current perspective on business operations

e-ISSN: 3125-1323

ARTICLE

Digital Supply Chains and Technological Innovation: Evidence from NEV Enterprises

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Abstract
This study investigates the influence of supply chain digitalization on the technological innovation performance of new energy vehicle (NEV) enterprises while examining the mediating role of supply chain configuration and the moderating role of supply chain discourse power. To achieve this objective, a comprehensive measurement framework for supply chain digitalization was developed and tested using a moderated mediation model. The analysis was based on panel data collected from Chinese A-share listed NEV firms over the period 2012–2023. The findings reveal that supply chain digitalization significantly enhances technological innovation, indicating its strategic importance in strengthening firms' innovation capabilities. The positive effect is particularly evident among non-state-owned enterprises and firms operating in regions characterized by more advanced digital ecosystems. Furthermore, diversified supply chain configuration serves as an important mechanism through which digitalization promotes innovation, while supply chain discourse power reinforces this relationship by strengthening the effectiveness of configuration decisions. These results contribute to the growing body of knowledge on supply chain digitalization and offer practical insights for managers and policymakers seeking to improve innovation outcomes and supply chain competitiveness within the NEV industry.

Keywords: Supply chain digitalization; technological innovation; supply chain configuration; supply chain discourse power; new energy vehicles.

Academic Editor: Daniel Wang

Received: April 28, 2026 | Revised: May 22, 2026 | Accepted: June 10, 2026 | Published: June 22, 2026

Citation: Fachry, M. S., & Silvia, N. A. (2026). Digital supply chains and technological innovation: Evidence from NEV enterprises. *Current Perspective on Business Operations, 2*(3), 270–291.

1. Introduction

The global automotive industry is undergoing a significant transformation toward new energy vehicles (NEVs) (Zahoor et al., 2023). NEVs refer to advanced automotive

products powered primarily by non-fossil energy sources and characterized by the deep integration of electrification, intelligence, and connectivity, where sustained technological innovation serves as a core source of competitiveness (Zhang & Qin, 2018; Hu et al., 2024). Compared with conventional internal combustion engine vehicles, NEVs differ fundamentally in their energy structure, propulsion systems, and intelligent functionalities. Their distinctive features, including electrified power systems, low-carbon energy consumption, and compatibility with digital technologies, represent the transition of the automotive industry toward green and intelligent mobility (Kendall, 2018; Li et al., 2020). As a new wave of technological revolution and industrial transformation accelerates worldwide, NEVs have become a strategic sector through which countries seek industrial leadership and firms pursue sustainable competitive advantage (Su et al., 2023).

Simultaneously, the rapid integration of the digital economy with the real economy has stimulated the emergence of new business models, operational mechanisms, and service innovations that generate competitive advantages for enterprises (Seyedghorban et al., 2020). Within this context, supply chain digitalization has emerged as an important development paradigm (Marmolejo-Saucedo & Hartmann, 2022). Through the application of digital technologies such as the Internet of Things (IoT), artificial intelligence (AI), big data analytics, blockchain, and digital twins, supply chain digitalization enhances information visibility, resource coordination, and operational efficiency while supporting sustainable development objectives (Huang & Tan, 2025; Nie et al., 2025). Given its close alignment with the technological characteristics of NEVs, supply chain digitalization is increasingly recognized as a critical mechanism for maintaining long-term competitiveness and improving technological innovation performance. Recognizing its strategic importance, the Chinese government launched pilot programs for supply chain innovation and application in 2018, encouraging enterprises to develop intelligent and collaborative supply chain systems. Previous studies have similarly confirmed that digital technologies can create significant opportunities for industrial upgrading and innovation in emerging economies (Chauhan et al., 2022; Lee et al., 2020).

China currently represents the world's largest and most dynamic NEV market (Yang et al., 2021). The industry has gradually shifted from a policy-driven growth stage supported by fiscal incentives and regulatory measures toward a market-oriented development model characterized by technological competition and business model innovation (Liu et al., 2022). This transition has intensified the need for firms to strengthen their technological innovation capabilities (Jiang & Xu, 2023). In line with this objective, China's New Energy Vehicle Industry Development Plan (2021–2035) explicitly emphasizes technological innovation as the primary strategic priority for future industry development. Leading enterprises such as BYD and CATL have responded by increasing research and development investments and integrating digital technologies into supply chain management processes. Through the combination of technological capabilities, including battery technology, intelligent algorithms, software-defined systems, and digitalized supply chain operations, these firms have improved supply chain responsiveness and innovation efficiency, thereby establishing competitive advantages in an increasingly dynamic market environment (Masiero et al., 2016).

