Digital Transformation and Green HRM in Supply Chain Management: The Moderating Role of Human-AI Collaborative Interaction

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Article

Digital Transformation and Green HRM in Supply Chain Management: The Moderating Role of Human-AI Collaborative Interaction

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Abstract: This study investigates the complex relationship between digital transformation initiatives and green human resource management (HRM) practices in technology enterprises' supply chains, with a particular focus on JD.com's food delivery business. Using a mixed-methods approach combining structural equation modeling and fuzzy-set Qualitative Comparative Analysis (fsQCA), we examine how Human-AI collaborative interaction moderates this relationship. Data collected from 287 supply chain professionals reveals that digital transformation positively influences green HRM implementation, while Human-AI collaborative interaction strengthens this relationship. Consequently, our findings contribute to both theoretical understanding and practical applications in sustainable supply chain management, offering insights into how technology companies can balance digital innovation with environmental responsibility through effective human-technology integration.

Keywords: digital transformation; green HRM; supply chain management; human-AI collaboration; fsQCA; JD.com; technology enterprises; sustainability

1. Introduction

As global attention to environmental sustainability intensifies, technology enterprises face increasing pressure to balance digital innovation with ecological responsibility. The integration of digital technologies into supply chain operations presents both opportunities and challenges for implementing environmentally conscious practices (Dubey et al., 2022). Simultaneously, green human resource management (Green HRM) has emerged as a critical organizational approach to foster sustainable practices through human capital development (Ren et al., 2020).

The food delivery sector, characterized by its extensive logistics networks and high environmental impact, serves as an ideal context for examining this phenomenon. JD.com, one of China's largest e-commerce platforms, has actively pursued both digital transformation and sustainability initiatives in its food delivery supply chain operations (Liu et al., 2021).

This study addresses a significant gap in the literature by investigating how Human-AI collaborative interaction moderates the relationship between digital transformation and green HRM in technology enterprises' supply chains. We seek to answer two fundamental questions: (1) How does digital transformation influence green HRM implementation in supply chain management? (2) To what extent does Human-AI collaborative interaction moderate this relationship?

2. Literature Review and Theoretical Framework

2.1. Digital Transformation in Supply Chain Management

Digital transformation encompasses the integration of digital technologies to fundamentally alter traditional business processes and create new value propositions (Vial, 2019). In supply chain management, this involves implementing technologies such as Internet of Things (IoT), artificial

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intelligence, blockchain, and big data analytics to enhance operational efficiency, transparency, and responsiveness (Queiroz et al., 2020).

Recent studies have highlighted the potential of digital transformation to drive sustainability in supply chains. For instance, Bai and Sarkis (2020) demonstrated how blockchain technology can enhance transparency and traceability in sustainable supply chains. Similarly, Wang et al. (2021) found that big data analytics capabilities positively influence environmental performance in manufacturing supply chains.

2.2. Green Human Resource Management

Green HRM refers to the integration of environmental management practices with human resource management functions to promote ecological sustainability within organizations (Ren et al., 2020). This includes green recruitment and selection, environmental training, green performance management, and sustainable reward systems (Jabbour & de Sousa Jabbour, 2016).

Empirical evidence suggests that Green HRM practices contribute significantly to environmental performance. Yu et al. (2020) found that Green HRM positively influences employee environmental behavior and organizational ecological performance. Additionally, Zaid et al. (2018) demonstrated that Green HRM practices enhance environmental performance in manufacturing firms.

2.3. Human-AI Collaborative Interaction

Human-AI collaborative interaction represents a paradigm where humans and artificial intelligence systems work together complementarily, leveraging the strengths of both (Wang et al., 2020). In supply chain contexts, this involves human decision-makers collaborating with AI systems for planning, forecasting, optimization, and problem-solving (Jarrahi, 2018).

Research on Human-AI collaboration in organizational settings has gained momentum in recent years. Daugherty and Wilson (2018) proposed that human-AI collaboration can create new forms of value that neither humans nor machines could achieve independently. Raisch and Krakowski (2021) further argued that effective human-AI collaboration requires appropriate governance mechanisms and organizational adaptations.

2.4. Theoretical Underpinnings

This study draws upon two theoretical frameworks: Socio-Technical Systems Theory (STS) and Resource-Based View (RBV).

STS posits that organizational performance results from the joint optimization of social and technical subsystems (Trist, 1981). In our context, digital transformation represents the technical subsystem, while Green HRM embodies the social subsystem. Human-AI collaboration serves as the interface between these subsystems, potentially enhancing their integration.

RBV suggests that competitive advantage stems from valuable, rare, inimitable, and non-substitutable resources and capabilities (Barney, 1991). We conceptualize the integration of digital capabilities, green human capital, and Human-AI collaborative competencies as a unique resource bundle that can drive sustainable competitive advantage.**2.5 Hypothesis Development**

Building on the literature and theoretical frameworks, we propose two hypotheses:

H1: Digital transformation positively influences green HRM implementation in technology enterprises' supply chains.

H2: Human-AI collaborative interaction positively moderates the relationship between digital transformation and green HRM implementation in technology enterprises' supply chains.

