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Enhancing the resilience of supply chains in the fashion apparel industry through intelligent logistics—evidence from China

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ABSTRACT

Enhancing the resilience of supply chains is a key factor in ensuring economic circulation and social development. This study examines the impact of intelligent logistics on the resilience of supply chains in the fashion industry, based on data from prefecture-level cities in China and A-share listed fashion apparel companies from 2008 to 2021. The findings show that intelligent logistics significantly enhance both the resistance and recovery capabilities of supply chains, promoting an overall improvement in supply chain resilience. The key mechanisms include expanding corporate market strategies, reducing transaction costs, and improving supply chain efficiency. This study not only broadens the research field of intelligent logistics' impact on supply chain resilience but also provides valuable references for the Chinese government to optimize relevant policies.

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1. Introduction

The current global economic landscape is undergoing historic changes, with various factors increasingly restricting supply chain security. These constraints include intensified competition among major powers, rising anti-globalization sentiments, reliance on other countries for key technologies, and obstacles posed by the pandemic of the century. In the 'VUCA' era—characterized by volatility, uncertainty, complexity, and ambiguity—the logistics industry, as a foundational, strategic, and leading sector supporting national economic development, plays a crucial role in extending the industrial chain, enhancing the value chain, and constructing the supply chain as part of the modern industrial system. In recent years, to adapt to the developmental needs of the digital age, the logistics industry has integrated new-generation information and logistics technologies—based on 'ABCDE' (Artificial Intelligence, Blockchain, Cloud Computing, Big Data, Edge Computing)—to form a new intelligent logistics ecosystem characterized by digitalization, intelligence, greening, networking, internationalization, and inclusivity (Chen et al., 2024; Li & Li, 2022).

The supply chain is not only the mainstay of the modern physical economy but also the primary source of logistics demand for the entire society. Intelligent logistics inherently facilitate economic circulation and maintain supply chain resilience and stability, effectively preventing phenomena such as 'chain breaks', 'chain blockages', and 'chain drop-offs'. Therefore, combining the intrinsic attributes and advancement methods of intelligent logistics to research whether the logistics industry can enhance the supply chain's crisis response capacity and explore new avenues for promoting supply chain resilience and security is an extremely important topic.

The innovation points and necessity of this study are reflected in the following aspects. Firstly, from the research perspective, existing studies primarily focus on the impact of the digital economy, industrial structure, and technological innovation on supply chain resilience, but no scholars have yet explored the causal relationship between intelligent logistics and supply chain resilience. This study, for the first time,

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explores new avenues for enhancing supply chain resilience from the enabling perspective of intelligent logistics, filling a gap in this research area and expanding the value creation domain of the logistics industry. Secondly, in terms of indicator measurement, this study adopts supply chain resistance and recovery as indicators to characterize supply chain resilience, overcoming deficiencies in the existing literature. Additionally, in robustness checks, this study substitutes these indicators to help achieve precise and scientific assessments of supply chain resilience and the impact of intelligent logistics. Thirdly, regarding mechanism pathways, this study delves into and verifies the mechanisms and transmission pathways through which intelligent logistics affect supply chain resilience from three angles: corporate market strategy layout, transaction costs, and supply chain efficiency, deepening the theoretical understanding of the 'black box' between the two.

Against the backdrop of increasing global uncertainty, the resilience and security of supply chains have become a focus for policymakers worldwide. This study not only fills a theoretical gap in the research on the relationship between intelligent logistics and supply chain resilience but also provides practical guidance at the policy level. The application of intelligent logistics has been shown to enhance the supply chain's responsiveness and risk resistance. Specifically, this study holds significant importance in the following areas: Firstly, by analyzing how intelligent logistics enhance supply chain resilience through improving corporate market strategy layout, reducing transaction costs, and increasing supply chain efficiency, this study provides policymakers with scientific evidence and practical recommendations, helping them formulate effective supply chain management and logistics policies to enhance national economic stability and risk resistance. Secondly, this study verifies the impact of intelligent logistics on supply chain resilience by selecting representative samples to ensure the general applicability of the results. The diversity and representativeness of the samples make the findings not only statistically significant but also operational and widely applicable in practice. Lastly, the findings and policy recommendations are not only significant for China but also provide references for other countries and regions. As a key means of enhancing supply chain resilience, the application experiences and research findings of intelligent logistics can be promoted globally, helping countries maintain supply chain stability and security when facing global economic fluctuations and emergencies.

In conclusion, by deeply exploring the mechanisms through which intelligent logistics enhance supply chain resilience, this study not only offers academic innovation and theoretical contributions but also provides valuable guidance for policy and practical applications, laying a solid foundation for further promoting the development of intelligent logistics and enhancing the supply chain's capacity to withstand external shocks. The remainder of this article is organized as follows: Section 2 summarizes prior relevant research. Section 3 introduces the empirical models and methods. Section 4 describes the data used in this study. Section 5 presents and discusses the estimated results. Finally, Section 6 concludes and offers some policy recommendations.

2. Literature review

2.1. Current research on supply chain resilience and security

Supply chain resilience and security are critical mechanisms that ensure enterprises' continuous operation and recovery capabilities in the face of external shocks. Lummus and Vokurka (1999) introduced the concept of supply chain management, highlighting the essential role of resilience in maintaining operations when confronted with uncertainties and external disturbances. This resilience is not only crucial for maintaining operations but also forms the foundation for creating long-term value (Guo et al., 2023). As global supply chains face increasingly complex challenges, the importance of supply chain resilience and security has become more pronounced (Teng & Lin, 2024). However, there remains a gap in the literature regarding the relationship between these two concepts, especially in the context of specific industries. Under the conditions of globalization and complex supply chain systems, resilience and security are closely related, although their focal points may differ in certain scenarios (Hussain et al., 2023). Thus, the integration of resilience and security mechanisms in enhancing supply chain performance remains a key challenge for both academia and industry.

2.2. The connection between Intelligent Logistics and supply chain resilience

Intelligent logistics, as an emerging technology and innovative management model, has shown significant potential in enhancing supply chain resilience. While supply chain adaptability has been discussed in the literature (Winkelhaus & Grosse, 2020; Gölgeci & Kuivalainen, 2020; Tokito et al., 2023), where resilience depends on the ability of firms to reorganize resources and optimize processes in response to external shocks, the role of Intelligent Logistics in this process has not been fully studied. Through empirical analysis, this article reveals for the first time the critical role of Intelligent Logistics in the fashion apparel industry. Specifically, Intelligent Logistics integrates information and logistics activities along the supply chain, accelerating information flow and improving supply chain transparency, thereby enhancing firms' responsiveness and decision-making speed. This capability is particularly crucial when dealing with fluctuations in market demand and changes in the external environment.

Furthermore, Intelligent Logistics enables companies to better adjust and expand their market layouts (Nakandala et al., 2022; Bai et al., 2024). The study finds that by utilizing Intelligent Logistics technologies, companies can not only reduce supply chain operating costs but also rapidly enter new markets. This expanded capability further enhances supply chain flexibility, allowing it to respond more effectively to uncertainties in global markets. Therefore, the role of Intelligent Logistics in improving supply chain resilience in the fashion apparel industry goes beyond technological improvements; it also includes a deep impact on supply chain strategy, offering a new perspective for the application of Intelligent Logistics in various supply chain environments.

