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Research on the Influencing Mechanism of Retail Enterprise Leadership on Digital Transformation

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ABSTRACT

In the digital economy era, the imperative for business management to embrace digital transformation (DT) has solidified its status as a crucial strategic choice. This transformation is particularly pronounced among retailers within a milieu of rapidly advancing technology and shifting consumer behaviors. Anchored in the enterprise dynamic capability theory, this study introduces a moderated mediation model to investigate how digital leadership (DL) steers the DT in retail enterprises under specific conditions and pathways. An empirical analysis of survey data collected from 156 retail enterprises illustrates that DL indirectly propels DT through organizational innovation (OI). Additionally, digital dynamic capabilities (DDC) intensify the intermediary role of OI, thus magnifying the impact of DL on DT. By situating the research within a dynamic capability framework, the study provides both theoretical insights and pragmatic guidance to refine DT strategies within the retail sector.

Keywords: Digital leadership, Organizational innovation, Digital transformation, Digital dynamic capability, Retail enterprise.

INTRODUCTION

Over the past few years, innovative technologies such as IoT (Internet of Things), advanced data analytics (big data), and scalable cloud platforms have profoundly impacted the operating models of retailers and have continued to drive retailers to undergo digital transformation. The Boston Consulting Group carried out a survey and research on 2,296 companies from 28 nations globally and discovered that the enterprises with the highest degree of digital maturity outpace others in value creation. From 2017 to 2020, the performance of digitally mature enterprises in aspects such as revenue growth rate, return on investment, cost reduction, stock price increase, and market share expansion were conspicuously superior to that of enterprises with a lower level of digitalization. The probability of attaining a target growth of over 10% was 20% - 50% higher. Moreover, the rapid growth of online retail has driven retail enterprises toward data-driven transformation, further accelerating the digitalization of the retail industry, notably enhancing its digital maturity from 2019 to 2020[1]. Against this backdrop, adopting a strategy for digital innovation has become crucial for enterprises.

Previous research indicates that many retail enterprises currently face several challenges during heir transition to digitalization: Leaders often demonstrate weak digital awareness in management decision-making, and entrepreneurs' digital literacy is not easily translated into actual momentum for driving enterprise transformation. Many researchers emphasize that in the process of achieving comprehensive digital upgrades, leaders need to quickly adjust their roles, actively adapt to the demands of digital development, and clearly define their digital strategic objectives, and formulate a clear implementation plan, as well as improve their own digital skills and promote the dissemination and application of digital technology knowledge. By forming and managing efficient teams, establishing trust-based collaboration mechanisms, and optimizing decision-making processes, they can improve the

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agility and adaptability of their organizations in the digital ecosystems, and ultimately achieve the strategic goals of digital transformation[2]. Leadership, as a significant factor influencing organizational innovation, is beneficial for promoting organizational change and innovation. Nevertheless, with the alterations brought to enterprises by digital transformation, the traditional and sole strategic approaches and leadership held by enterprise leaders evidently cannot handle the multi-dimensional digital revolution[3]. A growing body of scholars and business leaders has begun acknowledging the importance of digital leadership. They are increasingly focused on examining its origins, definitions, and unique traits, along with its connections to strategic alliances, market orientation, and the management of innovation [4].

In the era of the emerging smart economy, the increasing complexity of production factors and the diversification of internal interactions have made traditional management approaches inadequate to address modern organizational demands [5]. Case studies on successful DT show that leaders are often required to possess digital expertise aligned with job requirements, as well as the leadership skills to actively guide employees in embracing and integrating into the wave of digital changes[6]. Against the backdrop of the digital economy, traditional leadership approaches alone are inadequate to tackle the challenges brought about by advancements in information technology[7]. The significance of DL in achieving successful DTs is paramount, marking it as a pivotal area of research[8].

In summary, this research constructs a mediated moderation model to explore how DL impacts retail enterprises' DT and to assess the moderating role of digital dynamic capabilities. Theoretically, this research expands the scope of related studies by micro-analyzing the internal factors influencing digital evolution, providing a fresh theoretical perspective for examining the technological transitions of retail enterprises. Practically, the findings deliver critical insights that aid retail businesses in enhancing their leadership and management tactics for the digital age, optimizing strategies, and boosting DT capabilities.

