

Article

Key Factors Influencing the Operation of Logistics Companies in Self-Operation and Outsourcing Cooperation Mode: An LDA-TISM-SNA Approach

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Abstract

The self-operation and outsourcing cooperation mode has become an important approach for logistics companies to cope with demand fluctuations and resource constraints. However, the hierarchical mechanisms and network characteristics of the factors driving the development of logistics companies in this cooperative mode remain underexplored. A three-stage analytical framework integrating Latent Dirichlet Allocation (LDA), Total Interpretive Structural Modeling (TISM), and Social Network Analysis (SNA) was developed in this study to systematically identify core influencing factors and reveal their interactive structural relationships. The results reveal seven key determinants of enterprise development: the resource management level, the logistics service level, market competition, the outsourcing service level, risk factors, operational costs, and sustainability benefits. The quantitative SNA results demonstrate that operational costs achieve the highest point centrality value of 83.333, acting as the most direct and core outcome factor in the influence network. By contrast, the resource management level, the logistics service level, market competition, and the outsourcing service level are the fundamental root factors of the entire influencing system and generate prominent spillover effects. Accordingly, logistics companies should prioritize refined cost control while enhancing resource integration, service capacity cultivation, and outsourcing management to improve operational resilience and sustainable competitive advantages. This study not only deepens theoretical understanding of the hybrid self-operation and outsourcing operation mode but also provides targeted practical guidance for the transformation, upgrading, and high-quality development of modern logistics companies.

Keywords: self-operation; outsourcing; influencing factors; latent Dirichlet allocation; social network analysis; logistics companies



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1. Introduction

In recent years, propelled by the rise of shared logistics, the self-operation and outsourcing cooperation mode has emerged as a new strategy driving the development of the logistics industry. Logistics companies are entrusting a portion of their logistics tasks, previously handled through in-house systems, to resource service providers rather than internally managing the entire process of logistics operations [1,2]. Amidst the rapidly evolving environment, logistics companies must leverage self-operation and outsourcing cooperation to establish resilient internal and external networks, enabling continual enhancement. This mode manifests across diverse domains, including manufacturing [3,4],

healthcare [5–7], and transportation [8,9]. In the Asia–Pacific region, Western Europe, and the United States, an increasing number of logistics companies have gained outsourcing experience. Companies such as UPS, Kuehne + Nagel, XPO Logistics, DHL, Deppon, SF Express, STO Express, and YTO Express have implemented various degrees of collaboration between self-operation and outsourcing models.

The services provided by logistics companies across multiple domains, including economics [10,11], resources [12], society [13], and industry and transportation [14], represent a complex system engineering endeavor. Consequently, the operational advancement of logistics companies in the self-operation and outsourcing cooperation mode is inevitably influenced by a myriad of factors originating from various domains [15,16]. Hence, in the specific implementation, the following issues are raised:

RQ1: *What are the factors influencing the operational development of logistics companies within the self-managed and outsourced cooperation models?*

RQ2: *What are the interrelationships between these key factors? What are the most fundamental factors?*

RQ3: *What are the positions and relative importance of the various influencing factors?*

Addressing these questions can assist decision-makers in prioritizing the control of key driving factors, grasping critical aspects in enhancing their developmental progress, and thereby reducing economic costs and comprehensively elevating the developmental level of logistics companies. While numerous scholars have researched the influencing factors of logistics enterprises [17,18], there is a dearth of investigations specifically focused on the self-operation and outsourcing mode. The key research highlights of this study are as follows:

- A novel LDA-TISM-SNA three-stage analytical framework is proposed to explore the driving factors of logistics firms in the self-operation and outsourcing cooperation mode.
- A probabilistic topic modeling approach is employed to identify the key factors influencing the development of logistics companies in the self-operation and outsourcing cooperation mode, supported by a large body of literature.
- Based on the support of practitioners as well as relevant researchers, this work highlights the hierarchical relationships among drivers through the TISM approach to uncover the root causes affecting the development of logistics companies.
- SNA is employed to examine the roles and positions of the influencing factors and their significance.

The remaining sections of this paper are organized as follows: Section 2 provides a literature review on the factors influencing logistics companies in the current research. Section 3 introduces the three-stage integrated analytical framework proposed in this study. Section 4 presents the research results and analysis, along with managerial, theoretical, and policy implications of the research. Finally, Section 5 concludes the paper and provides an outlook on future research directions.

2. Literature Review

In recent years, there has been widespread scholarly interest in studying influencing factors in logistics companies. This section explores the research efforts related to the influencing factors in logistics companies, the self-operation and outsourcing cooperation mode, as well as the various decision-making methods employed by researchers, providing valuable insights for research and practice in relevant fields.