2.3. Mechanisms by which Intelligent Logistics improves supply chain efficiency

Supply chain efficiency is one of the key indicators of supply chain resilience (Fahim & Mahadi, 2022; Guo et al., 2023). Improved efficiency not only enhances a supply chain's recovery capabilities but also strengthens a firm's market competitiveness (Tang & Meng, 2021; Liao, 2023). Existing literature (Hosseini et al., 2019; Liu et al., 2020; Shang, 2022; Li et al., 2023) discusses recovery mechanisms in supply chains but provides limited exploration of how logistics technologies directly impact supply chain efficiency. This article addresses this gap by revealing various mechanisms through which Intelligent Logistics improves supply chain efficiency. Firstly, Intelligent Logistics optimizes resource allocation and simplifies operational processes, enabling the supply chain to move goods at lower costs and higher speeds. Intelligent Logistics technologies, such as automated warehousing systems, intelligent transportation, and real-time tracking systems, not only reduce time consumption and human errors inherent in traditional logistics but also improve the accuracy and timeliness of information flow.

Secondly, Intelligent Logistics accelerates product turnover and reduces inventory buildup, thereby improving firms' capital utilization efficiency. Intelligent Logistics systems can analyze market demand in real time and dynamically adjust inventory levels, reducing imbalances between supply and demand caused by information delays. The empirical study conducted in this article demonstrates that these mechanisms significantly enhance supply chain recovery capabilities and provide firms with a more flexible and efficient operational model, which is particularly crucial in the rapidly changing environment of the fashion apparel industry.

Lastly, the widespread adoption of Intelligent Logistics not only reduces transaction costs for firms but also optimizes collaboration efficiency across the supply chain. With Intelligent Logistics technologies, information within the supply chain becomes more transparent, and inter-firm collaboration becomes more seamless, thereby reducing information asymmetries and friction costs within the supply chain. Through empirical data, this article verifies the effectiveness of Intelligent Logistics in improving overall supply chain efficiency and resilience to external shocks. These findings provide policymakers and companies with a concrete framework to demonstrate how Intelligent Logistics technologies can enhance both the resilience and efficiency of supply chains.

3. Theoretical analysis and research hypotheses

At present, China is at the junction of a new round of technological revolution, industrial transformation, and supply chain resilience enhancement, facing the triple challenges of incompleteness, instability, and lack of robustness in supply chain construction. Disruption has become a significant constraint hindering the improvement of supply chain resilience (Guo et al., 2024). It is evident that the enhancement of supply chain resilience in China needs to adjust from resisting 'disruption' and quickly recovering from it. Traditional logistics, through packaging, transportation, warehousing, loading and unloading, processing, and distribution, delivers products from upstream to downstream of the supply chain, resulting in a long product turnover cycle. This leads to asymmetry between the final product and rapidly changing personalized market demand, causing unstable supply and demand relationships in the market and thus affecting the resilience and security of the supply chain. Intelligent logistics provides a new approach for overcoming this dilemma. Compared with traditional logistics, intelligent logistics can not only shorten the product turnover cycle through typical scenarios such as 'Internet + efficient transportation', 'Internet + intelligent warehousing', 'Internet + convenient distribution', and 'Internet + smart terminals' (Tang & Veelenturf, 2019) but also enhance the functionality of logistics platforms, promoting the docking of bilateral markets between upstream and downstream enterprises in the supply chain and reducing the asymmetry of information in the supply chain. Specifically, intelligent logistics may drive the resilience of the supply chain through the following channels. First, intelligent logistics can break the spatial and temporal restrictions of the chain domain and region, expand the strategic market layout of enterprises, thereby strengthening the supply chain's 'extending chain' and 'supplementing chain' capabilities and promoting supply chain resilience. Second, intelligent logistics helps to alleviate the degree of information asymmetry faced by enterprises and reduce transportation costs, improve transaction costs, thereby optimizing cooperation and collaboration between upstream and downstream enterprises in the supply chain and enhancing supply chain resilience. Third, intelligent logistics can promote the circulation speed of products and funds, improve the efficiency of the supply chain, help to enhance trade between upstream and downstream enterprises in the supply chain, and improve supply chain resilience. Following this, the article analyses the mechanism through which intelligent logistics improve supply chain resilience through these three channels.

First, from the perspective of market strategic layout, previous research has indicated that strengthening a supply chain's 'extending chain' and 'supplementing chain' capabilities is an important means to improve supply chain resilience (Xu et al., 2022). The improvement of the supply chain's 'extending chain' and 'supplementing chain' capabilities usually manifests as the expansion of enterprises' market scope and an increase in potential partners, i.e. the expansion of the strategic layout of the enterprise market. Theoretically, intelligent logistics can expand the strategic layout of the enterprise market in three ways. First, intelligent logistics is beneficial for weakening the external information constraints between upstream and downstream enterprises in the supply chain. As profit-oriented organizations, enterprises typically aspire to access broader markets and consumer groups. Constrained by the blockage of information flow in traditional logistics, opportunities for enterprises to explore markets in other regions and to discover new users are limited, with long distances causing asymmetry of information and low efficiency in information transmission, leading to fleeting cooperative opportunities between enterprises in the supply chain; however, intelligent logistics, through logistics platforms for sharing information, effectively mitigates the isolation of information among supply chain node enterprises and breaks spatial and temporal constraints, further promoting the flow of information throughout the entire supply chain and thereby enhancing node enterprises' awareness of market demand. Therefore, intelligent logistics can optimize the information environment between upstream and downstream enterprises in the supply chain (Goldfarb & Tucker, 2019), facilitating trade cooperation beyond distance barriers. Second, intelligent logistics are conducive to broadening enterprises' sales channels. The logistics platforms fostered by intelligent logistics drive the transformation of the supply chain from enterprise-led to platform ecosystem-led; that is, the business model of the supply chain evolves from closed collaboration to open cocreation (Akbari & Hopkins, 2022; Kamble et al., 2022; Bak et al., 2023), increasing the number of potential partners between upstream and downstream enterprises, which is beneficial for broadening enterprises' sales channels. Intelligent logistics also helps in leveraging the platform to search for international customer information and lower the threshold for exports, achieving the alignment of rules between domestic and international markets and further expanding enterprise sales channels to the international market (Han & Wang, 2022). Finally, intelligent logistics is advantageous for enterprises focusing on the 'long tail market'. By utilizing digital analysis technology, intelligent logistics effectively penetrates the hidden and volatile characteristics of real customer demands by conveying information through logistics platforms, allowing enterprises to finely segment and accurately grasp customer needs (Lumpkin & Dess, 2004).

