sharing.

For employees with lower pressure evaluations, digital leadership can strengthen these pathways, thereby enhancing green innovation.

3) Enterprise Life Cycle Differences in Influence Mechanisms:

a) Startup Enterprises: Digital leadership promotes green innovation via green operation management and green information sharing, with pressure evaluation playing no moderating role.

b) Mature Enterprises: Digital leadership primarily promotes green innovation through green operation management and green information sharing. For employees with lower pressure evaluations, enhanced digital leadership can significantly boost green operation management, thereby driving green innovation.

4) Regional Differences in Influence Mechanisms:

a) Eastern Region: As a well-developed area, digital leadership in the eastern region promotes green innovation through green information sharing.

b) Western Region: Digital leadership in the western region promotes green innovation mainly through green operation management. Attention should be paid to reducing employee pressure, avoiding affecting operational results, and affecting the level of green innovation.

Despite its contributions, this study has certain limitations that warrant attention in future research. Specifically:

1) Moderator variable: This study examines only the moderating effect of pressure evaluation. Future research could consider other dimensions, such as team resilience and environmental dynamism, to provide a richer understanding of the relationship between digital leadership and green innovation in manufacturing firms. This would deepen our understanding of how different factors influence the relationship between digital leadership and green innovation.

2) Enterprise Characteristics: Although this paper compares the impact mechanisms across enterprise ownership lifecycle and region, further research is needed to investigate whether and how enterprise scale and industry type affect these mechanisms. Exploring the reasons behind any observed differences would provide valuable insights into the nuanced dynamics of green innovation.

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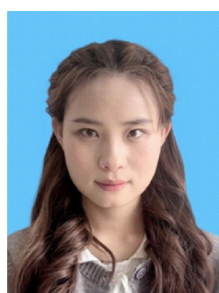
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