2.1. Research on Influencing Factors in Logistics Companies

Current scholarly research on influencing factors in logistics companies can be broadly categorized into internal and external factors, which have been extensively discussed by scholars. In terms of internal influencing factors, Onstein [19] identified several key factors driving the distribution structure decisions in logistics companies based on a comprehensive review of the relevant literature, including “demand level”, “service level”, “product characteristics”, and “logistics costs”. Through in-depth interviews with logistics experts, Mikl [20] identified three main factors that need to be considered when evaluating the impact of digital logistics startups on existing logistics companies: company size, market cultivation strategies, and transportation modes. Gunasekaran et al. [21] highlighted the competitive advantage of technology levels in logistics and supply chains. Scholars have also identified that internal factors such as organizational structure [22], human resources [23], and business models [24,25] play significant roles in the operational and decision-making processes of logistics companies.

Logistics companies face a multitude of external influences, primarily stemming from market competition and environmental uncertainty [26]. The research conducted by Hofer et al. concludes that environmental uncertainty has a substantial impact on the procurement decisions of shippers in logistics outsourcing arrangements [27]. Gultekin et al. [28] integrated qualitative research and the fuzzy DEMATEL method to explore the uncertainties and risks faced by logistics service providers during the pandemic. The findings identified demand fluctuations, government regulations, and supply chain disruptions as the primary factors, and the key risks for logistics service providers were closely linked to human factors. With the rapid advancement of the digital transformation of smart logistics, the theoretical connotations of influencing factors have been greatly enriched. Numerous studies have shown that machine learning [29], reinforcement learning [30], and intelligent optimization algorithms [31,32] have been widely applied to logistics facility location, route planning, and dynamic resource scheduling. Among them, deep reinforcement learning (DRL) is increasingly adopted to tackle complex logistics decision-making problems, such as vehicle routing, fleet management, dynamic scheduling, and resource allocation in uncertain environments [33]. Research on electric vehicle routing problems (EVRPs) indicates that intelligent optimization methods can effectively improve energy efficiency and charging scheduling, boost transportation performance, and support sustainable operations in the logistics industry [34]. Meanwhile, resource allocation approaches based on machine learning are commonly used to optimize warehouse operations, transportation resource deployment, and supply chain coordination [35,36]. The above studies demonstrate that sound information infrastructure not only enables data integration and information sharing but also provides technical support for intelligent resource management and operational optimization. Accordingly, against the backdrop of digital transformation and the development of intelligent logistics, the informatization level and resource management capability act as critical factors affecting logistics service performance.

2.2. Research on Self-Operation and Outsourcing Cooperation Mode

When a logistics firm’s internal resources fail to satisfy customer demands or entail excessive in-house costs, part of its operational tasks can be outsourced to professional service providers to complement the firm’s resource shortages [37]. Outsourcing plays a vital role in both supply-side and demand-side service management, covering not only information technology [38,39] but also multiple logistics links, including warehousing, packaging, transportation and distribution [40–42]. Efficient resource outsourcing helps logistics companies improve operational performance, while service suppliers reduce costs by undertaking transportation businesses consigned by outsourcers. Nevertheless, outsource-

ing does not always produce positive outcomes. Partnership quality, inherent corporate asset risks, and competency risks constitute critical contributors to potential outsourcing failures [43]. Subsequent scholars have conducted in-depth research on outsourcing ties between manufacturers and retailers. Relevant findings suggest that manufacturers should retain partial direct customer services rather than outsourcing all services to retailers in certain scenarios, as such an arrangement can result in Pareto improvements for all stakeholders [44]. Feng et al. [45] highlight the inherent complexity of service outsourcing and propose that elaborately designed outsourcing contracts are essential to guarantee timely and high-quality service fulfillment.

The self-operation and outsourcing cooperation mode explored in this paper is not equivalent to the traditional logistics outsourcing mode. Traditional outsourcing means enterprises fully divest non-core businesses and entrust their entire operation to third-party service providers. In contrast, this study focuses on a hybrid operational form where in-house and outsourced businesses coexist, interact and cooperate dynamically within logistics companies. Outsourcing delivers an innovative alternative for the logistics sector. Hu et al. [46] explore whether e-retailers should outsource their express delivery to third-party courier firms. Their results indicate that integrated self-operated logistics channels rarely generate remarkable benefits for online retailers, who prefer employing courier companies as intermediaries to avoid heavy logistics expenses arising from Stackelberg and Nash games with offline retailers. E-retailers only obtain first-mover advantages when acting as the leader in Stackelberg games. Wang and Huang [47] examine a scenario where two express logistics firms outsource operations to an identical platform. Their empirical results show that platform collaboration generally raises corporate profit margins and lowers product prices for end consumers. By contrast, moderate customer loyalty toward direct sales channels drives up product prices while boosting corporate profitability. Liu et al. [48] investigate how platforms' logistics infrastructure strategies affect their channel decisions and further influence manufacturers' selection between platform-owned logistics and third-party logistics (3PL). Their conclusions reveal that platforms opt for hybrid channels when their in-house logistics capability substantially outperforms third-party providers, whereas they tend to construct self-run logistics if third-party logistics competence remains at low or medium levels.