Second, in terms of transaction cost, which is an important factor affecting cooperative collaboration between firms upstream and downstream of the supply chain (Lv & Shang, 2023; Farooque et al., 2022), collaborative collaboration fosters joint decision-making and business trust between firms and reduces uncertainty in business cooperation, thus enhancing supply chain resilience. For firms, Intelligent Logistics can reduce transaction costs by lowering information asymmetry and transport costs (Goldfarb & Tucker, 2019). On the one hand, upstream supply chain firms need to incur search costs in detecting market demand, and downstream firms need to find suitable suppliers. With the help of digital technology, Intelligent Logistics can fully understand the creditworthiness of upstream and downstream enterprises in the supply chain, and enterprises can flexibly adjust the transaction details according to the market situation, thus reducing their search costs (Lin & Teng, 2024). Even after business cooperation between upstream and downstream enterprises in the supply chain, they still need to pay the costs of signing, communication and supervision, and if one party fails to fulfill the terms of the contract, they still need to pay the costs of breaching the contract or the costs of looking for other business partners in exchange. Intelligent logistics can integrate supply and demand information in the supply chain, and enterprises can not only choose business partners through the logistics platform but also compare potential counterparts, which helps upstream and downstream enterprises in the supply chain adapt and screen their business partners and effectively reduces the probability of entering into contracts with enterprises that may default on their contracts or engage in opportunistic behaviors (Li et al., 2022) and further reduces transaction costs. This further reduces transaction costs. On the other hand, transport cost is an important component of the transaction cost of enterprises; enterprises will comprehensively consider the trade cost when choosing suppliers (Huang et al., 2023), and high and long-distance transport costs will reduce the willingness of enterprises to cooperate. The traditional logistics model is limited by the lack of digital, intelligent, and networked capabilities, and transport costs remain high, whereas intelligent logistics supports the supervision and management and optimization of the entire life cycle of product circulation (packaging, transportation, warehousing, loading and unloading, processing and distribution, and information services) in a highly flexible and integrated manner, improving the resource allocation efficiency of the logistics industry and effectively lowering the transaction costs faced by enterprises. For example, vehicleless carriers and driverless technologies are used in transport links, and automatic handling technologies such as automated guided vehicles (AGVs) and autonomous mobile robots (AMRs) are used in warehousing links (Cohen et al., 2022).

Third, in terms of supply chain efficiency, which is reflected in the frequent trade exchanges between firms upstream and downstream of the supply chain, the improvement of supply chain efficiency enables firms to integrate more deeply into the supply chain trade network, strengthens the synergistic relationship between firms in the supply chain, and thus improves supply chain resilience (Huang et al., 2022). Theoretically, Intelligent Logistics can significantly reduce the number of days of capital turnover and inventory turnover and improve the efficiency of the supply chain because, on the one hand, the information effect of Intelligent Logistics causes upstream and downstream enterprises in the supply chain to gradually form an interconnected supply chain ecosystem (Liao, 2023) and promotes the relationship between upstream and downstream enterprises in the supply chain to change from 'one-way dependence' to 'two-way dependence' (Liao, 2023). 'This kind of business cooperation greatly reduces the possibility of early delivery, late collection', accelerates the speed of capital exchange between the upstream and downstream of the supply chain, and the resulting continuous cash flow is conducive to reducing the number of days of capital turnover (Liao, 2023) and reducing the number of days of capital turnover (Liao, 2023). The resulting sustained cash flow is conducive to shortening the number of working days (Nakandala et al., 2022). In addition, the online trading function of Intelligent Logistics provides a virtual trading platform for both upstream and downstream enterprises in the supply chain, which is conducive to standardizing trading operations and accelerating the turnover speed of the enterprise's capital chain, thus improving the efficiency of the supply chain. On the other hand, in terms of smooth product circulation in the supply chain, traditional logistics are confined by the lack of intelligent scenarios and the low degree of rationalization of transport structures, resulting in low product circulation efficiency. In this scenario, enterprises often face the problem of inventory accumulation, which leads to inefficiency in the supply chain. The emergence of Intelligent Logistics not only increases the reserve of intelligent facilities in logistics links and improves the operational efficiency of core links but also realizes the integration of intermodal transport through the whole process by comprehensively utilizing road, railway and water transport modes to improve the efficiency of different logistics links and effectively reduce the number of days of inventory turnover of enterprises. Intelligent logistics can also provide auxiliary decision-making functions for the forecasting, planning and program evaluation of enterprise inventory management through an integrated information platform, which can further optimize enterprise inventory management and improve the efficiency of the supply chain (Yin & Ran, 2022).

Based on the above analysis, this article proposes the following hypotheses.

Hypothesis 1: Intelligent logistics can effectively improve supply chain resilience.

Hypothesis 2: Intelligent logistics can improve supply chain resilience by expanding the strategic layout of the enterprise market.

Hypothesis 3: Intelligent logistics can improve supply chain resilience by reducing enterprise transaction costs.

Hypothesis 4: Intelligent logistics can improve supply chain resilience by enhancing supply chain efficiency.

The theoretical framework of this article is shown in Figure 1.

4. Research design

4.1. Model and variable definition

The core aim of this article is to identify the effect of Intelligent Logistics on supply chain resilience; therefore, the proposed basic econometric model is set as follows:

$$Resil_{ijt} = \alpha_0 + \alpha_1 IL_{ijt} + X_{control}\alpha_2 + C_i + \lambda_t + \varepsilon_{ijt}$$

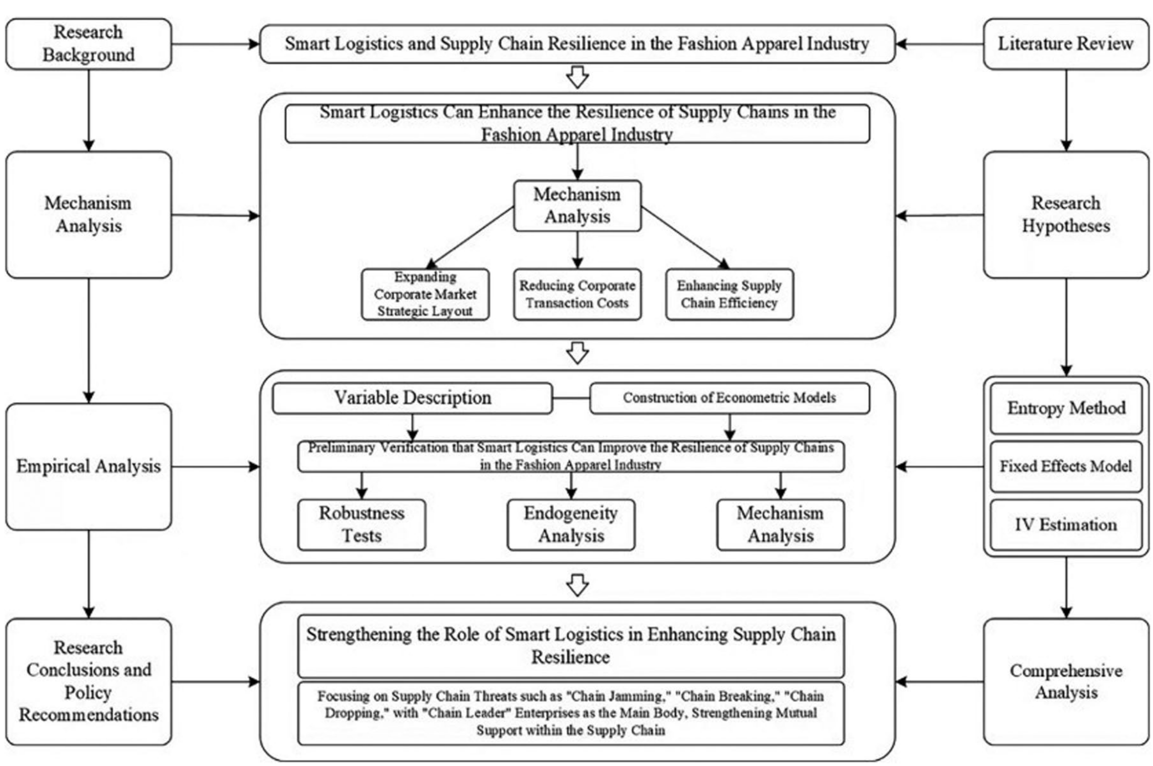

Figure 1. Technology roadmap.

where the subscripts i, j, and t are the city, enterprise and year, respectively. $Resil_{ijt}$ denotes the level of supply chain resilience, which is decomposed into two variables—supply chain resistance (Resis) and supply chain resilience (Recov)—in this article. IL_{ijt} represents the level of regional logistics intelligence development, α_1 is the coefficient of the core explanatory variable of focus, $X_{control}$ represents the set of control variables, C_i and λ_t represent the individual and year fixed effects, respectively, and ε_{ijt} represents the random error term.