LITERATURE REVIEW

Currently, DL has emerged as one of the most recent subjects in the domain of leadership research. Nevertheless, within the scholarly domain, a unified understanding of the precise conceptual definition of DL has not been established. Various authorities and academics have proposed differing interpretations. For example, Vanwart *et al.* defined DL as the capacity of leaders to leverage advanced technologies to enhance production activities and efficiently manage technological resources, like devices and applications, to bolster connections among organizational staff within the scope of digital technological transformation. This leadership style distinctly focuses on the leader's proficiency in effectively harnessing resources characterized by digital properties[9]. Belitski *et al.* held that DL is a dynamic procedure that integrates organizational culture and technical knowledge and interacts with technologies and personnel both within and outside the organization[10]. Klus *et al.* described DL as an innovative form of leadership in which leaders develop a unique and significant vision for driving the organization's DT and realize it through strategic execution[11]. In a similar vein, Gilli *et al.* described DL as leaders' competence in leveraging digital platforms and systems to optimize resource allocation and guide teams toward achieving long-term goals[12].

In the age of digital intelligence, retail enterprises establish new scenarios, reconfigure business processes, and introduce new models in accordance with the fresh demands of consumers to accommodate diverse changes. Research concerning DT, OI, and digital capabilities is expanding. OI pertains to the adoption of new management practices either within the internal workings of the enterprise or in its dealings with external entities[13]. DT represents the process through which businesses apply digital technologies to transform their vision, strategy, organizational structure, business operations, and corporate culture, thus fostering innovation to keep pace with a rapidly changing digital environment[14]. Moreover, digital dynamic capabilities are described as the abilities of businesses undergoing transformation to more effectively respond to digital competition and exploit opportunities to alter their resource base[15].

DL and DT

In the age of digital economy, enterprise managers have to confront novel challenges brought forth by new scenarios, new technologies, new processes and new competitions. At such a time, managers are required to fully unleash the

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data-driven effect through the utilization of dynamic capability to support the digitalization process at various stages and achieve the three-dimensional transformation of enterprises' digitalization[16]. During pivotal phases of DT, ongoing innovation is vital to respond to swiftly changing market demands. DL excels in conducting data-driven decision-making analysis, aligning technology with strategic planning, and facilitating the implementation of innovation strategies, iterative upgrades, and transformational practices[17]. Clearly, the proactive development of DL is crucial in enhancing organizational DT and supporting organizations in smoothly executing digital transitions[18]. Based on this insight, the study formulates the hypothesis as follows:

H1: DL plays a notably positive role in facilitating DT.

DL and OI

The capacity of enterprise managers constitutes one of the significant elements influencing OI[19]. DL assumes a salient position in sustaining OI and competitive advantage[20]. In line with dynamic capability theory, the competencies and expertise of enterprise managers are essential factors that shape the dynamic capabilities of organizations, which subsequently influence OI. DL plays a pivotal role in facilitating the integration of internal and external resources and restructuring organizational capabilities, further enabling organizations to break free from traditional models and embrace new development paradigms[21]. Traits such as proactive risk-taking, agility, and a strong capacity for change and innovation, inherent in DL, are likely to have a positive effect on OI[22]. Enhancing DL allows managers to apply digital strategic thinking, assess the future direction of the enterprise, innovate digital management practices, and improve organizational competitiveness and agility. It also helps firms accurately capture signals of dynamic market changes and swiftly implement competitive strategic actions, such as launching innovative products, optimizing product categories, and offering unique services, thereby enhancing organizational competitiveness and strengthening resilience for sustainable development[23]. On this basis, the study formulates the hypothesis as follows:

H2: DL plays a notably positive role in facilitating OI.

OI and DT

The rise of the digital industry has shaped a new era, where enterprise strategy adjustment and innovation go beyond restructuring business processes, starting instead with OI to facilitate the generation of new values[24]. It also entails reengineering the current business models and processes, breaking away from the path dependence on traditional management models, achieving intelligent production, precise sales, efficient resource management, and completing the subversive innovation of management paradigms and management systems[25]. DT introduces new challenges to the organizational management paradigm and drives significant changes in the structure, governance, internal control, and operational mechanisms of enterprises[26]. Consequently, the core of DT in enterprise management is rooted in deep OI supported by digital technology[27]. OI is a critical pathway for enterprises to achieve sustainable growth and acts as a driving force for comprehensive DT[28]. Building on this, the study formulates the hypothesis as follows:

H3: OI acts as a critical intermediary between DL and DT.