2.3. Methodology of Research on Influencing Factors

Existing research on influencing factors in logistics companies predominantly focuses on quantitative and qualitative factors. The former have been widely applied in the study of influencing factors in studies relying on extensive data collection and statistical analysis to investigate the relationships between factors through the establishment of mathematical models and hypothesis testing. Regression analysis [49], interpretative structural modeling [50], structural equation modeling [51,52], and the analytic hierarchy process (AHP) [22,53,54] are commonly used quantitative methods. For instance, Karam [55] integrated the Fuzzy Delphi Method and AHP to identify and prioritize the obstacles faced by the freight industry in the process of sustainable development. The AHP was employed to determine the prioritization and ranking of obstacle categories and their associated obstacles. On the other hand, the latter mainly used literature collection [16], expert surveys, and interviews to identify the influencing factors, employing expert rating methods to determine the degree of influence for each factor [56–59]. For example, based on semi-structured interviews with senior executives in the liner shipping industry, Raza et al. [60] identified the challenges and obstacles faced during the digital transformation process of maritime logistics. The study emphasizes key drivers and digital technologies for digital transformation, as well as potential pathways or strategies that can lead to successful

shipping operations, providing valuable insights for the development of the maritime logistics industry.

The above review of existing studies reveals several research gaps. Although numerous studies have explored the influencing factors of logistics firms and the self-operation and outsourcing cooperation mode, existing research on the latter mainly focuses on strategy selection and performance evaluation. The driving factors affecting logistics companies in the self-operation and outsourcing cooperation mode, as well as the hierarchical structure and interrelationships among these factors, remain underexplored. Moreover, previous studies have predominantly relied on statistical analysis and expert surveys. While statistical methods are limited in revealing the interconnectedness among factors, expert-based approaches are often constrained by subjective judgments. Text mining was therefore employed in this study to identify the key driving factors in the self-operation and outsourcing cooperation mode and further investigate their interrelationships, providing a more scientific and objective perspective for understanding the development of logistics companies.

3. Methodology

We employed a three-stage framework to develop an integrated LDA-TISM-SNA model, as illustrated in Figure 1. In the first stage, the LDA topic model was adopted to screen core influencing factors. In the second stage, the TISM model was used to explore the implicit interaction mechanisms among these factors. In the third stage, the SNA method was applied to investigate the functional roles and relative importance of each factor. Detailed procedures for the three stages are elaborated in Sections 3.1–3.3, respectively.

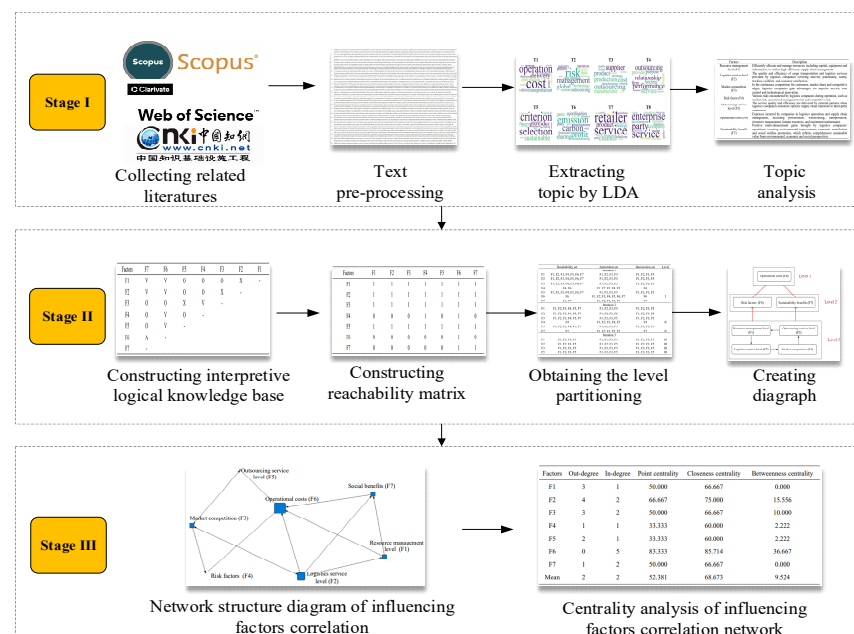


Figure 1. Research framework.