4.1.1. Explanatory variables

The word 'Resilience' is derived from the Latin word 'Resilire', which is translated as 'return to the original state' and indicates the ability of a system to recover from an external perturbation. Resilience is the ability of a system to recover after an external perturbation. Based on the definition of resilience, this article divides supply chain resilience into two dimensions: supply chain resistance, which represents the ability of the supply chain to resist external shocks, and supply chain resilience, which represents the ability of the supply chain to recover after being hit by external shocks.

1. Supply chain resistance (Resis). Supply resistance reflects the stability of the cooperative relationship between upstream and downstream enterprises in the supply chain; that is, in the face of external perturbations, enterprises can still maintain collaborative relationships. In this article, we use the number of stable customers/5 of the top five customers to characterize supply chain resistance. Take $f_{it}(i,c_j)$ to denote whether there exists a supply relationship between enterprise i and customer c_j (j = 1, 2…, 5) in year t. If there exists, then $f_{it}(i,c_j)$ = 1, and vice versa, is 0. Take $f_{it-1}(i,c_j)$ to denote the supply relationship between enterprise i and customer c_j in year $t-1$. If there exists, then $f_{it-1}(i,c_j)$ = 1, and vice versa 0; using $F_{it}\left(i,c_j\right)=f_{it}(i,c_j)\times f_{it-1}(i,c_j)$) to indicate whether there is a stable supply relationship between firm i and customer c_j in year t, if $F_{it}\left(i,c_j\right)$ = 1, it means that there is a stable supply relationship between firm i and customer c_j in year t, and vice versa. exists. Based on the above definition of the firm-customer supply relationship, this article proposes adopting the following method to reflect the composite value of the stable relationship between firm i and its top five customers.

$$Rsis_{it} = \sum_{j=1}^{5} \frac{F_{it}\left(i,c_j\right)}{5}$$

1. When Resis∈[0,1], the larger the value is, the stronger the resistance of the supply chain.
2. Supply chain resilience (Recov). Supply chain resilience reflects the rebound ability of upstream and downstream enterprises in the supply chain to deviate from the original operation trajectory when they are hit by external shocks, and they can even achieve chain upgrading by 'responding to changes and taking advantage of the situation'; thus, the degree of 'deviation' of enterprise performance can reflect the resilience of the supply chain after being hit by shocks. Therefore, the degree of 'deviation' of enterprise performance can reflect the resilience of the supply chain after it is hit. In this article, we construct the following econometric model, using the residuals (the difference between the actual observed value and the estimated value) to capture the changes and responses of the economic performance of enterprises when they are subjected to external perturbations in different periods; the larger the value is, the stronger the supply chain resilience is, and the weaker it is.

$$Performance_{it} = \beta_0 + \beta_1 IL_{ijt} + X_{control}\beta_2 + C_i + \lambda_t + \varepsilon_{ijt}$$

Performance represents the business performance of the firm, which is measured by the ratio of EBITDA to the number of employees. A series of control variables related to firm performance are added to the model, including firm size, firm age, leverage, board size, and the proportion of independent directors (Indpe).

4.1.2. Core explanatory variables

The core explanatory variable is intelligent logistics (IL). In this article, we construct an evaluation index system for logistics intelligentization from the three dimensions of development impetus, development environment and development benefit (Table 1), and we propose the use of the entropy power method to measure the development level of logistics intelligentization in China's prefecture-level cities. The environmental development index under the dimension of environmental benefits is measured by the entropy weight method for the three indicators of industrial sulfur dioxide emissions, industrial wastewater emissions, and industrial soot emissions.

4.2. Sample selection and data sources

This study uses data from 270 prefecture-level cities in China and A-share listed fashion apparel companies from 2008 to 2021 as the initial research sample to systematically explore the impact of intelligent logistics on supply chain resilience in the fashion apparel industry and its underlying mechanisms. The data is sourced from two levels: city-level and company-level. City-level data comes from the 'China City Statistical Yearbook', published by the National Bureau of Statistics of China, which includes detailed statistical information on the economic, social, and infrastructure aspects of each prefecture-level city. During data extraction, we ensured that all indicators were processed according to a consistent standard to ensure comparability. Additionally, missing data were addressed using linear interpolation to minimize the impact of incomplete data on the model's results. Company-level data is sourced from the Cathay Pacific database (CSMAR), which contains detailed financial information, market performance, shareholder structure, and other relevant data of A-share listed companies in China. From this, we extracted financial and operational data for all A-share listed fashion apparel companies and processed it as follows: (i) excluding companies marked as 'ST' or '*ST' during the sample period, as well as delisted companies, to ensure the robustness of the research sample; (ii) excluding samples with missing values in the regression analysis to ensure data completeness; and (iii) applying 1% bilateral shrinkage (Winsorize) to the main continuous variables to reduce the influence of outliers on the results.

During the data collection process, several potential biases may arise: firstly, differences in reporting standards across cities and companies, particularly in earlier years when some indicators may not have been collected according to uniform standards. Secondly, data from certain cities may be incomplete or missing, especially for more remote areas, which could lead to a geographical bias towards more developed regions. Thirdly, using data from listed companies may introduce sample selection bias, as these

Table 1. Entropy method.

First-level indicator	Second-level indicator	Third-level indicator	Attribute
Development momentum	Technological advancement	Number of patents in the logistics industry	+
		Proportion of science and technology expenditure in fiscal expenditure	+
	Human capital	Proportion of logistics industry employees × higher education population	+
		Ratio of education expenditure to fiscal expenditure	+
Development environment	Structural optimization	Ratio of education expenditure to fiscal expenditure	+
		Proportion of added value in logistics industry to regional GDP	+
	Trade environment	Ratio of total imports and exports to regional GDP	+
		Ratio of actual foreign investment to regional GDP	+
	Infrastructure	Ratio of Highway Mileage to Area Size	+
		End of the Year Post Office	+
		Proportion of Fixed Asset Investment in Regional GDP	+
Development benefits	Smart applications	logistics industry revenue× (number of internet broadband access users/GDP)	+
		number of internet broadband access users	+
		Number of mobile phone users at the end of the year	+
	Overall benefits	Total freight volume	+
		The ratio of postal service revenue to total population	+
		The ratio of logistics industry revenue to total population	+
		(Current year logistics industry revenue − last year logistics industry revenue)/last year logistics industry revenue	+
	Environmental benefits	Environmental Pollution Index	−

companies are typically larger and better governed, meaning the results may not fully represent smaller firms. Future research can further investigate the potential biases identified in this study.

5. Empirical results and analyses

5.1. Benchmark regression analysis

Figure 2 and Table 2 reports the results of the benchmark regression. Columns (1) and (2) include individual, industry, region and province fixed effects, while columns (3) and (4) add time fixed effects. In columns (1) and (2), the estimated coefficients of variable IL are 0.0237 and 0.0554 and are significant at the 10% and 1% levels, respectively, which initially suggests that Intelligent Logistics can promote supply chain resistance and supply chain resilience. In columns (3) and (4), the coefficient estimates of the core explanatory variable IL are still significantly positive, which again confirms the positive effect of Intelligent Logistics on supply chain resistance and supply chain resilience. The above findings validate hypothesis 1 of this article that Intelligent Logistics can effectively improve supply chain resilience.