The moderating function of DDC

The emergence of digitalization has significantly altered the operational framework of the retail sector, becoming a central element for value generation within the industry. Digital technology functions as a crucial facilitator of transformation in the retail sector, with advancements like big data and artificial intelligence significantly influencing this evolution [29]. The fundamental mechanism behind the DT in retail lies in the technology-driven overhaul of production and distribution systems, which are oriented around consumer demand[30]. Digital capability enhances enterprises' ability to allocate resources effectively and optimize their integration, while DL further drives OI by improving these digital capabilities[31]. Research has shown that digital capability, as a distinct dynamic capability during the DT process, offers valuable resources and development opportunities, helping enterprises uncover new business prospects and generate additional value[32]. Based on these insights, the study formulates the hypothesis as follows:

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H4: DDC exert a positive moderating effect in leadership promoting OI.

The swift iterative characteristic of digital technology has resulted in the unpredictability of consumption demands, preferences, and channels, causing the market environment within which the retail industry operates to be highly dynamic as never before. To adjust to this highly dynamic digital setting, retail enterprises can merely successfully carry out their DT strategies by constantly enhancing their digital capability. On the path to successful DT, enterprises must continuously explore and precisely seize digital opportunities, creatively develop products and service that meet consumers' digital preferences and drive the iteration and restructuring of business models. This approach not only delivers exceptional value to customers but also facilitates the efficient integration of digital assets with organizational resources. By enhancing adaptability and competitiveness in the digital wave, enterprises can achieve a seamless transition from traditional to digital models, laying a solid foundation for long-term development while building unique competitive advantages and sustainable vitality[33]. Amidst the swift evolution of digital technologies and the unpredictability of environmental conditions, retail organizations must develop adaptive digital competencies to proficiently navigate their extensive DT. Building on this, the study proposes the following hypotheses:

H5: DDC exert a positive moderating effect in OI promoting DT.

In conclusion, this study develops the conceptual framework depicted in Figure 1:

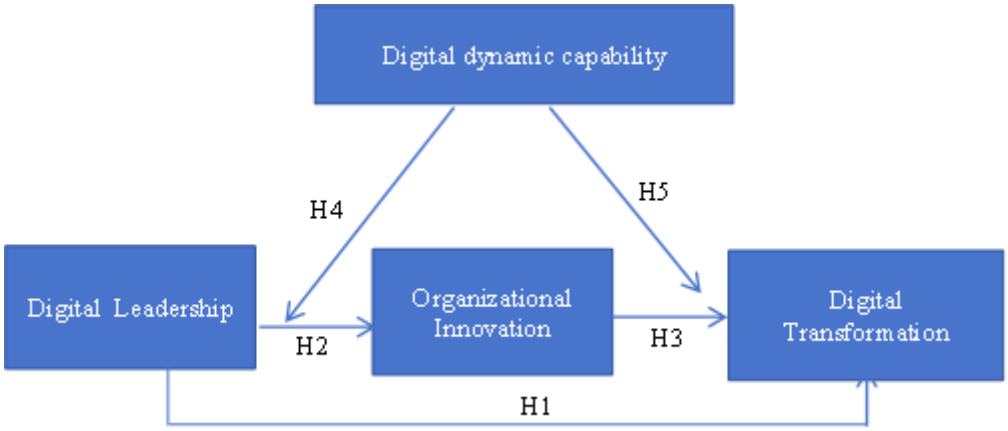

Figure 1. Research Framework

RESEARCH METHODOLOGY

Samples and data collection

This study focuses on middle and senior managers from Chinese retail enterprises to ensure a comprehensive reflection of the actual circumstances related to DL, OI, DT, and other digital aspects within these enterprises. An online survey that lasted for one month was carried out by sending links from April to May 2024. First, to ensure the quality and response rate of the questionnaires, suitable sample enterprises were identified with recommendations from retail industry associations. Human resource managers of the participating enterprises were contacted via phone, WeChat, and email to explain the survey's purpose and methodology, as well as to confirm the participants. Ultimately, 165 enterprises agreed to participate. In this study, electronic questionnaires were disseminated via the WeChat platform. After collection, a thorough screening process ensured validity by excluding non-compliant responses. As a result, 156 valid responses were collected, achieving a response efficiency of 95.5%. The core attributes of the valid sample enterprises are outlined in Table 1.