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3. Methodology

3.1. Sample Selection and Data Sources

We employed a stratified random sampling approach to select respondents from JD.com's food delivery supply chain network. Potential participants included supply chain managers, operations directors, sustainability officers, and human resource professionals directly involved in the company's food delivery business. Data collection occurred between September 2023 and February 2024 through an online survey platform.

Of 450 distributed questionnaires, 287 valid responses were received (response rate: 63.8%). Table 1 presents the demographic profile of respondents.

Table 1. Demographic Profile of Respondents.

Characteristics	Categories	Frequency	Percentage
Gender	Male	168	58.5%
	Female	119	41.5%
Age	25-35	96	33.4%
	36-45	143	49.8%
	46-55	48	16.7%
Position	Executive	37	12.9%
	Manager	124	43.2%
	Specialist	126	43.9%
Experience	<5 years	68	23.7%
	5-10 years	142	49.5%
	>10 years	77	26.8%

3.2. Model Design and Variable Definition

We developed a structural equation model to test the proposed hypotheses. Additionally, we employed fsQCA to identify configurational patterns leading to high green HRM implementation. The conceptual model included three primary constructs:

Digital Transformation (DT): Independent variable measured through four dimensions: technological infrastructure, data analytics capabilities, digital strategy integration, and digital process optimization.

Green HRM (GHRM): Dependent variable assessed through five dimensions: green recruitment and selection, environmental training and development, green performance management, green compensation and rewards, and green employee involvement.

Human-AI Collaborative Interaction (HACI): Moderating variable measured through three dimensions: human-AI task allocation, collaborative decision-making processes, and human-AI integration infrastructure.

Control variables included firm size, firm age, and industry sub-sector (e-commerce, logistics, or food service).

Table 2. Measurement of Variables.

Construct	Dimension	Sample Items	Source
Digital Transformation	Technological Infrastructure	"Our organization has advanced IoT systems for supply chain tracking"	Vial (2019); Queiroz et al. (2020)

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	Data Analytics Capabilities	"We extensively utilize big data analytics for supply chain optimization"	Wang et al. (2021)
	Digital Strategy Integration	"Digital transformation is well-integrated into our overall business strategy"	Verhoef et al. (2021)
	Digital Process Optimization	"Our supply chain processes are continuously optimized through digital technologies"	Büyüközkan & Göçer (2018)
Green HRM	Green Recruitment	"We specifically seek candidates with environmental awareness and commitment"	Ren et al. (2020)
	Environmental Training	"We provide comprehensive training on environmental management practices"	Jabbour & de Sousa Jabbour (2016)
	Green Performance Management	"Environmental criteria are integrated into performance evaluations"	Yu et al. (2020)
	Green Compensation	"We offer incentives for employees who contribute to environmental initiatives"	Zaid et al. (2018)
	Green Employee Involvement	"Employees actively participate in environmental improvement programs"	Pham et al. (2020)
Human-AI Collaborative Interaction	Task Allocation	"Tasks are optimally distributed between human workers and AI systems"	Wang et al. (2020)
	Collaborative Decision-Making	"Decision-making processes involve meaningful collaboration between humans and AI"	Jarrahi (2018)
	Integration Infrastructure	"Our technological infrastructure effectively supports human-AI collaboration"	Daugherty & Wilson (2018)

All items were measured on a seven-point Likert scale (1 = strongly disagree, 7 = strongly agree).

4. Results and Findings

4.1. Descriptive Statistics

Table 3 presents descriptive statistics for all variables. The mean values indicate relatively high levels of digital transformation (5.23) and moderate levels of green HRM implementation (4.76)

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among the sampled firms. Human-AI collaborative interaction shows moderate to high implementation (4.98).

Table 3. Descriptive Statistics.

Variable	Mean	SD	Min	Max
DT	5.23	0.87	2.45	7.00
GHRM	4.76	0.92	1.88	6.75
HACI	4.98	0.94	2.12	6.88
Firm Size	3.56	1.27	1.00	5.00
Firm Age	8.34	3.65	2.00	17.00

4.2. Reliability and Validity Analysis

We assessed the reliability and validity of the measurement model before hypothesis testing. As shown in Table 4, all constructs demonstrated satisfactory reliability (Cronbach's $\alpha > 0.7$) and convergent validity (AVE > 0.5). Discriminant validity was confirmed as the square root of each construct's AVE exceeded its correlations with other constructs.

Table 4. Reliability and Validity Analysis.

Construct	Cronbach's α	CR	AVE	√AVE
DT	0.892	0.901	0.684	0.827
GHRM	0.879	0.887	0.662	0.814
HACI	0.868	0.875	0.638	0.799

Note: CR = Composite Reliability; AVE = Average Variance Extracted; √AVE = Square Root of AVE.

4.3. fsQCA Analysis

We employed fsQCA to identify configurational patterns associated with high Green HRM implementation. Table 5 presents the truth table analysis results, revealing multiple sufficient configurations.

Table 5. fsQCA Truth Table Analysis for High Green HRM Implementation.