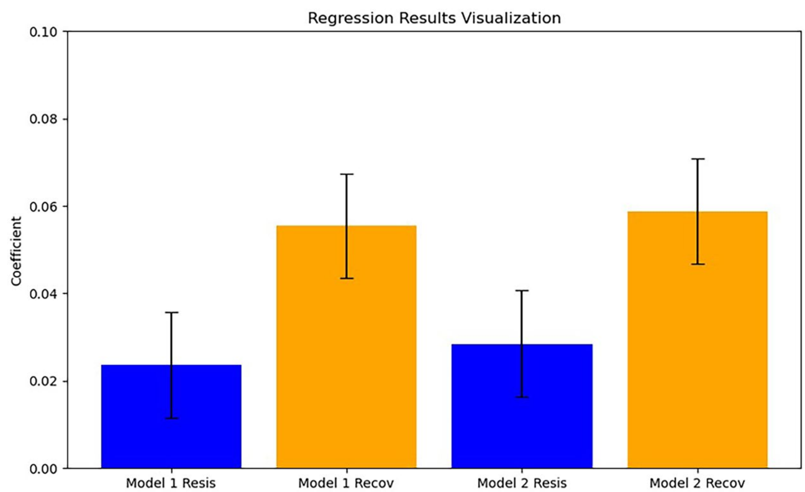

Figure 2. Benchmark regression analysis.

Table 2. Base regression.

	(1)	(2)	(3)	(4)
	Resis	Recov	Resis	Recov
IL	0.0237*	0.0554***	0.0285**	0.0588***
	[1.9590]	[4.6592]	[2.3152]	[4.8625]
Size	0.0308*	0.0946***	0.0946***	0.0962***
	[2.1618]	[3.2502]	[8.1074]	[8.1633]
Age	−0.0014	0.0384	0.0384***	0.0400***
	[−0.0794]	[1.6495]	[2.6569]	[2.7359]
Lev	−0.0060	−0.0063	−0.0063	−0.0057
	[−0.5542]	[−0.7178]	[−0.7882]	[−0.7062]
Board	0.0112	0.0426*	0.0426**	0.0392**
	[0.4419]	[1.8333]	[2.2610]	[2.0614]
Indpe	0.0297*	0.0351**	0.0351***	0.0333***
	[2.0886]	[2.4741]	[3.2458]	[3.0639]
_cons	−0.0021	−0.0061	−0.0253***	−0.0257***
	[−0.1797]	[−0.6509]	[−4.1684]	[−4.2272]
r2	0.1864	0.1930	0.1898	0.1959
F	3.6581	16.4437	3.4756	16.4507
p	0.0006	0.0000	0.0010	0.0000
Control	YES	YES	YES	YES
Code	YES	YES	YES	YES
Ind	YES	YES	YES	YES
City	YES	YES	YES	YES
Pro	YES	YES	YES	YES
Year	NO	NO	YES	YES

t statistics in brackets.
*$p<0.1$, **$p<0.05$, ***$p<0.01$.

5.2. Endogeneity issues

The research in this article may have an endogeneity problem. Although the level of regional logistics intelligence development is an exogenous variable, the choice of business partners of enterprises in the supply chain may be endogenous because the level of logistics intelligence development in the region where the enterprise is located may affect the enterprise's choice of business partners. To overcome the endogeneity problem, this article uses the interaction term between the topographic relief of prefecture-level cities and the time variable (sample time span) as the instrumental variable (IV) for Intelligent Logistics. On the one hand, the greater the topographic relief is, the greater the number of mountain ranges and rivers, the poorer the regional transport and network infrastructure development, and the lower the level of logistics intelligence development in the region. Therefore, there should be a significant negative correlation between the degree of topographic relief and Intelligent Logistics, while the degree of topographic relief, as a naturally occurring geographic condition in the history of the region, usually exists objectively and is not directly related to supply chain resilience to satisfy exogenous conditions. Thus, terrain relief is a reasonable instrumental variable. Table 3 reports the instrumental variable regression results. Column (1) shows the results of the first-stage regression, where the coefficient estimate of variable IV is negative and passes the test of significance at the 1 percent level, as expected in this article. Columns (2) and (3) show the results of the second-stage regressions, where the coefficient estimates of variable IL are significantly positive at the 5 percent and 1 percent levels, respectively, suggesting that the core findings of the article still hold after the instrumental variables have been treated for endogeneity problems.

5.3. Robustness tests

In this article, we use the number of stable customers/5 of the top five customers to characterize supply chain resistance in the benchmark regression and use the ratio of EBITDA to the number of employees as a corporate performance indicator to measure supply chain resilience. In this section, based on the definition of stable customers in the previous section, the ratio of the sales of stable customers in the top five customers to the total sales of the top five customers is used to characterize supply chain

Table 3. Endogeneity analysis.

	(1)	(2)	(3)
	IL	Resis	Recov
IL		0.0237**	0.0554***
		[2.2084]	[4.8245]
IV	−0.121***		
	[−5.1797]		
Size	0.0929***	0.0308*	0.0946***
	[3.1463]	[2.1618]	[3.2502]
Age	0.0375	−0.0014	0.0384
	[1.5820]	[−0.0794]	[1.6495]
Lev	−0.0070	−0.0060	−0.0063
	[−0.7175]	[−0.5542]	[−0.7178]
Board	0.0421	0.0112	0.0426*
	[1.6671]	[0.4419]	[1.8333]
Indpe	0.0350**	0.0297*	0.0351**
	[2.4921]	[2.0886]	[2.4741]
_cons	−0.0254***	−0.0248***	−0.0253***
	[−8.5450]	[−9.4907]	[−8.8119]
r2	0.1898	0.1864	0.1930
F	3.2181	3.2431	9.4104
p	0.0366	0.0356	0.0005
LM	56. 6612***		
Wald F	78.2578		
Control	YES	YES	YES
Code	YES	YES	YES
Year	YES	YES	YES
Ind	YES	YES	YES
City	YES	YES	YES
Pro	YES	YES	YES

t statistics in brackets.
*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

resistance (Resis2), and the ratio of return on equity (Roe) is used as a corporate performance indicator to measure supply chain resilience (Recov2). Regressing the above remeasured supply chain resistance and supply chain resilience indicators, as shown in columns (1)–(4) of Table 4 and Figure 3, it can be found that the estimated coefficients of the variable IL are significantly positive at least at the 5% level, and the core conclusions of this article are still robust.

5.4. Mechanism test

The previous section verified that Intelligent Logistics can effectively improve supply chain resilience, and this section focuses on verifying how Intelligent Logistics affect supply chain resilience. According to the theoretical deduction in the previous section, Intelligent Logistics can improve supply chain resilience by expanding the strategic layout of the enterprise market, reducing transaction costs and improving the efficiency of the supply chain in three ways.

The specific testing steps are shown in Figure 4.

If a, b, and c′ are significant and ab and c′ have the same sign, then the mediating effect is established.

Table 4. Robustness test.