Despite rapid industry growth, NEV enterprises continue to face substantial challenges, including raw material price volatility, technological bottlenecks, supply chain disruptions, and intensifying market competition (Shi et al., 2023). Addressing these challenges requires continuous technological innovation, which has been widely recognized as a critical driver of sustainable development in the automotive industry (Zahoor et al., 2023; Onat & Kucukvar, 2022). Considering the high technological complexity, rapid product iteration cycles, and strong supply chain dependence of NEVs, supply chain digitalization has become an increasingly viable strategy for enhancing technological innovation capabilities (Agrawal et al., 2024).

Existing research has extensively investigated the relationship between supply chain digitalization and innovation performance; however, the findings remain inconclusive. On the one hand, studies grounded in the dynamic capabilities perspective suggest that supply chain visibility, connectivity, and digital integration improve information transparency and organizational learning, thereby enhancing innovation outcomes (Dubey et al., 2018). Similarly, blockchain-enabled supply chains have been shown to reduce transaction costs and facilitate innovation activities (Schmidt & Wagner, 2019). Other studies argue that supply chain digitalization promotes collaborative innovation (Huang et al., 2023), green innovation (Ma et al., 2024), and open innovation (Teodorescu & Korchagina, 2021) by strengthening interactions among supply chain actors. On the other hand, some scholars contend that the costs associated with processing and managing large volumes of digital data may reduce R&D efficiency and innovation effectiveness, thereby discouraging technological innovation (Son et al., 2021; Wu et al., 2024a, 2024b). Consequently, whether supply chain digitalization consistently enhances technological innovation remains an open empirical question.

Research on technological innovation within the NEV industry has predominantly focused on external drivers such as policy instruments, technological applications, and organizational structures. Existing evidence demonstrates that innovation policies (Liu et al., 2020), industrial collaboration policies (Wang & Xue, 2024), purchase tax incentives (Li & Zhang, 2023), dual-credit policies (Ma et al., 2025), promotion policies (Xue et al., 2025), and pilot programs (Jiang & Xu, 2023) can stimulate innovation activities among NEV enterprises. However, empirical findings concerning government subsidies (Wang et al., 2022; Wu et al., 2024a, 2024b), technology adoption (Chen, 2022; Cheng et al., 2021), and organizational innovation structures (Cao et al., 2024; Wang et al., 2023) remain inconsistent. More importantly, existing studies have largely overlooked the internal organizational mechanisms through which supply chain digitalization influences technological innovation.

A review of the literature reveals three major research gaps. First, although supply chain digitalization has received considerable scholarly attention, empirical findings regarding its impact on technological innovation remain fragmented and inconclusive. Second, most studies rely on quasi-natural experiments and policy evaluation approaches (Luo et al., 2024; Ma et al., 2024; Xu et al., 2025), whereas quantitative investigations focusing specifically on NEV enterprises remain limited. Third, the mechanisms through which supply chain digitalization affects technological innovation have not been adequately explored, particularly the potential mediating roles of supply chain configuration and supply chain discourse power.

To address these gaps, this study investigates the impact of supply chain digitalization on technological innovation among Chinese NEV enterprises. Specifically, it develops a multidimensional measurement framework for supply chain digitalization and examines the mediating roles of supply chain configuration and supply chain discourse power. Furthermore, a moderated mediation framework is employed to uncover the mechanisms through which supply chain digitalization influences technological innovation and to identify the conditions under which these effects become more pronounced.

This study makes three important contributions. First, it extends digital technology affordance theory by establishing a direct relationship between supply chain digitalization and technological innovation within the context of strategic emerging industries. Second, it develops a comprehensive measurement index for supply chain digitalization encompassing digital infrastructure, organizational support, strategic value creation, and environmental sustainability dimensions, thereby enriching quantitative research in this field. Third, by incorporating supply chain configuration and supply chain discourse power into a moderated mediation framework, this study opens the "black box" of how supply chain digitalization contributes to technological innovation, extending the

application of resource-based and power theories in digital supply chain research while providing practical implications for the sustainable development of NEV enterprises.

2. Literature Review and Hypothesis Development

This study is grounded in Digital Technology Affordance Theory, Resource Dependence Theory, Configuration Theory, and Principal–Agent Theory to explain how supply chain digitalization enhances technological innovation in new energy vehicle (NEV) enterprises. Digital Technology Affordance Theory argues that firms can generate value and competitive advantages through effective interaction and alignment with digital technologies (Zhu & Jin, 2025). In the context of NEV enterprises, supply chain digitalization facilitates information sharing, resource integration, and collaborative decision-making among supply chain partners, thereby creating favorable conditions for technological innovation (Wang et al., 2025a, b).