Table 1: Profile of Sample Enterprises

Characteristic Variables	Category	Frequency	Percent %
Enterprise Age	Less than 3 years	8	5.1%

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Characteristic Variables	Category	Frequency	Percent %
	Between 3 and 6 years	13	8.3%
	Between 7 and 10 years	26	16.7%
	More than 10 years	109	69.9%
Enterprise Scale	Large: employ 500 or more people	30	19.2
	Medium: employ 50 to 499 people	78	50.0%
	Small: employ 10 to 49 people	37	23.7%
	Micro: employ fewer than 10 people	11	7.1%
Retail Format	Supermarket	6	3.8%
	Convenience store	20	12.8%
	Department store	37	23.7%
	Shopping center	39	25%
	Specialty store / Specialty shop	54	34.6%

To analyze the characteristics of the sample enterprises included in the study, statistical analysis was conducted on key attributes such as industry type, enterprise size, ownership structure, and regional distribution. The relevant information is summarized in Table 1.

Questionnaire Design and Reliability and Validity Testing

Given the critical role of questionnaire data quality in supporting research conclusions, the design phase strictly adhered to the use of well-established scales validated through extensive empirical studies for their high reliability. This approach ensures that the questionnaire precisely captures the information required for the study while minimizing measurement errors to the greatest extent possible. It lays a solid foundation for the reliability of subsequent data analysis and research findings, ensuring that the entire research process is built on robust data, thereby enhancing the scientific rigor and validity of the study. Through recommendations from the retail industry association, a pilot study was conducted involving 50 qualified senior executives, yielding 38 valid responses. The assessment of the pretest questionnaires' reliability and validity was conducted thereafter. The empirical results clearly demonstrate that the reliability tests conducted for the four key measurement dimensions—DL, OI, DDC, and DT—all yielded Cronbach's α coefficients exceeding the critical threshold of 0.8. This robust data performance highlights the exceptional reliability of the measurement scale within the context of this study. Furthermore, the KMO values for all variables exceeded 0.6, with $p < 0.0001$, indicating robust inter-variable correlations and affirming the appropriateness of the data for factor analysis. In light of these findings, the questionnaire underwent a process of refinement, leading to the execution of a comprehensive survey.

This study employs authoritative scales established in relevant academic literature to conduct precise quantitative assessments of four key variables: DL, OI, DT, and DDC. A five-level Likert scale is adopted, with 1 indicating the lowest level of agreement ('strongly disagree') and 5 representing the highest level ('strongly agree'). The specific content of the measurement for each variable is as follows:

i. DL: Five items were developed by Zeike *et al.*[20] was adopted, such as "The company's leaders are actively promoting the DT of the company". The scale demonstrated strong reliability, with a Cronbach's α coefficient of 0.88."
ii. DT: Five items were mainly designed and compiled by referring to the scales developed and used by Meng[34], Zhu *et al.*[35], such as "The company has taken substantive actions for DT, such as having a data platform and data analysis tools, etc.", was used and achieved a Cronbach's α of 0.889.
iii. OI: Five items were mainly designed and compiled by referring to the measurement tools created and applied by Xie *et al.*[32], such as "The company can can agilely respond to dynamic changes in internal operations and external market conditions.", which yielded a Cronbach's α of 0.866, reflecting robust reliability.

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iv. DDC: Six items were mainly designed by referring to the scales developed and used by Yuan *et al.*[36], Day[37], Warner *et al.*[15], such as "The enterprise can identify opportunities by using digital capability". The scale achieved a Cronbach's α of 0.9, indicating high reliability.

EMPIRICAL RESULTS AND ANALYSIS

Test of reliability and validity

For the purpose of data analysis, SPSS 22.0 was utilized to conduct assessments of reliability and validity, with the comprehensive results displayed in Table 2. When evaluating the reliability of the scale, special focus was placed on assessing its internal coherence. The CITC metrics for all 21 items exceeded 0.4, demonstrating strong inter-item correlations. This ensures the robustness of the scale and establishes a reliable basis for subsequent research. The Cronbach's α values for each dimension were as follows: 0.889 for DT, 0.88 for DL, 0.866 for OI, and 0.9 for DDC. The overall reliability coefficient was 0.896, surpassing the threshold of 0.8, indicating that the research data's reliability meets the standard and supports the progression to the next stage of the analysis process.