	(1)	(2)	(3)	(4)
	Resis2	Recov2	Resis2	Recov2
IL	0.0280**	0.0592***	0.0283**	0.0600***
	[2.4410]	[5.0308]	[2.4184]	[4.8444]
Size	0.0278*	0.0941***	0.0273*	0.0929***
	[1.8721]	[3.1349]	[1.7963]	[3.1463]
Age	−0.0015	0.0372	−0.0013	0.0375
	[−0.0856]	[1.5845]	[−0.0668]	[1.5820]
Lev	−0.0048	−0.0058	−0.0055	−0.0070
	[−0.4301]	[−0.6252]	[−0.4651]	[−0.7175]
Board	0.0125	0.0386	0.0142	0.0421
	[0.4410]	[1.5411]	[0.4883]	[1.6671]
Indpe	0.0291*	0.0344**	0.0307**	0.0350**
	[2.0483]	[2.4350]	[2.1805]	[2.4921]
_cons	−0.0248***	−0.0257***	−0.0246***	−0.0254***
	[−8.7772]	[−8.3950]	[−8.5433]	[−8.5450]
r2	0.1906	0.1966	0.1937	0.1993
F	3.0431	11.2249	3.3373	10.0298
p	0.0437	0.0002	0.0325	0.0003
Control	YES	YES	YES	YES
Code	YES	YES	YES	YES
Ind	YES	YES	YES	YES
City	YES	YES	YES	YES
Pro	YES	YES	YES	YES
Year	NO	NO	YES	YES

t statistics in brackets.
*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

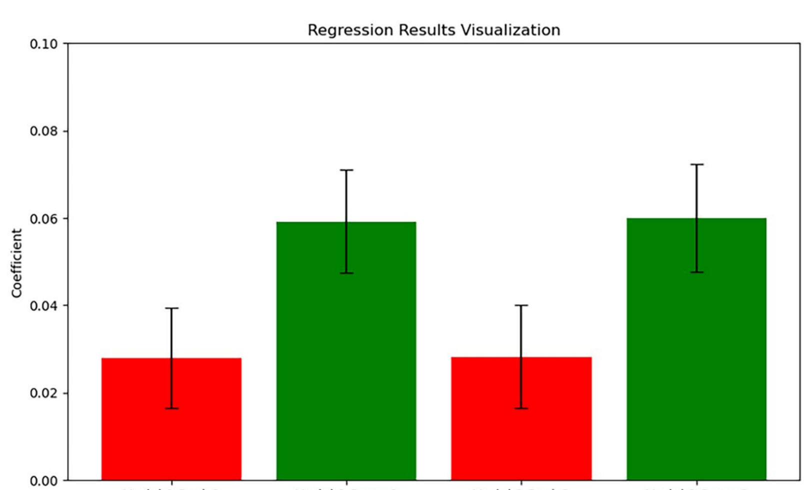

Figure 3. Robustness tests.

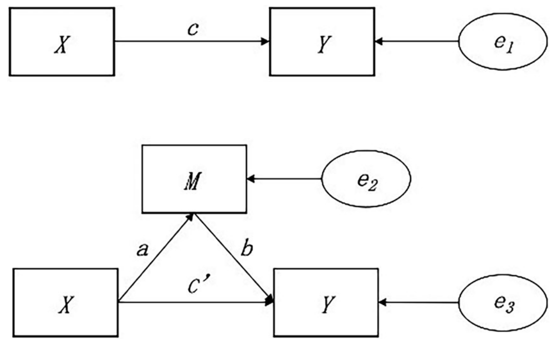

Figure 4. Mediating mechanism test.

Table 5. Mechanism analysis1.

	(1)	(2)	(3)
	Market	Resis	Recov
IL	0.0176***	0.0292**	0.0592***
	[3.2685]	[2.3555]	[4.8499]
Size	−0.0077	0.0287**	0.0947***
	[−1.4626]	[2.3577]	[7.9074]
Age	−0.0312***	−0.0010	0.0400***
	[−4.7565]	[−0.0642]	[2.6919]
Lev	0.0024	−0.0057	−0.0080
	[0.6780]	[−0.6896]	[−0.9793]
Board	0.0428***	0.0120	0.0390**
	[5.0058]	[0.6124]	[2.0178]
Indpe	0.0213***	0.0322***	0.0358***
	[4.3588]	[2.8613]	[3.2345]
Market		0.0326**	0.0291**
		[2.1703]	[1.9741]
_cons	−0.0134***	−0.0237***	−0.0261***
	[−4.9434]	[−3.8079]	[−4.2611]
r2	0.8340	0.1942	0.1996
F	14.9391	4.0465	14.5878
p	0.0000	0.0001	0.0000
Control	YES	YES	YES
Code	YES	YES	YES
Year	YES	YES	YES
Ind	YES	YES	YES
City	YES	YES	YES
Pro	YES	YES	YES

t statistics in brackets.
**p* < 0.1, ***p* < 0.05, ****p* < 0.01.

5.4.1. Market strategy layout channels

Intelligent logistics can overcome the information silos and time and space limitations between upstream and downstream enterprises in the supply chain through the in-depth embedding of digital technology, expanding the scope of trade and sales channels and focusing on the long-tail market. On this basis, the market strategy layout of supply chain node enterprises can be effectively expanded. The expansion of the market strategy means that business cooperation between node enterprises and other enterprises has further deepened. Existing studies show that an increase in the number of partners of supply chain node enterprises can not only strengthen the ability to extend the supply chain but also enhance the ability to supplement the supply chain, which is an important factor in improving the resilience of the supply chain. Market expansion is directly reflected in the rapid growth of sales revenue; therefore, this article adopts the growth rate of sales revenue to characterize the strategic layout of the enterprise's market. According to the regression results reported in column (1) of Table 5, the estimated value of the core variable IL on the mediating coefficient Market is 0.0176, which passes the significance test at the 1% level. Columns (2) and (3) add the mediator variable on the basis of the basic regression model, and the regression coefficients of the core explanatory variable IL on the explanatory variables Resis and Recov are 0.0292 and 0.0592, respectively. The regression coefficients of the core explanatory variable IL and the explanatory variables Resis and Recov are 0.0292 and 0.0592, respectively, which are significant at the 5% and 1% levels, while the regression coefficients of the mediator variable Market on the explanatory variables Resis and Recov are 0.0326 and 0.0291, respectively, which are both significant at the 5% level. Therefore, expanding the strategic layout of the enterprise market is an important realization channel for Intelligent Logistics to promote supply chain resilience (Figure 5), which is consistent with the expected results of hypothesis 2.

5.4.2. Transaction cost channel

Intelligent logistics can rely on the empowerment of digitalization and intelligence in the logistics industry to reduce the transaction costs faced by enterprises, such as search costs, signing costs, communication costs, supervision costs, and transport costs. A reduction in transaction costs can not only increase the opportunities for cooperation between enterprises and their business partners but also help enterprises establish cooperation with enterprises with wider geographic distances in the supply chain and expand the supply chain trade network to enhance supply chain resilience. Supply chain resilience. According to the literature, firms with higher asset specialization are prone to 'bargaining' by counterparties, and thus, higher asset specialization usually implies that firms face higher external transaction costs. In this article, asset specificity is characterized by the ratio of intangible assets to total assets. Column (1) of Table 6 shows that Intelligent Logistics can significantly reduce asset specificity, and the regression coefficients of the variable IL on Resis and Recov in columns (2) and (3) are 0.0339 and 0.0676 and are significant at the 1% level, respectively; the regression coefficients of the variable Asset on Resis and

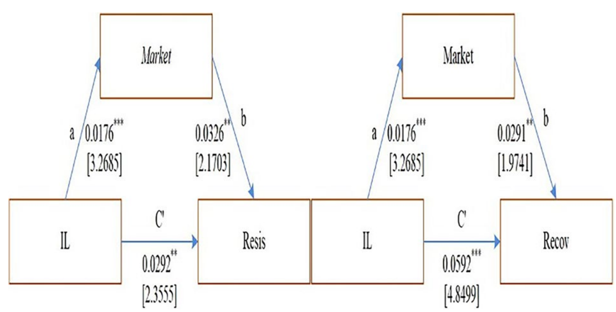

Figure 5. Mechanism analysis1.