3.1. LDA

The LDA model, proposed by Blei et al. [61], is a topic model that excels at modeling high-dimensional and heterogeneous textual data, enabling a clear understanding of the topic structure and its distribution from sparse and high-dimensional data. The LDA topic model consists of three layers of Bayesian models: the document layer, the topic layer, and the word layer. This model posits that text can be represented as a Dirichlet distribution of latent topics, where topics are probability distributions over words, and documents

are probability distributions over multiple topics, with individual articles in a document collection sharing a set of topics with varying probabilities.

The graphical model of LDA is depicted in Figure 2. Here, M represents the total number of documents in the corpus. The number of words in document j is denoted as N_j . Within document j , w_{ji} represents the observed value of word i , where all words are clustered into K topics. In the codebook, each topic k is treated as a multinomial distribution. The variables α and β denote Dirichlet prior hyperparameters, while π_j , z_{ji} , and φ_k are the latent variables subject to inference.

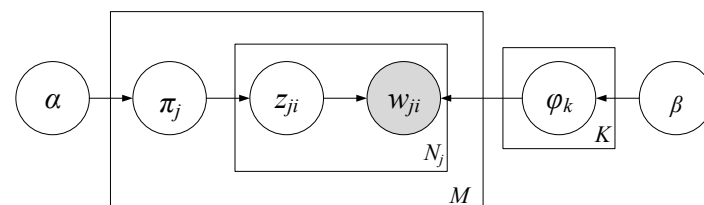


Figure 2. Graphical model of the latent Dirichlet allocation.

The topic model not only enables the exploration of latent semantic relationships between “text” and “words” but also provides a clear representation of the thematic structure and distribution within the text. Furthermore, the identified topics in the topic model consist of a core event or activity along with all the associated events and activities [62]. When analyzing the literature related to the operational development of logistics companies, these activities or events can be regarded as factors influencing logistics company development in the self-operated outsourcing collaboration mode. The topic model can therefore be employed to identify the influencing factors of logistics company development.

Importantly, the outputs of the topic model in this study were not directly treated as final variables. They were instead interpreted as preliminary thematic representations of the literature. To ensure robustness and conceptual validity, a structured expert interpretation process was further conducted to transform these topics into finalized influencing factors. Specifically, multiple experts independently reviewed the topic–word distributions, assigned preliminary semantic labels, and then engaged in iterative discussions to reach consensus. Any disagreements were resolved through re-examination of the original literature sources associated with each topic. Through this process, the final influencing factors were established as conceptually derived constructs rather than directly observed or statistically estimated causal variables.

3.2. TISM

Traditional factor analysis methods, such as those based on questionnaire survey data involving means, variances, and weights, typically focus primarily on the importance of individual factors while overlooking the underlying relationships between factors. However, the operational management of logistics companies is a complex system engineering endeavor, and the factors identified through the LDA topic model can be regarded as several subsystems within this complex system, exhibiting intricate interdependencies. Revealing these relationships can assist decision-makers in identifying key breakthrough points for company development. In this regard, Interpretative Structural Modeling (ISM) serves as a vital tool for analyzing complex systems by constructing multi-level hierarchical models to clarify the structural relationships between subsystems, thereby facilitating the achievement of the objectives of this study, the aim of which was to analyze the inherent relationships among influencing factors of logistics company development in the self-operation and outsourcing cooperation mode. Moreover, the ISM method places greater emphasis on the expertise and authority of interviewees in the research domain. Some

scholars have even suggested that, while ensuring the quality of interviewees, the number of interviewees required for the ISM model can be as low as two. In summary, the use of ISM for exploring the interrelationships of factors influencing logistics enterprise development with self-operated outsourcing collaboration is highly reasonable and practical, making it a suitable approach for this study.

In order to demonstrate the implicit causal reasoning among elements, we utilized TISM. This method is a comprehensive explanatory modeling technique employed to simplify and illustrate complex structures. It is more popular than its predecessor, ISM, as it not only provides the direction of relationships between two elements but also offers the reasoning behind their existence [63]. The specific steps involved in the TISM method are as follows:

Step 1: Defining the contextual relationships among influencing factors. By considering how one factor impacts another, the contextual relationships between a predefined set of factors are identified through the insights provided by a panel of expert members.

Step 2: Construction of an explanatory logic knowledge base. Through appropriate logical reasoning, an explanatory logic knowledge base is constructed that quantifies the existence of a relationship between a pair of factors.

Step 3: Establishment of a Structural Self-Interaction Matrix (SSIM) through pairwise comparisons of factors. V represents the relation from element i to element j exclusively (unidirectional); A represents the relation from element j to element i exclusively (unidirectional); X represents the bidirectional relation between elements i and j ; and O indicates that there is no relation between the elements.