From the validity analysis results, it can be observed that the factor loadings of the measurement items for each variable lie within the range of 0.566 to 0.879. Employing the principal component analysis approach, after conducting factor extraction for 21 items, ultimately, four common factors with eigenvalues greater than 1 were extracted. The cumulative explanation of the four factors for the overall variance was 68.279% > 50%, suggesting that the extracted four factors could account for 68.279% of the information among a total of 21 items. Furthermore, the variance explanation rates (information extraction amounts) of the four factors were respectively 18.498%, 16.627%, 16.757%, and 16.398%. The distribution of the information extraction amounts was relatively homogeneous. Comprehensive analysis indicates that the results of this factor analysis are favorable.

The validity analysis results indicate that the factor loadings of the measurement items for each variable range from 0.566 to 0.879. Through principal component analysis of the 21 measurement items, four principal components with eigenvalues exceeding 1 were successfully identified. These components collectively account for 68.279% of the information contained in the original 21 items, significantly surpassing the 50% threshold. The proportions of variance explained by each component are 18.498%, 16.627%, 16.757%, and 16.398%, respectively, reflecting a well-balanced distribution of extracted information. This highlights the robust performance of the factor analysis in both information capture and structural validity.

The Bartlett's test of sphericity was applied to examine the data related to DT, DL, OI, and DDC. The approximate chi-square statistic obtained was 1983.308, with a corresponding p-value of 0.0, which is significantly below the conventional significance level of 0.05. Based on these results, the null hypothesis was rejected, indicating significant differences among the variables. Additionally, the calculated KMO measure was 0.906, well above the threshold of 0.8 [38]-[40]. These findings strongly confirm the excellent validity of the research data, providing robust support for the effective progression of the research process.

Table 2: Findings from Reliability and Convergent Validity Testing

Variables	Indicators	CITC	Factor loading	Reliability (α)	% of Variance	Cumulative % of Variance
DT	A1	0.731	0.779	0.889	18.498%	18.498%
	A2	0.665	0.735			
	A3	0.742	0.83			
	A4	0.694	0.742			
	A5	0.825	0.86			
DL	B1	0.706	0.799	0.88	16.627%	35.124%
	B2	0.713	0.805			

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Variables	Indicators	CITC	Factor loading	Reliability (α)	% of Variance	Cumulative % of Variance
	B3	0.725	0.777			
	B4	0.742	0.791			
	B5	0.687	0.795			
OI	C1	0.734	0.756	0.866	16.757%	51.882%
	C2	0.69	0.735			
	C3	0.712	0.765			
	C4	0.707	0.729			
	C5	0.601	0.715			
DDC	D1	0.756	0.793	0.9	16.398%	68.279%
	D2	0.773	0.766			
	D3	0.865	0.825			
	D4	0.584	0.566			
	D5	0.53	0.696			
	D6	0.861	0.879			
Total Cronbach α	0.916					
KMO Value	0.906					
Bartlett Test	Chi-Square Statistic 1983.308					
	Degrees of Freedom (df) 42					
	p-Value 0.0					

To assess the scale's consistency and validity, separate analyses were conducted for each variable. The results (Table 2) confirm its strong internal consistency and convergent accuracy.

Correlation analysis

An analysis of correlation was performed to investigate the interrelationships between DT, DL, OI, and DDC. The results encompass the average values, standard deviations, correlation coefficients, and significance levels (Table 3).

The correlation analysis results highlight a notable positive relationship between DL and DT, with a coefficient value of 0.405, confirmed to be statistically significant at the 0.01 threshold. This finding suggests that strengthening DL aligns closely with advancing DT, together forming a critical driving force in the digitalization process.

Further examination demonstrates that DL plays a pivotal role in promoting OI, as reflected by a coefficient of 0.392, also statistically significant at the 0.01 level. This outcome underscores the role of DL in fostering OI, thereby boosting competitiveness and adaptability in a digitalized environment.

Moreover, the connection between OI and DT is characterized by a coefficient of 0.402, again exhibiting statistical significance at the 0.01 level. This indicates that enhancing OI capabilities provides essential support for DT, expediting organizational growth and change in the digital era.

The analysis results reveal that DDC maintains strong positive relationships with DT, DL, and OI, all achieving statistical significance at the 0.01 threshold. Specifically, the measured association between DDC and DT is 0.399, illustrating that enhanced digital dynamic capability enables organizations to drive digital transformation more effectively. Its link with DL, quantified at 0.242, underscores how DDC strengthens leaders' capacity to steer organizational digitalization efforts. Furthermore, the connection with OI reaches 0.596, emphasizing the pivotal role of DDC in advancing organizational innovation[41]-[43].