Table 6. Mechanism analysis2.

	(1)	(2)	(3)
	Asset	Resis	Recov
IL	−0.0323*	0.0339***	0.0676***
	[−1.6822]	[2.6763]	[3.5606]
Size	0.0517***	−0.0106	0.1306***
	[2.6317]	[−0.9007]	[7.1704]
Age	−0.0246	−0.0067	0.1002***
	[−0.9668]	[−0.4763]	[4.3721]
Lev	−0.0256*	0.0006	−0.0060
	[−1.8418]	[0.0653]	[−0.5416]
Board	0.0131	0.0600***	0.0720**
	[0.4386]	[5.0221]	[2.0140]
Indpe	0.0071	0.0359***	0.0459***
	[0.4142]	[2.9608]	[2.6389]
Asset		−0.0042***	−0.0112***
		[−5.4811]	[−5.9503]
_cons	−0.0012	−0.0327***	−0.0574***
	[−0.1326]	[−3.6902]	[−5.2954]
r2	0.2638	0.0686	0.2434
F	2.9622	6.4566	10.7202
p	0.0042	0.0000	0.0000
Control	YES	YES	YES
Code	YES	YES	YES
Year	YES	YES	YES
Ind	YES	YES	YES
City	YES	YES	YES
Pro	YES	YES	YES

t statistics in brackets.
$^{*}p<0.1$, $^{**}p<0.05$, $^{***}p<0.01$.

Recov are −0.0042 and −0.0112 and are significant at the 1% level, respectively. The regression coefficients of the variable Asset on Resis and Recov are −0.0042 and −0.0112, respectively, and are significant at the 1% level. This result better verifies the theoretical hypothesis of this article (Figure 6), which indicates that Intelligent Logistics can reduce the transaction costs of enterprises and thus improve the resilience of the supply chain, and Hypothesis 3 is supported by empirical evidence.

5.4.3. Supply chain efficiency channels

Theoretically, Intelligent Logistics is conducive to improving supply chain efficiency by shortening the number of days of capital turnover and inventory turnover, while the improvement of supply chain efficiency implies that the interactions between different node enterprises of the supply chain in producing and distributing specific products or services are more frequent and that the node enterprises can carry out business cooperation more efficiently, which strengthens supply chain cooperation and collaboration and thus improves supply chain resilience. In terms of supply chain efficiency (SCE), studies have used enterprises' inventory of nonfinished goods as an indicator of supply chain efficiency (Huang et al., 2022). However, the efficiency of the supply chain is represented only by the inventory level, which ignores factor mobility among the node enterprises of the supply chain. In this article, supply chain efficiency is further represented by inventory turnover days based on the inventory stock of enterprises, and the algorithm is ln(365/Inventory Turnover Rate). This indicator is chosen mainly for the following two considerations. First, the number of days of inventory turnover effectively overcomes the measurement error of lower supply chain efficiency due to the retention of safety stock by enterprises. To prevent the risk of uncertainty, enterprises will hold a certain amount of safety stock, so it is not the case that the smaller the stock is, the higher the supply chain efficiency. Second, inventory turnover days reflect the frequency of dialog and trade transactions between upstream and downstream enterprises in the supply chain, reflecting supply chain flexibility and responsiveness, and the lower the turnover days are, the faster the inventory can be liquidated, and the higher the efficiency of the supply chain. From the regression results reported in column (1) of Table 7, it can be found that the regression results of the core explanatory variables IL and supply chain efficiency are significantly negative, and the regression coefficients of the variable IL on Resis and Recov in columns (2) and (3) are 0.0610 and 0.0871, respectively, and they are significant at the 1% level; the regression coefficients of the variable SCE on Resis and Recov are −0.0212 and −0.0212 and −0.0211, respectively, and the regression coefficients of the variable SCE on Recov are −0.0212 and −0.0212 and −0.0212, respectively. The regression coefficients of the variable SCE on Resis and Recov are −0.0212 and −0.0125 and are significant at the 10% and 5% levels, respectively, indicating that Intelligent Logistics can effectively shorten the number of days of inventory turnover of enterprises, improve the efficiency of the supply chain, and promote the resilience of the supply chain to enhance the results, which is consistent with the expected results of hypothesis 4 (Figure 7).

6. Conclusions and policy implications

Enhancing supply chain resilience and security is the foundation of a sound national economic cycle and is also an inevitable requirement for ensuring long-term stable and high-quality economic and social development. This article empirically analyzes the impact and mechanisms of Intelligent Logistics on

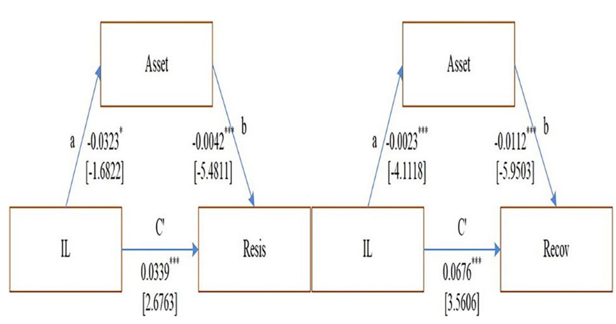

Figure 6. Mechanism analysis2.

Table 7. Analysis of mechanisms3.

	(1)	(2)	(3)
	SCE	Resis	Recov
IL	−0.0023***	0.0610***	0.0871***
	[−4.1118]	[3.2810]	[4.7098]
Size	0.0963***	0.0041	0.0741***
	[4.4645]	[0.2182]	[3.9327]
Age	0.0621**	−0.0289	0.0354
	[2.3670]	[−1.1299]	[1.3866]
Lev	0.0017	0.0088	−0.0000
	[0.1583]	[0.7052]	[−0.0002]
Board	−0.0409	0.0510	0.0904**
	[−1.2749]	[1.3498]	[2.4061]
Indpe	0.0273*	0.0330*	0.0598***
	[1.6711]	[1.6870]	[3.0718]
SCE		−0.0212*	−0.0125**
		[−1.8480]	[−2.4995]
_cons	−0.0045	0.0092	−0.0744***
	[−0.3724]	[0.5728]	[−4.6596]
r2	0.2373	0.2291	0.2171
F	3.7615	3.2656	7.7960
p	0.0005	0.0018	0.0000
Control	YES	YES	YES
Code	YES	YES	YES
Year	YES	YES	YES
Ind	YES	YES	YES
City	YES	YES	YES
Pro	YES	YES	YES

t statistics in brackets.
*$p<0.1$, **$p<0.05$, ***$p<0.01$.