Supply chain digitalization enables firms to improve technological innovation by strengthening knowledge acquisition, knowledge integration, and innovation decision-making processes. Through the application of digital technologies such as big data analytics, artificial intelligence, cloud computing, and Internet of Things (IoT), firms can efficiently collect, process, and disseminate information across procurement, manufacturing, inventory management, and distribution activities (Le et al., 2025; Cheng et al., 2023). These capabilities support organizational learning and facilitate the transformation of knowledge into innovative products and technologies. Artificial intelligence further contributes to innovation by enabling predictive analytics, intelligent decision-making, and the identification of emerging technological opportunities (Aldoseri et al., 2024; Mohsen, 2023). Therefore, supply chain digitalization is expected to positively affect technological innovation.

Furthermore, supply chain configuration serves as a critical mechanism linking supply chain digitalization to technological innovation. Resource Dependence Theory suggests that firms rely on external stakeholders to obtain strategic resources required for organizational survival and growth (Fink et al., 2006). Through digital transformation, firms can improve visibility across supply chain activities and establish more diversified relationships with suppliers and customers. Such diversified supply chain configurations provide access to heterogeneous knowledge, technologies, and market information while reducing dependence on specific partners (Kim & Park, 2024). Consequently, firms gain greater flexibility in responding to technological changes and market uncertainties, thereby enhancing innovation performance (Shen et al., 2025; Li et al., 2025).

In addition, supply chain discourse power is proposed as a moderating factor influencing the effectiveness of supply chain configuration in promoting technological innovation. Firms possessing stronger discourse power have greater influence over supply chain decisions, resource allocation, and collaborative activities (Li et al., 2023). This enhanced influence facilitates knowledge sharing, strategic coordination, and innovation-related cooperation among supply chain members, thereby strengthening the innovation benefits derived from supply chain configuration (Zhao, 2019; Yin et al., 2025).

Based on the theoretical arguments, the research framework is developed as illustrated below.

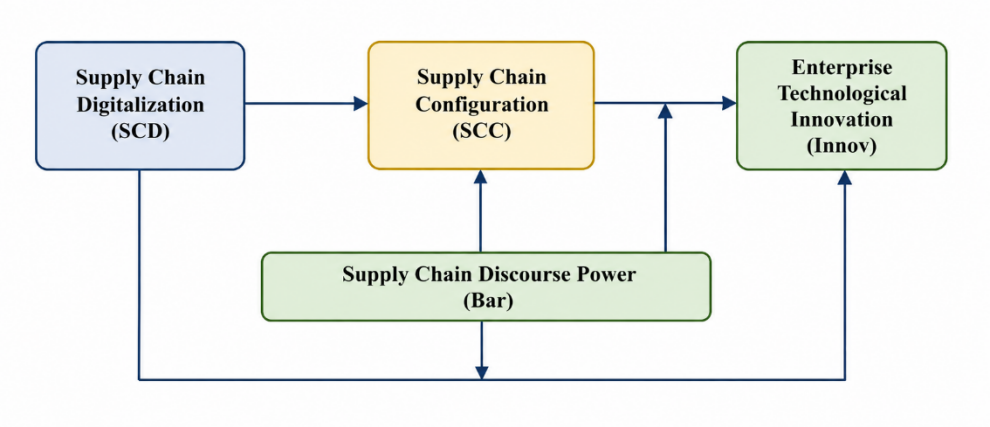

Figure 1. Research Framework

Accordingly, the following hypotheses are proposed:

H1. *Supply chain digitalization positively affects technological innovation in NEV enterprises.*

H2. *Supply chain configuration mediates the relationship between supply chain digitalization and technological innovation in NEV enterprises.*

H3a. *Supply chain discourse power positively moderates the relationship between supply chain configuration and technological innovation in NEV enterprises.*

H3b. *Supply chain discourse power positively moderates the mediating effect of supply chain configuration in the relationship between supply chain digitalization and technological innovation in NEV enterprises.*

3. Research Methods

To empirically test these hypotheses, this study uses Chinese A-share listed NEV enterprises from 2012 to 2023 as the research sample. This period captures the rapid development and technological transformation of China's NEV industry. Following prior studies, firms designated as ST and *ST are excluded, observations with missing values are removed, and all continuous variables are winsorized at the 1% level to mitigate the influence of extreme observations.