Step 4: Obtaining the final reachability matrix through the initial reachability matrix and transitivity, following the specific rules outlined in Wang's work.

Step 5: Level partitioning. In this step, the hierarchical configuration is achieved by constructing reachability and antecedent sets.

Step 6: Creation of the diagram. The hierarchical configuration obtained in Step 5 is visually represented in the form of a graph. Unlike ISM, the relevant transitivity is preserved, accurately representing the hierarchy and providing a better understanding of the influence among factors.

3.3. SNA

SNA constructs relational models among participants, utilizing graph theory, mathematical modeling, and other approaches to characterize the structural features of group connections as well as their impacts on group operation and individual actors within the group. In an SNA graph, each factor is abstracted as a node. The network structure and its evolutionary dynamics are explored by examining the interconnections and interaction intensity between nodes. The core of SNA lies in identifying the most influential nodes and quantifying network centrality metrics.

Within this study's SNA framework, nodes stand for core influencing factors involved in logistics companies' resource optimization, while edges denote the interactive relationships among these factors. The SNA technique enables visual mapping of inner-factor correlations and quantitatively evaluates interaction strength via standardized network indicators and has been widely adopted to unpack operating mechanisms of complex networks. To date, scholars have applied this methodology across industrial structure, healthcare, energy, and economic management research.

In the present research, SNA was utilized to quantify the relative importance of each influencing factor from the perspective of nodal centrality. Centrality indicators reflect the status and functional role of individual nodes in the network, including degree, closeness,

and betweenness centrality. The selection of these indicators follows the criteria specified in *Social Network Analysis: A Handbook*, authored by Scott [64].

(1) Degree centrality

Degree centrality reflects the central location of a node in the network. A higher value means the corresponding influencing factor has more correlations with other factors and is positioned closer to the network center. Its calculation formula is

$$De = \frac{n}{N-1} \quad (1)$$

where D_e stands for node degree, n is the number of factors directly associated with the target factor, and N denotes the total number of nodes in the network.

(2) Closeness centrality

Closeness centrality equals the sum of distances from a certain node to all other nodes. A smaller total distance implies shorter connecting paths and tighter links between this node and all remaining nodes. Proposed by Bavelas as the reciprocal of total distance, closeness centrality indicates how independently a node operates from the control of others; a higher value suggests the factor is prone to becoming a core hub and establishes more direct correlations with other factors. It is subdivided into inbound closeness and outbound closeness, which separately describe how the input and output of a factor are restricted by the entire network. The computational formula is

$$C_{APi}^{-1} = \sum_{j=1}^n d_{ij} \quad (2)$$

where C_{APi} is the closeness of node i , and d_{ij} is the shortcut distance between nodes i and j .

(3) Betweenness centrality

Betweenness centrality measures the capacity of one node to govern the connections between other node pairs. Higher values signify stronger competitive advantages and greater controlling power over the relationships among other influencing factors [65]. The formula is expressed as

$$CB_i = \frac{2 \sum_{j=1}^{n-1} \sum_{k=2}^n b_{jk}(i)}{N^2 - 3N + 2} \quad (3)$$

subject to $j \neq i \neq k, j < k$. In the formula, CB_i refers to the betweenness centrality of node i , and $b_{jk}(i)$ quantifies the capability of factor i to dominate the linkage between factor j and factor k .

4. Results and Analysis

4.1. LDA Analysis

The LDA method was first employed to identify key factors influencing the operational development of logistics companies through a review of the relevant literature. In this section, the process of identifying these influential factors will be presented.

4.1.1. Relevant Literature Collection

The objective of this research is to explore the core driving factors of operational management for logistics companies in the self-operation-outsourcing cooperation mode. Relevant papers published from early 2016 to the end of 2025 were retrieved from the Scopus and Web of Science (WOS) databases, which are widely adopted by global scholars

owing to their comprehensive literature coverage [66,67]. The retrieval formula is specified as follows: TITLE-ABS-KEY (“logistics” OR “supply chain”) AND TITLE-ABS-KEY (“outsourcing” OR “self-operation” OR “collaborative logistics” OR “third-party logistics”) AND NOT TITLE-ABS-KEY (“regression”) AND PUBYEAR > 2015 AND PUBYEAR < 2026. After preliminary retrieval, 3079 publications were obtained from Scopus and 3346 from Web of Science. Following elimination of irrelevant papers and duplicate removal across the two databases, a final dataset of 4524 valid publications was retained.