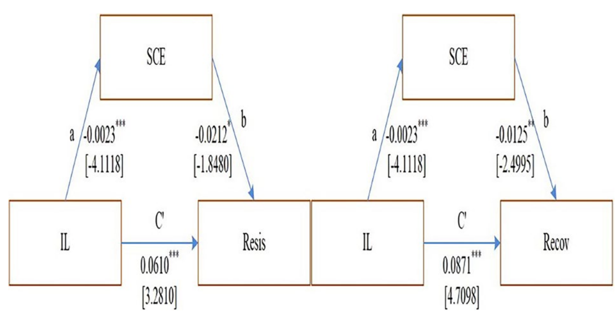

Figure 7. Analysis of mechanisms3.

supply chain resilience based on data from Chinese prefecture-level cities and A-share listed fashion apparel companies from 2008 to 2021. The study finds that Intelligent Logistics helps promote supply chain resistance and resilience, meaning that Intelligent Logistics can improve supply chain resilience, and the core conclusions remain valid after applying the instrumental variable method and robustness testing using substitute variables. The mechanism test shows that Intelligent Logistics can improve supply chain resilience by expanding the strategic layout of enterprises, reducing transaction costs, and improving supply chain efficiency. This research provides important practical significance and policy implications on how to enhance supply chain resilience in the context of the urgent need to improve supply chain resilience and industrial chain security.

In the current context of global economic challenges, the role of Intelligent Logistics in enhancing supply chain resilience has become increasingly prominent. Therefore, policymakers are advised to make the application of Intelligent Logistics a core focus of the smart transformation policy in the logistics industry. Specific measures could include the following: First, strengthen the construction of security systems in product circulation processes. Policies should promote the linkage between logistics enterprises and security inspection departments to establish information-sharing mechanisms, particularly regarding the safety of transported goods, ensuring transparency and security during the circulation of goods. Enterprises should be encouraged to widely apply cutting-edge technologies such as the Internet of Things (IoT), cloud computing, and big data to monitor the flow of products in real-time, predict, and warn of potential delays and interruptions at each supply chain node. For example, establishing standardized digital security monitoring systems can ensure the security of critical supply chain nodes, thereby reducing the risk of supply chain disruptions.

Next, build supply-demand coordination platforms. The government should actively support the development and implementation of industry-level supply chain coordination platforms to help enterprises achieve supply chain security information sharing and resource coordination, breaking down the information silos among node enterprises. For instance, a digital platform can be used to connect supply and demand and provide real-time data analysis and forecasting to help businesses quickly adjust supply chain processes, lower risks, and optimize efficiency.

In addition, policies should encourage investment in big data technology to create data-driven supply chain management systems. By analyzing real-time data on consumer behavior, market demand, and logistics processes, enterprises can accurately predict market changes and promptly adjust supply chain strategies. Public-private partnerships can be leveraged to establish regional or industry-wide big data platforms that help businesses achieve efficient supply chain management at the lowest cost, meeting the increasingly diverse needs of consumers. Furthermore, policies should guide enterprises to take advantage of their geographical proximity to consumption hubs, optimizing inventory management and logistics scheduling, allowing quick responses to demand, and ensuring that upstream and downstream enterprises can access and process key market information, thereby enhancing the flexibility and responsiveness of the entire supply chain.

Issues such as 'stuck chains', 'broken chains', and 'dropped chains' are significant threats to improving supply chain resilience. To address these challenges, it is recommended to focus on 'chain master' enterprises and adopt the following strategies to strengthen mutual support within the supply chain. First, cultivate the leadership role of 'chain master' enterprises. Policies should prioritize supporting these companies as they typically have stronger resource allocation and technological innovation capabilities, enabling them to coordinate and drive upstream and downstream enterprises. The government should provide policy incentives (such as tax benefits and technical subsidies) to support 'chain master' enterprises in integrating small and medium-sized enterprises into the supply chain, encouraging collaboration among large, medium, and small enterprises. For promising 'chain master' enterprises, specific funding and technical support should be provided to enhance their leading position within the supply chain.

Promote the integration of 'specialized, special new', 'single champion', and 'hidden champion' enterprises into the chain. The government should encourage more of these enterprises to join the supply chains led by 'chain master' companies. By enhancing their core technical capabilities and collaborative innovation, these companies can further strengthen supply chain resilience. Policymakers can develop targeted action plans for these companies, clearly outlining the standards for integrating into supply chains and offering appropriate financing and technical support.

Establish digital supply chain alliances. Digital transformation is the future trend within existing supply chains. The government is advised to promote the creation of digital supply chain alliances centered around 'chain master' enterprises, using digital tools (such as blockchain technology, artificial intelligence, and big data) to connect upstream and downstream supply chain enterprises, optimizing resource allocation and enhancing collaboration efficiency. For example, by integrating real-time information from different nodes within the supply chain via a digital platform, information asymmetry can be reduced, and overall supply chain collaboration and transparency can be improved. The government can provide specific funding to support digital transformation, driving the intelligent modernization of industrial supply chains.

Lastly, policymakers should map key supply chain links. For iconic and specialized industrial supply chains, governments should draw 'key link maps' and attract appropriate enterprises to fill gaps and strengthen supply chains through precise investment attraction. For example, policies can focus on certain weak links in the supply chain, particularly in the supply of critical materials or technologies, actively strengthening those areas to achieve sustainable supply chain development.

By implementing these measures, the government can effectively promote collaboration between 'chain master' enterprises and small and medium-sized businesses, reinforcing supply chain resilience and flexibility while driving the long-term stability and efficiency of supply chains.

6.1. Limitations and future research

Although this study provides meaningful insights into how Intelligent Logistics enhances supply chain resilience in the fashion apparel industry, it has some limitations and areas for improvement. First, the research is primarily based on data from Chinese prefecture-level cities and A-share listed fashion apparel companies from 2008 to 2021. While this data reflects the Chinese market, geographic and industry limitations may introduce sample bias. Incomplete data from some cities, especially in remote areas, may cause regional bias. Additionally, the reliance on A-share listed companies may lead to sample selection bias, potentially failing to fully represent small and medium-sized enterprises. Although we applied data filtering and Winsorization techniques to mitigate these issues, they may not entirely eliminate the biases.

Future research should expand the data sample to include more non-listed companies and data from other countries and regions to verify the broad applicability of Intelligent Logistics in enhancing supply chain resilience. Cross-industry studies are also important for exploring the effects of Intelligent Logistics in other sectors, such as manufacturing or high-tech industries, to gain a comprehensive understanding of its role in different supply chain environments.

Furthermore, future research can refine the application scenarios of Intelligent Logistics, examining the differences in adoption depth and breadth among various types and sizes of enterprises to more accurately assess its impact on supply chain resilience and efficiency. As this study is conducted within China's specific policy and market environment, future research should consider how different policy frameworks affect the implementation of Intelligent Logistics. Particularly in the context of globalization and increasing supply chain challenges, cross-national comparisons will provide more actionable insights for policymakers.

Finally, combining real-time updates from big data and emerging technologies will improve data accuracy and breadth, enhancing the reliability and applicability of research findings. By further expanding sample ranges, conducting cross-industry analysis, and validating findings under different policy environments, future research can provide broader theoretical support and practical guidance on how Intelligent Logistics can enhance supply chain resilience.

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Authors' contributions

There authors were involved in the conception, design and selection of the topic for this study. Mr. Junjie Cai and Dr. Ismawati Sharkawi were responsible for the preparation of the material, data collection and preliminary analyses. Dr. Ismawati Sharkawi, Dr. Shairil Izwan Taasim were responsible for the planning and supervision of the research topic. The manuscript was drafted by Mr. Junjie Cai, Dr. Ismawati Sharkawi and Dr. Shairil Izwan Taasim provided comments and edits. Three of authors read and approved the final manuscript.

Availability of data

The data and related materials covered in this article are in the supporting documents. Data available on reasonable request from the corresponding author Mr. Junjie Cai.

Disclosure statement

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