Technological innovation is measured using the natural logarithm of the number of invention patent applications plus one, including both independent and jointly applied patents, following Fu et al. (2024), Jiang and Xu (2023), and Yang et al. (2024). Supply chain digitalization is measured through a multidimensional evaluation system encompassing digital infrastructure, organizational support, strategic value, and environmental sustainability dimensions. The entropy weighting method is employed to construct a comprehensive digitalization index. Supply chain configuration reflects the degree of diversification and coordination among upstream and downstream partners, whereas supply chain discourse power represents the firm's influence and bargaining position within the supply chain network.

Table 1. Supply Chain Digitalization Evaluation Index System

Primary Indicators	Secondary Indicators	Tertiary Indicators	Indicator Attributes
Supply Chain Digitalization	Digital Infrastructure	Number of 5G base stations deployed	+
		Length of long-distance optical fiber cables	+
		Number of Internet broadband access ports	+

Primary Indicators	Secondary Indicators	Tertiary Indicators	Indicator Attributes
		Number of websites per 100 enterprises	+
		E-commerce sales volume	+
		Number of public charging piles	+
	Organizational Support	Degree of digital transformation	+
		R&D investment ratio	+
		R&D personnel ratio	+
	Strategic Value	Operating profit margin	+
		Operating expense ratio	−
		Inventory turnover period	−
	Environmental Protection	Environmental protection concept disclosure	+
		Environmental investment	+
		Carbon emission intensity	−

Table 2. Variable Definitions and Measurements

Variable Type	Variable Name	Symbol	Variable Description	Data Source
Dependent Variable	Enterprise Innovation	*Innov*	The natural logarithm of the number of enterprise independently and jointly applied invention patents plus 1	Intellectual Property Office
Explanatory Variable	Supply Chain Digitalization	*SCD*	Comprehensive index of supply chain digitalization	National Bureau of Statistics, Ministry of Industry and Information Technology, China Electric Vehicle Charging Infrastructure Promotion Alliance, China Stock Market & Accounting Research Database (CSMAR)
Mediating Variable	Supply Chain Configuration	*SCC*	1 − [(Proportion of purchases from top 5 suppliers + Proportion of sales to top 5 customers)/2]	CSMAR
Moderating Variable	Supply Chain Discourse Power	*Bar*	1 if the sum of stock market value and book value of liabilities is higher than the industry median; otherwise 0	CSMAR
Control Variable	Enterprise Size	*Size*	Natural logarithm of total assets	CSMAR
	Enterprise Age	*FirmAge*	Current year − year of establishment + 1	CSMAR
	Asset–Liability Ratio	*Lev*	Total liabilities / Total assets	CSMAR
	Cash Ratio	*Cashflow*	Cash flow / Total assets	CSMAR
	Tobin's Q Value	*TobinQ*	Enterprise market value / Asset replacement cost	CSMAR
	Equity Concentration	*Top1*	Proportion of the largest shareholder	CSMAR
	Duality of Chairman and General Manager	*Dual*	1 if the chairman and general manager are the same person; otherwise 0	CSMAR
	Number of Supervisors	*Ss*	Total number of supervisors	CSMAR

To examine the direct effect of supply chain digitalization on technological innovation, the following baseline regression model is specified:

$$Innov_{\{it\}} = \alpha_0 + \alpha_{1SCD_{\{it\}}} + \alpha_{2Controls_{\{it\}}} + \eta_i + \lambda_t + \backslash mu_i + \varepsilon_{\{it\}} \quad (1)$$

where (Innov_{it}) denotes technological innovation, (SCD_{it}) represents supply chain digitalization, and (Controls_{it}) refers to the set of control variables. Firm, year, and industry fixed effects are represented by (\eta_i), (\lambda_t), and (\mu_i), respectively.

To test the mediating role of supply chain configuration, the following mediation models are estimated:

$$SCC_{\{it\}} = \beta_0 + \beta_{1SCD_{\{it\}}} + \beta_{2Controls_{\{it\}}} + \eta_i + \lambda_t + \backslash mu_i + \varepsilon_{\{it\}} \quad (2)$$

$$Innov_{\{it\}} = \gamma_0 + \gamma_{1SCD_{\{it\}}} + \gamma_{2SCC_{\{it\}}} + \gamma_{3Controls_{\{it\}}} + \eta_i + \lambda_t + \backslash mu_i + \varepsilon_{\{it\}} \quad (3)$$

where (SCC_{it}) denotes supply chain configuration.