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In conclusion, digital leadership, organizational innovation, and digital transformation display robust interrelationships, collectively forming a foundational framework for driving organizational digital development.

These results offer empirical support for the research hypotheses and underscore the interconnectedness among the variables investigated. The analysis reveals significant pairwise positive relationships among DT, DL, and OI, forming the core framework for organizational digital development. Meanwhile, DDC, through its strong positive associations with DT, DL, and OI, is deeply embedded in the digitalization process, playing a critical moderating role. It serves as a key driver in fostering steady development and innovative transformation within organizations. These findings not only provide a solid theoretical foundation and practical guidance for optimizing digital strategies but also inject substantial momentum for achieving sustainable growth in the digital era.

Table 3: The Results of Pearson Correlation Analysis

	Mean	**S.D.**	**1**	**2**	**3**	**4**
DT	3.144 (n=156)	1.533	1			
DL	3.156 (n=156)	1.341	0.405** (p=0.0)	1		
OI	3.017 (n=156)	1.328	0.402** (p=0.0)	0.392** (p=0.0)	1	
DDC	3.132 (n=156)	1.478	0.399** (p=0.0)	0.242** (p=0.002)	0.596** (p=0.0)	1

* At the 0.05 level (two-tailed), the correlation is significant.

** At the 0.01 level (two-tailed), the correlation is significant

To analyze the relationships between variables, Pearson correlation analysis was conducted using SPSS software, and a correlation matrix was generated. The detailed results are summarized in Table 3.

Hypothesis testing

Testing of main effects and mediating effects

In this study, DL is treated as the predictor variable, OI serves as the mediating variable, and DT is the outcome variable. Before examining the mediation effect, the data for all variables were standardized. Following data preprocessing, the mediation effect was tested using hierarchical regression analysis.

In testing hypothesis H1, linear regression analysis was conducted with DL as the predictor and DT as the outcome to examine their relationship. As shown in Table 4, the model passed the F-test ($p < 0.05$), indicating a substantial influence of DL on DT. Further analysis shows that the regression coefficient of DL is 0.469, demonstrating strong statistical relevance ($p < 0.01$) and confirming its notable contribution to driving DT.

In this experiment, DL was designated as the independent variable, while OI was identified as the dependent variable to assess H2. A linear regression analysis was conducted to investigate the correlation between DL and OI. As shown in Table 4, the model successfully passed the F-test ($p < 0.05$), thereby affirming its statistical significance. The regression coefficient for DL was 0.38, which is significant at the 0.01 level ($p < 0.01$), indicating that DL has a significant positive effect on OI.

Next, hypothesis H2 was tested by examining the relationship between DL and OI, with DL as the predictor and OI as the outcome. As shown in Table 4, the analysis confirmed the validity of the model ($p < 0.05$), indicating that DL has an impact on OI. The regression coefficient of DL was 0.38, reaching a high level of statistical relevance ($p < 0.01$), confirming that DL significantly contributes to OI.

Finally, to test H3, which proposes that OI mediates the relationship between DL and DT, a regression analysis was conducted. In this study, DL and OI were treated as predictors, while DT was the outcome variable, with relationships

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examined step by step. As shown in Table 4, the model was validated ($p < 0.05$), confirming its relevance. The coefficient for DL was 0.338, demonstrating significance ($p < 0.01$) and highlighting its positive impact on DT.

The regression coefficient for OI was 0.343, which was also significant at the 0.01 level ($p < 0.01$), suggesting a positive influence of OI on DT. Subsequent mediation analysis indicated that the inclusion of OI as a mediating variable resulted in a reduction of the direct effect of DL on DT, although this effect continued to be significant. This provides evidence that OI may play a mediating role in the relationship between DL and DT.

The regression coefficient for OI was 0.343, which was also noteworthy at the 0.01 threshold ($p < 0.01$), indicating a positive impact of OI on DT. Further mediation analysis revealed that incorporating OI as an intermediary led to a decline in the direct influence of DL on DT, though this influence remained statistically valid. This finding supports the notion that OI may serve as a bridging mechanism in the connection between DL and DT.