To enrich data sources and avoid sample bias caused by reliance on the English database, we supplemented CNKI papers and annual reports of benchmark logistics companies, given abundant domestic research findings in this research field. With identical retrieval keywords, an initial set of 2032 publications were retrieved from CNKI. Subsequent title screening was conducted to eliminate irrelevant studies, leaving 1477 Chinese publications. In terms of company selection, the top 10 companies listed in China Top 50 Logistics Companies released by China Federation of Logistics & Purchasing were chosen, namely, COSCO Shipping Holdings, Xiamen Xiangyu, SF Holding, Beijing JD Logistics, Sinotrans, Shanghai Kuaishun Logistics, China National Materials Storage and Transportation, YTO Express, China Railway Materials, and Yunda Express. All selected companies adopt a hybrid operation mode combining self-operation and outsourcing. Summaries of their annual reports over the latest decade were collected as textual data. Data collection was restricted by the short establishment history of individual firms and limited data accessibility, and a total of 72 valid annual report excerpts were obtained. All collected Chinese academic publications and company annual report summaries were integrated into a unified Chinese text corpus for subsequent analysis.

4.1.2. Text Pre-Processing

The literature comprises extensive texts containing a plethora of specialized terms, with semantically coherent expressions following established norms and maintaining continuity. Hence, the initial step in topic analysis involves tokenizing the literature. Given that English texts consist of words, spaces, and punctuation marks, a straightforward approach involves splitting the words into an array based on spaces and punctuation marks. We employed the Natural Language Toolkit (NLTK) to accomplish this. In addition, the Jieba segmentation tool for Chinese text tokenization was adopted in this study. Equipped with a ready-to-use integrated Python 3.11.5 library, Jieba can accurately split sentences with easy operation and has been widely applied in the field of Chinese text analysis. It is necessary to apply stop-word processing to the results to ensure the objectivity and accuracy of the analysis results. In this study, we employed “stopwords.txt” to filter out stop words from the tokenized results, thereby establishing a precise corpus.

4.1.3. Identification of Influencing Factors

(1) LDA model construction and corpus update

Following the research workflow illustrated in Figure 1, the LDA topic model was constructed after corpus establishment. The LDA topic model was developed with the Python programming language. The number of topics was preliminarily set to 20, and 15 characteristic words were selected for each topic to generate the original topic–word matrix. This process was restricted by page length. The preliminary “topic–word” matrices for both Chinese and English texts are attached in Tables A1 and A2 in Appendix A.

The results in Tables A1 and A2 reveal that the preliminary “topic–word” matrices extracted still contain some noise words, such as “high”, “paper”, “based”, and “through”. Therefore, further stop-word filtering was necessary. By incorporating the words to be filtered into the stopwords.txt file, we were able to rerun the LDA program package. It is

important to note that an excessive number of topics may lead to numerous topics lacking clear semantic information. Conversely, if the number of topics is too small, a single topic might encompass multiple layers of semantic information. Determining an appropriate number of topics K is thus crucial in scientific research.

(2) Perplexity

After topic segmentation, the optimal number of topics needed to be confirmed. An excessively large number of topics tends to generate numerous topics without distinct semantic meanings; on the contrary, too few topics cause a single topic to cover multiple heterogeneous semantic layers. Hence, scientifically specifying the optimal topic quantity is essential.

Perplexity was adopted as the evaluation indicator to select the optimal number of topics (denoted by K) for valid LDA model assessment [68]. In general, perplexity gradually declines with rising topic numbers, and a lower perplexity corresponds to stronger generalization performance of the topic model. The calculation formula for perplexity is as follows:

$$\text{Perplexity}(D) = \exp \left\{ - \frac{\sum_{d=1}^M \log p(\omega_d)}{\sum_{d=1}^M N_d} \right\} \quad (4)$$

where D stands for the document set of the corpus, M denotes the total number of documents, N_d is the total count of words in each document, and $p(\omega_d)$ denotes the overall occurrence frequency of word ω_d in texts.

(3) Coherence scores

Perplexity generally declines with the growth in the number of topics, which implies improved generalization performance of the LDA model. Nevertheless, lower perplexity does not always guarantee better modeling outcomes as an overabundance of topics tends to trigger model overfitting. To address this problem, the topic coherence test was introduced to preferentially retain topics with high coherence scores [69].

(4) Results of the influencing-factor identification

We set the iterations = 100 and the number of topics = [0, 10]. Figures 3 and 4 present the calculated perplexity and coherence scores with different topic quantities for the English and Chinese corpora, respectively. The highest coherence score for the English dataset appears at eight topics, with its perplexity close to the minimum value. The optimal coherence of the Chinese dataset is achieved at six topics. Accordingly, eight topics were finalized for English texts and six topics for Chinese texts.