To examine the moderating role of supply chain discourse power, the following models are employed:

$$Innov_{\{it\}} = \rho_0 + \rho_{1SCD_{\{it\}}} + \rho_{2Bar_{\{it\}}} + \rho_{3(SCD_{\{it\}} \times Bar_{\{it\}})} + \rho_{4Controls_{\{it\}}} + \eta_i + \lambda_t + \backslash mu_i + \varepsilon_{\{it\}} \quad (4)$$

$$SCC_{\{it\}} = \sigma_0 + \sigma_{1SCD_{\{it\}}} + \sigma_{2Bar_{\{it\}}} + \sigma_{3(SCD_{\{it\}} \times Bar_{\{it\}})} + \sigma_{4Controls_{\{it\}}} + \eta_i + \lambda_t + \backslash mu_i + \varepsilon_{\{it\}} \quad (5)$$

$$Innov_{\{it\}} = \omega_0 + \omega_{1SCD_{\{it\}}} + \omega_{2SCC_{\{it\}}} + \omega_{3Bar_{\{it\}}} + \omega_{4Controls_{\{it\}}} + \omega_{5(SCC_{\{it\}} \times Bar_{\{it\}})} + \eta_i + \lambda_t + \backslash mu_i + \varepsilon_{\{it\}} \quad (6)$$

where (Bar_{it}) represents supply chain discourse power.

Following the estimation procedure, mediation and moderated mediation effects are assessed by examining the significance and direction of the relevant path coefficients. All statistical analyses are conducted using Stata 18.0.

4. Results

4.1. Descriptive Statistics

Descriptive statistics for all research variables are presented in **Table 3**. The results indicate that the average value of technological innovation (Innov) among Chinese NEV enterprises is 1.732, with values ranging from 0.000 to 9.042. This variation reflects substantial differences in innovation performance across firms. Supply chain digitalization (SCD) shows an average value of 0.070, with a minimum value of 0.001 and a maximum value of 0.371, suggesting that although many firms have initiated digital transformation efforts within their supply chains, the overall level of digitalization remains relatively modest and unevenly distributed.

Similarly, the descriptive statistics of supply chain configuration (SCC), supply chain discourse power (Bar), and the control variables reveal considerable heterogeneity among enterprises. Such variation provides a suitable empirical foundation for examining the relationships proposed in this study.

Table 3. Descriptive Statistics

Variable	Sample Size	Mean Value	Standard Deviation	Minimum Value	Maximum Value
Innov	5,828	1.732	1.554	0.000	9.042
SCD	6,025	0.070	0.040	0.001	0.371
SCC	5,618	0.632	0.159	0.000	0.986

Bar	5,694	0.476	0.499	0.000	1.000
Size	6,017	22.069	1.260	19.431	25.968
FirmAge	6,025	26.069	5.453	8.000	46.000
Lev	6,025	0.418	0.185	0.066	0.872
Cashflow	6,025	0.657	0.894	0.029	5.833
TobinQ	5,109	1.904	1.010	0.870	6.824
Top1	5,699	33.040	14.560	7.710	74.300
Dual	5,750	0.363	0.481	0.000	1.000
Ss	5,919	3.338	0.875	0.000	9.000

4.2. Multicollinearity Test

Given that supply chain digitalization is operationalized as a multidimensional construct, a Variance Inflation Factor (VIF) analysis was conducted to assess potential multicollinearity among its dimensions. The dimensions examined include digital infrastructure, organizational support, strategic value, and environmental protection.

As reported in **Table 4**, all VIF values are substantially below the commonly accepted threshold of 10. The mean VIF is 1.21, indicating the absence of serious multicollinearity concerns. These findings confirm that the dimensions capture distinct aspects of supply chain digitalization and support the validity of the proposed measurement framework.

Table 4. Variance Inflation Factor (VIF) Results

Variable	VIF	1/VIF
Digital Infrastructure	1.02	0.984643
Organizational Support	1.34	0.744727
Strategic Value	1.41	0.709190
Environmental Protection	1.08	0.921887
Mean VIF	**1.21**	—

4.3. Benchmark Regression Analysis

The benchmark regression results are summarized in **Table 5**. Column (1) reports the baseline model without fixed effects, whereas Column (2) incorporates year, province, and industry fixed effects. Columns (3) and (4) further include control variables to improve model robustness.

Across all specifications, supply chain digitalization (SCD) exhibits a positive and statistically significant coefficient at the 1% significance level. The results demonstrate that firms with higher levels of supply chain digitalization achieve stronger technological innovation performance. These findings suggest that digitalized supply chains facilitate information sharing, knowledge integration, and resource coordination while reducing information asymmetry and uncertainty throughout innovation processes.

By improving connectivity across supply chain participants and enabling more efficient allocation of innovation-related resources, supply chain digitalization functions as a strategic driver of technological innovation in NEV enterprises. Therefore, Hypothesis H1 is supported.