Table 4: Test Results of the Mediating Effect of OI

	DL	OI	DT
constant	1.665** (t=5.844)	1.817** (t=7.561)	1.042** (t=3.252)
DL		0.38** (t=5.284)	0.338** (t=3.803)
OI			0.343** (t=3.738)
N	156	156	156
R^2	0.164	0.153	0.234
Adjusted R^2	0.159	0.148	0.224
F Value	F(1,154)=30.224 p=0.0	F(1,154)=27.919 p=0.0	F(2,153)=23.372 p=0.0

* p<0.05 ** p<0.01

To assess the mediating effect of OI, a mediation analysis was conducted (Table 4).

Test of moderating effect

This study investigated the moderating influence of DDC on the relationship between DL and OI to evaluate H4. The data presented in Table 5(a) indicates that the interaction term between DL and DDC exhibits statistical relevance ($t = 2.2805$, $p = 0.024$). It indicates that DDC influences the effect of DL on OI, exhibiting significant differences in the intensity of this interaction across varying levels of DDC. The coefficient result for the interaction term is 0.1175, suggesting that DDC exerts a positive moderating effect, amplifying the influence of DL on OI. Additional information can be found in the straightforward slope diagram presented in Figure 2(a).

Table 5(a): Findings on the Moderating Role of DDC 1

	Model 1	Model 2	Model 3
Constant	1.817** (t=7.561)	0.734** (t=3.085)	2.979** (t=44.507)
DDC		0.472** (t=8.384)	0.473** (t=8.517)
DL*DDC			0.118* (t=2.28)
DL	0.38** (t=5.284)	0.255** (t=4.143)	0.24** (t=3.93)
N	156.0	156.0	156.0
R^2	0.153	0.42	0.439
Adjusted R^2	0.148	0.412	0.428
F	F(1.0,154.0)=27.919 p=0.0	F(2.0,153.0)=55.388 p=0.0	F(3.0,152.0)=39.672 p=0.0
ΔR^2	0.153	0.266	0.019

* p<0.05 ** p<0.01

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To examine how DDC moderates the link between DL and OI, SPSS software was utilized to perform a stepwise regression analysis. The findings are presented in Table 5(a).

The effect of DL on OI changes based on the DDC level, as shown in Figure 2(a). When DDC is high, the slope of the relationship is steeper, indicating a stronger influence of DL on OI. In contrast, at lower levels of DDC, the slope flattens, suggesting a weaker effect. This variation demonstrates that the strength of the impact of DL on OI is not uniform across different levels of DDC. At varying levels of DDC, it demonstrates a notable moderation effect, strengthening the link between DL and OI.

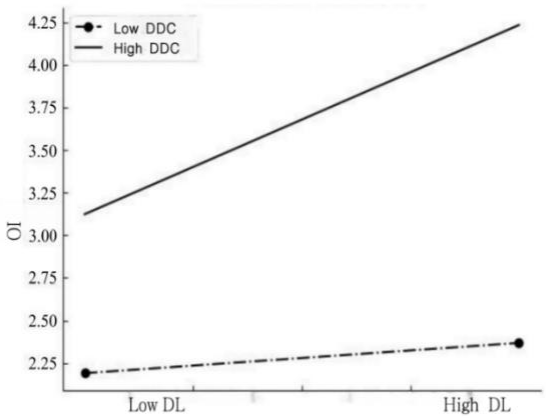

Figure 2(a). The Slope Chart of the Moderating Effect of DDC on DL-OI

Secondly, the study focused on assessing the moderating influence of DDC on the relationship between OI and DT in order to test H5. As shown in Table 5(b), OI exerts a notable influence on DT ($t = 5.4488$, $p < 0.05$). With the introduction of the moderating variable DDC, the interaction term between OI and DDC demonstrates significance ($t = 2.2398$, $p = 0.0266 < 0.05$). This suggests that the impact of OI on DT exhibits considerable variation across distinct levels of DDC. The regression coefficient for the interaction term is 0.2005, indicating that DDC enhances the relationship between OI and DT in a positive manner. The beneficial moderating influence is additionally depicted in the simple slope graph.

Table 5(b): Findings on the Moderating Role of DDC 2

	Model 1	**Model 2**	**Model 3**
Constant	1.697** (t=6.027)	1.409** (t=4.771)	2.99** (t=26.273)
OI	0.479** (t=5.449)	0.304** (t=2.835)	0.289** (t=2.722)
DDC		0.261** (t=2.742)	0.303** (t=3.162)
OI*DDC			0.201* (t=2.24)
N	156.0	156.0	156.0
R^2	0.162	0.201	0.226
Adjusted R^2	0.156	0.19	0.211
F	F(1.0,154.0)=29.689 p=0.0	F(2.0,153.0)=19.231 p=0.0	F(3.0,152.0)=14.83 p=0.0
$\triangle R^2$	0.162	0.039	0.026

* p<0.05 ** p<0.01

To examine the moderating effect of DDC on the relationship between OI and DT, SPSS software was used to conduct a hierarchical regression analysis. The detailed results are provided in Table 5(b).