(5) Influencing-factor identification results

After the LDA topic extraction process, the identified topics and their representative keywords were further reviewed and interpreted by a panel of experts consisting of scholars in logistics management and industry practitioners. The experts independently examined the semantic meanings of each topic and evaluated the consistency between topic keywords and the proposed influencing-factor labels. Through iterative discussion and consensus-building, the final influencing factors were determined. This procedure was intended to improve the interpretability and practical relevance of the topic modeling results and reduce potential bias arising from individual researcher interpretation. Tables 1 and 2 present the topic–word matrices generated from the Chinese and English corpora, respectively. Figures 5 and 6 employ word cloud visualization to illustrate the classification results of factors influencing the operational development of logistics companies in the self-operation–outsourcing collaborative mode.

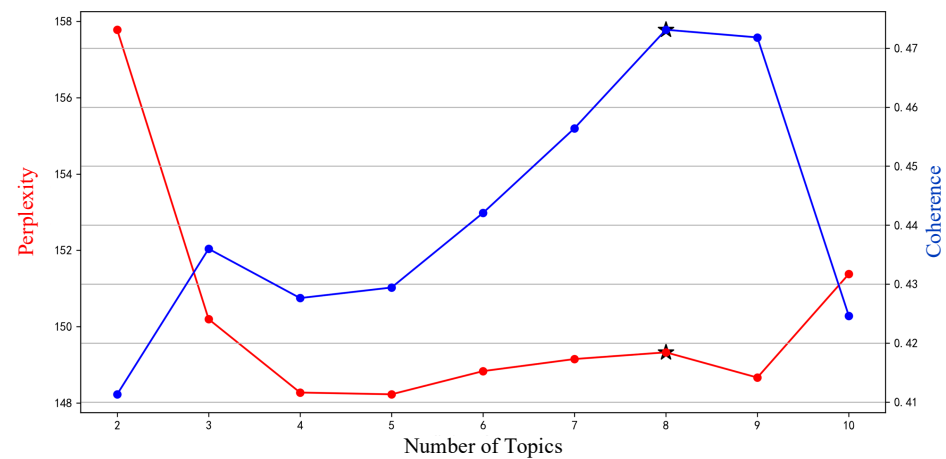


Figure 3. Perplexity with different numbers of topics in English texts (The asterisk represents the optimal number of topics).

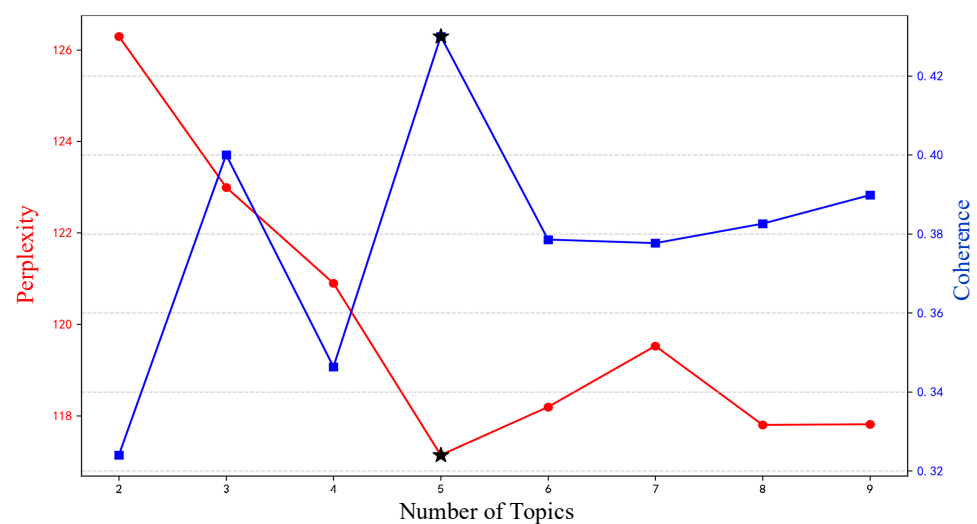


Figure 4. Perplexity with different numbers of topics in Chinese texts (The asterisk represents the optimal number of topics).

Table 1. “Topic–word” matrix and categorization results in English corpus.

Topic	15 Words	Categorization
T 1	cost, operation, delivery, transportation, distribution, demand, vehicle, party, result, network, customer, collaborative, problem, time, different	Operational cost
T 2	risk, management, global, outsourcing, data, technology, industry, operation, system, case, process, challenge, information, new, international	Risk management
T 3	outsourcing, supplier, cost, production, product, manufacturer, strategy, manufacturing, quality, market, sourcing, decision, firm, contract, procurement	Outsourcing strategy
T 4	performance, outsourcing, relationship, service, finding, provider, purpose, firm, factor, management, customer, practice, impact, limited, effect	Outsourcing performance evaluation

Table 1. *Cont.*

Topic	15 Words	Categorization
T 5	selection, criterion, provider, sustainable, fuzzy, evaluation, making, sustainability, reverse, party, industry, green, environmental, framework, important	Service provider selection
T 6	emission, carbon, profit, sharing, coordination, game, mechanism, party, financing, remanufacturing, enterprise, decentralized, price, policy, result	Environmental sustainability
T 7	service, retailer, product, channel, strategy, commerce, platform, agricultural, price, party, consumer, profit, manufacturer, fresh, retail	Retail supply chain service
T 8	service, enterprise, party, company, development, transport, business, market, customer, information, quality, provider, value, commerce, activity	Service quality

Table 2. “Topic–word” matrix and categorization results in Chinese corpus.