Table 5. Benchmark Regression Results

Variables	(1) Innov	(2) Innov	(3) Innov	(4) Innov
SCD	7.255*** (0.520)	10.539*** (0.813)	4.993*** (0.706)	3.674*** (0.759)
Size			0.491*** (0.025)	0.547*** (0.030)
FirmAge			−0.021*** (0.004)	−0.027*** (0.004)
Lev			−0.253** (0.128)	−0.286* (0.146)

Variables	(1) Innov	(2) Innov	(3) Innov	(4) Innov
Cashflow			0.016 (0.022)	0.041 (0.027)
TobinQ				0.168*** (0.023)
Top1				−0.004** (0.002)
Dual				0.011 (0.043)
Ss				0.177*** (0.030)
Constant	1.222*** (0.038)	0.991*** (0.056)	−8.836*** (0.527)	−10.590*** (0.622)
N	5,828	5,828	5,828	4,810
R^2	0.0351	0.1837	0.2850	0.3149
Year Fixed Effects	No	Yes	Yes	Yes
Province Fixed Effects	No	Yes	Yes	Yes
Industry Fixed Effects	No	Yes	Yes	Yes

Notes: Standard errors are reported in parentheses. $p < 0.10$, $\mathbf{p} < 0.05$, $\boldsymbol{p} < 0.01$.

4.4. Robustness Tests

To ensure the reliability of the findings, several robustness tests were performed.

4.4.1. Alternative Measures of Technological Innovation

First, technological innovation was decomposed into independent innovation and collaborative innovation. Independent innovation was measured using the natural logarithm of independently filed invention patents plus one, whereas collaborative innovation was measured using the natural logarithm of jointly filed invention patents plus one.

The results reveal that supply chain digitalization continues to exert a positive and significant effect on both forms of innovation, confirming the robustness of the baseline findings.

4.4.2. Alternative Sample Periods

Second, observations from 2015 and 2020 were excluded to mitigate potential disturbances associated with the stock market turbulence and public health crisis. The positive effect of supply chain digitalization remained statistically significant.

Furthermore, the sample was divided into two sub-periods based on the release of China's *New Energy Vehicle Industry Development Plan (2021–2035)*. The positive relationship between supply chain digitalization and technological innovation remained significant in both periods.

4.4.3. Alternative Estimation Method

Third, because patent counts are non-negative integer variables, a negative binomial regression model was employed as an alternative estimation approach. The results remained consistent with the baseline regressions, further supporting the robustness of the findings.

Endogeneity Test

Finally, to address potential endogeneity arising from reverse causality, the two-period lagged value of supply chain digitalization was used as an instrumental variable within a two-stage least squares (2SLS) framework.

The first-stage results demonstrate a strong positive relationship between the instrumental variable and current supply chain digitalization. Additionally, the

Kleibergen–Paap LM test and Cragg–Donald Wald F-statistic confirm the validity and strength of the selected instrument. The second-stage regression results continue to show a positive and significant effect of supply chain digitalization on technological innovation, indicating that endogeneity concerns do not alter the main conclusions.

Table 6. Robustness Test Results

Variables	(1) Innov	(2) Innov	(3) Innov	(4) Innov	(5) Innov	(6) Innov	(7) Innov	(8) Innov
SCD	3.403***	1.764***	3.463***	5.464***	3.851***	3.903***		9.635***
	(0.787)	(0.567)	(0.801)	(1.250)	(1.081)	(0.890)		(2.235)
IV							0.415***	
							(0.033)	
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−9.612***	−6.714***	−10.837***	−10.453***	−10.820***	−22.063***	−0.051***	−11.813***
	(0.650)	(0.459)	(0.669)	(0.926)	(0.877)	(0.909)	(0.009)	(0.807)
N	4,810	4,810	4,055	2,620	2,189	4,811	3,965	3,965
R^2 / Pseudo R^2	0.2859	0.2094	0.3198	0.3473	0.3079	0.1105	0.6626	0.3089
Year / Province / Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LM Test							$p = 0.0000$	
Cragg–Donald Wald F Statistic							672.786	

4.5 Heterogeneity Analysis

4.5.1. Enterprise Ownership

The first heterogeneity analysis examines differences between state-owned enterprises (SOEs) and non-state-owned enterprises (NSOEs). The results, presented in Table 7, reveal that supply chain digitalization has a stronger positive effect on technological innovation among non-state-owned enterprises.

A possible explanation is that non-state-owned firms generally possess greater organizational flexibility, stronger market responsiveness, and fewer institutional constraints. Consequently, they are better positioned to leverage digital technologies for innovation and strategic transformation.