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Further analysis showed that the impact of OI on DT varies according to the level of DDC, as depicted in Figure 2(b). When DDC is high, the effect of OI on DT becomes significantly stronger. Conversely, when DDC is low, the influence is weaker. This inconsistency suggests that DDC moderates the relationship between OI and DT, amplifying the effect of OI at higher levels of DDC.

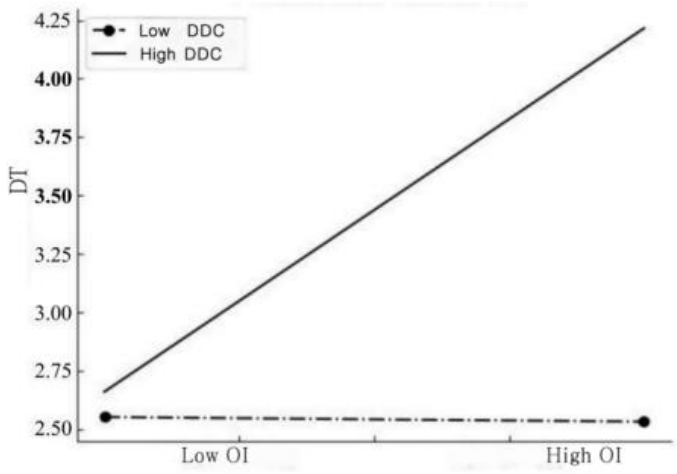

Figure 2(b). The Slope Diagram of the Moderating Effect of DDC on OI - DT

CONCLUSION AND IMPLICATION

Building on dynamic capability theory, this study explores the role and mechanisms of DL in driving the DT of retail enterprises. The empirical findings lead to the following conclusions:

i. DL in retail enterprises demonstrates a notable positive influence on DT.
ii. OI in retail enterprises serves as a mediator between DL and DT.
iii. DDC serves as a key moderating factor in the links between DL and OI, as well as between OI and DT. Specifically, when DDC is high, the effect of DL on OI becomes substantially stronger. Similarly, at higher levels of DDC, the influence of OI on DT is markedly enhanced.

Practical and theoretical contributions

This study's theoretical contribution is centered on enhancing the comprehension of the interplay between DL and DT. The current body of research concerning the mechanisms and empirical evidence surrounding the influence of DL on DT is notably sparse, especially in terms of the interplay between DL and OI. A distinct gap exists in the research examining the ways in which deep learning facilitates open innovation[17]. Building on dynamic capability theory, this study integrates OI and DDC to investigate their roles in the process through which DL influences DT.

Beyond its academic contributions, this study provides substantial real-world value. The DT of retail enterprises emphasizes building digital platforms and nurturing innovation within organizational models. Emphasis should be placed on developing DL among managers to effectively drive organizational transformation. By leveraging DL, the pathways to DT can be enhanced and reinforced.

Moreover, DDC plays a moderating role in the relationship between DL and DT, amplifying their connection. Therefore, in addition to strengthening DL, efforts should also focus on enhancing the digital capabilities of retail enterprises. This will improve competitiveness, stimulate innovation, and support sustainable growth. Ultimately, this combination enables DL to more effectively drive OI and facilitate comprehensive DT in retail enterprises.

Limitations

This research also presents avenues for further exploration. First, while this study adopts a dynamic capability theory perspective to analyze the effects of DL, DDC, and OI on DT, other theoretical frameworks could be explored to

identify additional influencing factors. Future studies could, for instance, integrate aspects such as corporate strategy and business model innovation into models that examine the drivers of DT.

Secondly, further analysis reveals that 73% of the sampled retail enterprises fall within the category of small and medium enterprises, making them the primary components of the retail sector. Accordingly, future research could focus on this key characteristic, incorporating the unique traits of small and medium enterprises as critical antecedents or effective control variables. This would enable a deeper exploration of their distinct patterns and underlying mechanisms in the digital transformation process, ultimately driving the digital upgrading and structural optimization of the entire retail industry.

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