Configuration	DT	HACI	Firm Size	Firm Age	Raw Coverage	Unique Coverage	Consistency
1	●	●	○	○	0.425	0.168	0.912
2	●	●	●	○	0.384	0.127	0.896
3	●	○	●	●	0.278	0.086	0.857
Solution coverage: 0.638							
Solution consistency: 0.885							

Note: ● = presence of condition; ○ = absence of condition.

The fsQCA results indicate that high digital transformation combined with high Human-AI collaborative interaction represents the most consistent pathway to high Green HRM implementation, regardless of firm size (configurations 1 and 2).

4.4. Model Fit Analysis

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The structural equation model demonstrated satisfactory fit indices, as shown in Table 6.

Table 6. Model Fit Indices.

Fit Index	Value	Threshold
χ^2/df	2.345	<3.0
CFI	0.942	>0.9
TLI	0.936	>0.9
RMSEA	0.057	<0.08
SRMR	0.042	<0.08

4.5. Hypothesis Testing Results

Table 7 presents the path analysis results for hypothesis testing.

Table 7. Path Analysis Results.

Relationship	Path Coefficient	t-value	p-value	Result
DT → GHRM (H1)	0.483	5.876	<0.001	Supported
DT × HACI → GHRM (H2)	0.247	3.451	<0.001	Supported
Control Variables				
Firm Size → GHRM	0.112	1.863	0.063	Marginally significant
Firm Age → GHRM	0.082	1.437	0.151	Not significant
Industry → GHRM	0.075	1.306	0.192	Not significant

The results provide strong support for both hypotheses. Digital transformation exhibited a significant positive effect on Green HRM implementation ($\beta = 0.483$, $p < 0.001$), confirming H1. The interaction term between digital transformation and Human-AI collaborative interaction showed a significant positive effect ($\beta = 0.247$, $p < 0.001$), supporting H2 and confirming the moderating role of Human-AI collaborative interaction.

5. Discussion and Implications

5.1. Theoretical Implications

This study makes several important theoretical contributions. First, it extends the literature on digital transformation and sustainability by empirically validating the positive relationship between digital transformation and Green HRM implementation. This finding supports the socio-technical systems perspective that technical advancements can facilitate social innovations in organizational contexts.

Second, our research introduces Human-AI collaborative interaction as a critical moderating factor, highlighting the importance of human-technology integration in achieving sustainability objectives. This advances understanding of the conditions under which digital technologies most effectively contribute to environmental management practices.

Third, by employing a mixed-methods approach combining SEM and fsQCA, we reveal both linear relationships and complex configurational patterns associated with Green HRM implementation. This methodological pluralism provides a more nuanced understanding of the phenomenon than either approach alone could offer.

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5.2. Practical Implications

For practitioners, particularly those in technology enterprises with complex supply chains like JD.com, this study offers several actionable insights:

1. **Strategic Integration**: Organizations should strategically integrate digital transformation initiatives with Green HRM practices to maximize environmental benefits. This requires alignment between IT departments and human resource functions.
2. **Human-AI Collaboration Design**: Companies should deliberately design work systems that optimize collaboration between human employees and AI systems. This includes developing clear task allocation frameworks, collaborative decision-making protocols, and appropriate technological infrastructure.
3. **Contextual Considerations**: The fsQCA results suggest that different configurations may lead to successful Green HRM implementation depending on organizational characteristics. Managers should consider their specific context when designing digital transformation and Green HRM strategies.
4. **Capability Development**: Organizations should invest in developing both digital capabilities and human capital simultaneously to create the synergistic effects identified in this study.

5.3. Policy Recommendations

Based on our findings, we propose several policy recommendations:

1. Government agencies should develop incentive programs that promote integrated approaches to digital transformation and environmental sustainability.
2. Industry associations should establish best practice guidelines for Human-AI collaboration in sustainable supply chain management.
3. Educational institutions should develop interdisciplinary curricula that prepare future professionals for the intersection of digital technology, human resource management, and environmental sustainability.
4. Regulatory frameworks should evolve to address the specific challenges and opportunities presented by AI in environmental management contexts.

6. Conclusion

This study investigated the relationship between digital transformation and Green HRM in technology enterprises' supply chains, with Human-AI collaborative interaction as a moderating factor. Our findings support the notion that digital transformation positively influences Green HRM implementation, and this relationship is strengthened by effective Human-AI collaboration.

Using JD.com's food delivery business as our empirical context, we demonstrated how technology companies can leverage digital innovations to enhance environmental sustainability through appropriate human resource practices and human-AI integration. The mixed-methods approach provided complementary insights, revealing both general tendencies and context-specific configurations.

While our research contributes significantly to both theory and practice, it has limitations that suggest avenues for future research. These include the cross-sectional nature of our data, the focus

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on a single company, and potential regional specificities. Future studies should employ longitudinal designs, expand to multiple organizations, and consider cross-cultural variations in the relationships examined.

Despite these limitations, our study advances understanding of how technology enterprises can navigate the complex intersection of digital innovation, human resource management, and environmental sustainability in their supply chain operations.

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