4.5.2. Regional Digital Ecosystem

The second heterogeneity analysis considers differences in regional digital ecosystems. Regions with intensive digital resources exhibit a stronger positive relationship between supply chain digitalization and technological innovation compared with regions characterized by weaker digital environments.

This finding suggests that a supportive digital ecosystem enhances information flow, technology diffusion, and innovation resource allocation, thereby amplifying the innovation benefits derived from supply chain digitalization. Nevertheless, a significant positive effect remains observable even in regions with relatively limited digital resources, indicating the broad applicability of digital supply chain transformation across different regional contexts.

Table 7. Heterogeneity Analysis Results

Variables	(1) State-owned	(2) Non-state-owned	(3) Intensive	(4) Non-intensive
SCD	0.329 (1.623)	4.889*** (0.914)	2.928*** (0.978)	2.554** (1.154)
Controls	Yes	Yes	Yes	Yes
Constant	−10.967*** (1.471)	−10.238*** (0.732)	−10.584*** (0.760)	−10.007*** (1.043)
N	1,073	3,478	3,038	1,771
R^2	0.4878	0.3031	0.3458	0.3625
Year / Province / Industry FE	Yes	Yes	Yes	Yes

4.6. Mechanism Analysis

To further investigate the underlying mechanisms, this study examines the mediating role of supply chain configuration (SCC) and the moderating role of supply chain discourse power (Bar).

The mediation analysis demonstrates that supply chain digitalization significantly enhances supply chain configuration. In turn, supply chain configuration positively influences technological innovation. The Sobel test confirms that the indirect effect is statistically significant, indicating that supply chain configuration partially mediates the relationship between supply chain digitalization and technological innovation. Therefore, Hypothesis H2 is supported.

Regarding moderation effects, the interaction between supply chain digitalization and supply chain discourse power is positive and significant. This finding indicates that firms possessing stronger discourse power within the supply chain can more effectively convert digitalization initiatives into innovation outcomes.

Further analysis reveals that supply chain discourse power strengthens the mediating effect of supply chain configuration. Specifically, firms with greater influence over supply chain partners are better able to coordinate resources, facilitate information sharing, and integrate heterogeneous knowledge, thereby amplifying the innovation benefits generated through diversified supply chain configurations.

These results provide empirical support for Hypotheses H3a and H3b.

Table 8. Mediation and Moderated Mediation Results

Variables	(1) SCC	(2) Innov	(3) Innov	(4) SCC	(5) Innov
SCD	0.164** (0.077)	3.345*** (0.780)	−0.158 (0.854)	0.241** (0.099)	−0.548 (0.881)
SCC		1.600*** (0.146)			1.038*** (0.170)
Bar			−0.689*** (0.086)	0.010 (0.009)	−1.442*** (0.194)
SCD × Bar			6.802*** (0.977)	−0.137 (0.105)	6.453*** (1.000)
SCC × Bar					1.189*** (0.265)
Controls	Yes	Yes	Yes	Yes	Yes
Constant	−0.094* (0.050)	−9.674*** (0.667)	−10.929*** (0.918)	−0.109 (0.067)	−10.665*** (0.934)
N	4,534	4,532	4,810	4,534	4,532
R^2	0.2547	0.3285	0.3243	0.2550	0.3398
Year / Province / Industry FE	Yes	Yes	Yes	Yes	Yes
Sobel Test	$p = 0.044$				

5. Discussion

This study investigates the relationships among supply chain digitalization, supply chain configuration, supply chain discourse power, and technological innovation in Chinese new energy vehicle (NEV) enterprises. The empirical findings demonstrate that

supply chain digitalization significantly enhances technological innovation, indicating that digital transformation within supply chains has become an important strategic mechanism for improving innovation capability in the NEV industry. These findings support the arguments of Wu et al. (2024a, b) and Huang et al. (2023), who identified supply chain digitalization as a key driver of enterprise innovation. By facilitating information transparency, knowledge sharing, and resource integration across supply chain partners, digitalization enables firms to reduce information asymmetry and improve innovation efficiency.

The results further reveal that supply chain configuration partially mediates the relationship between supply chain digitalization and technological innovation. This finding suggests that digitalization promotes technological innovation not only through direct improvements in information processing and coordination but also through the optimization of supply chain structures. Diversified supply chain configurations allow firms to access heterogeneous knowledge, technologies, and market resources from multiple partners, thereby increasing strategic flexibility and reducing innovation risks. This finding is consistent with the resource dependence perspective proposed by Fink et al. (2006) and the configuration perspective of Flynn et al. (2010), which emphasize that effective resource allocation and coordination across supply chain networks are essential for organizational performance and innovation.

Another important finding concerns the moderating role of supply chain discourse power. The results indicate that enterprises with stronger discourse power are better able to transform diversified supply chain configurations into technological innovation outcomes. This supports the arguments of Li et al. (2023) and Zhao (2019), who emphasized that firms possessing stronger influence within supply chain networks can coordinate resources more effectively, improve information sharing, and strengthen collaborative relationships. Consequently, supply chain discourse power amplifies both the direct and indirect effects of supply chain digitalization on technological innovation.

The heterogeneity analysis demonstrates that the innovation-enhancing effect of supply chain digitalization is more pronounced among non-state-owned enterprises and firms operating in regions with well-developed digital ecosystems. Compared with state-owned enterprises, non-state-owned firms generally possess greater flexibility, stronger market responsiveness, and fewer institutional constraints, enabling them to adopt digital technologies and implement innovation strategies more effectively. This finding is consistent with Han et al. (2023), who highlighted the importance of collaborative networks and organizational flexibility in supporting technological innovation. Furthermore, firms located in regions with intensive digital resources benefit from stronger digital infrastructure, better technology diffusion, and more efficient access to innovation resources. These findings are aligned with Fan et al. (2025), who argued that supportive digital ecosystems foster innovation by facilitating knowledge exchange, digital connectivity, and collaborative learning.

From a theoretical perspective, this study extends the application of digital technology affordance theory within the context of strategic emerging industries, particularly the NEV sector. Previous studies have largely focused on the macro-level impacts of digital technologies, whereas this study provides evidence of how supply chain digitalization translates into innovation outcomes at the enterprise level. In addition, by integrating digital technology affordance theory with resource dependence theory, configuration theory, and power theory, this study offers a more comprehensive explanation of how digitalization influences technological innovation through supply chain mechanisms.

The findings also contribute to the ongoing debate regarding the innovation effects of supply chain digitalization. While Wu et al. (2024a, b) suggested that excessive reliance on digital resources may eventually reduce cost advantages and create an inverted U-shaped relationship between digitalization and innovation, the present study identifies a

consistently positive relationship within the NEV industry. Moreover, unlike Huang et al. (2023), who focused on integrated innovation, and Ma et al. (2024), who examined sustainable green innovation, this study specifically investigates technological innovation. Similarly, while Ke (2022), Yuan and Sun (2024), and Marin et al. (2023) concentrated on distribution enterprises and SMEs, the present research focuses on NEV enterprises, thereby extending the applicability of existing theories to a strategically important and technology-intensive industry.

Overall, the results reinforce the view that supply chain digitalization is a critical enabler of technological innovation. The findings provide practical insights for NEV enterprises seeking to improve innovation performance through digital transformation, while also offering guidance for policymakers and industry stakeholders in strengthening digital ecosystems and promoting collaborative innovation across supply chains.

6. Conclusions

This study investigates the impact of supply chain digitalization on technological innovation in Chinese new energy vehicle (NEV) enterprises using data from A-share listed firms between 2012 and 2023. The findings demonstrate that supply chain digitalization significantly enhances technological innovation, confirming its role as a critical driver of innovation capability in the NEV industry. Furthermore, supply chain configuration serves as a partial mediator, indicating that digitalization promotes innovation not only directly but also indirectly by encouraging a more diversified and flexible supply chain structure. The results also reveal that supply chain discourse power strengthens the positive effect of supply chain configuration on technological innovation and amplifies the indirect influence of supply chain digitalization through supply chain configuration.

The study further shows that the innovation benefits of supply chain digitalization vary across firms and regions. Specifically, the positive impact is stronger among non-state-owned enterprises and firms operating in regions with more developed digital ecosystems. These findings highlight the importance of organizational flexibility, resource integration capability, and supportive digital environments in maximizing the value of supply chain digitalization. From a theoretical perspective, this study extends digital technology affordance theory and enriches resource dependence, configuration, and power theories by uncovering the mechanisms through which supply chain digitalization facilitates technological innovation in strategic emerging industries.

Despite these contributions, several limitations should be acknowledged. The analysis focuses exclusively on Chinese A-share listed NEV enterprises, which may restrict the generalizability of the findings to small and medium-sized enterprises, non-listed firms, and international contexts. In addition, supply chain digitalization was operationalized through four dimensions, which may not fully capture the complexity of digital transformation processes. Future studies may expand the sample scope, incorporate cross-country comparisons, refine the measurement of supply chain digitalization, and employ mixed-method approaches combining quantitative and qualitative evidence. Further investigation into the roles of organizational culture, digital capability, innovation strategy, and institutional environments would also provide deeper insights into how supply chain digitalization contributes to technological innovation across different industrial settings.

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