Topic	15 Words	Categorization
T 1	operating cost, uncertainty, human resources, economic benefit, service supplier, credit risk, innovation, systematic nature, regulatory authority, profit distribution, social benefit, operational risk, sustainability, partner, decision-making	Operational cost
T 2	service level, business model, service system, information system, integration, profit model, policies and regulations, operational risk, distribution mechanism, environmental pollution, retail price, innovation, partner, network system, third party	Third-party service level
T 3	resource allocation, income distribution, personalization, resource sharing, corporate credit, sensitivity, information network, management system, government department, information system, artificial intelligence, innovation, regional cooperation, cost reduction, efficiency increase, distribution mechanism	Resource management level
T 4	competitiveness, management level, functional type, policy orientation, information network, public service, management system, information technology, transportation, service level, regional cooperation, resource management, industrialization, customer relationship, business model	Competitive capability
T 5	environmental factor, emission, social responsibility, management level, sustainable development, transportation cost, green, retail industry, social welfare, market, economic, industrial policy, risk management, environmental variable, regional cooperation	Sustainability benefits

In Table 1, based on the English corpus, T1 centers on enterprise operational efficiency involving transportation scheduling, network layout, and collaborative delivery arrangement. T2 mainly focuses on risk management, covering outsourcing risks, informatization risks, and industrial operational risks. T3 concentrates on outsourcing strategy formulation from the perspective of procurement, production, and supplier cooperation. T4 is oriented toward outsourcing performance evaluation concerning the interactive relationship between companies and outsourcing service suppliers. T5 mainly relates to supplier selection with green and sustainable evaluation criteria and fuzzy decision-making methods. T6 targets environmental sustainability, including carbon emission control, profit-sharing mechanisms, and remanufacturing cooperation under policy constraints. T7 lays emphasis on retail platform and sales channel layout together with fresh agricultural product com-

mercial operation. T8 primarily reflects logistics service quality and the value creation of service providers in market operations.



Figure 5. Clustering results of influencing factors in English corpus.



Figure 6. Clustering results of influencing factors in Chinese corpus.

In Table 2, based on the Chinese corpus after English word segmentation, T1 is categorized into operational cost, which covers enterprise expense expenditure, various uncertain risks, stakeholder cooperation, and profit allocation decision-making. T2 corresponds to the third-party service level, focusing on third-party service system construction, business mode innovation, and supply chain resource integration. T3 is defined as the resource management level, revolving around resource optimal allocation, digital management, regional collaborative operation, and the achievement of cost saving and efficiency improvements. T4 is summarized as competitive capability, including multiple supporting elements such as technical capability, customer operation, policy guidance, and cross-regional cooperation. T5 is classified into sustainability benefits and integrates environmental governance, social welfare, industrial policy, and economic development from the environmental, social, and economic dimensions.

A comparison of Table 1 (English corpus) and Table 2 (Chinese corpus) reveals that operational cost, environmental sustainability, service quality, resource management capability, and risk management are consistently identified in both datasets. Such cross-linguistic convergence indicates that these factors are widely recognized as fundamental determi-

nants of logistics company development in the self-operation and outsourcing cooperation modes. The consistency of the results across independent language corpora enhances confidence in the robustness and content validity of the selected indicators. Meanwhile, several divergent influencing factors are detected between the Chinese and English corpora, which can be reasonably explained by practical and research context differences. Foreign scholars pay more attention to cross-border logistics, international trade policy and global supply chain disruption risks owing to the mature international outsourcing market. By contrast, the domestic literature focuses more on policy regulation of the domestic logistics industry, platform economy development, and road transportation administrative management, which are closely tied to China's unique logistics institutional environment and industrial development characteristics. Such indicator discrepancies originate from disparities in industrial environments and research perspectives between China and overseas markets, reflecting the regional heterogeneity of practical logistics operations.

(6) Summary of the influencing factors

Logistics companies in the self-operation and outsourcing cooperation mode are affected by multiple factors, including operational cost, risk management, outsourcing strategy, outsourcing performance evaluation, service provider selection, and so on. However, certain content overlaps and hierarchical subordinate relationships exist among these factors. Specifically, outsourcing strategy, outsourcing performance evaluation, and service provider selection all belong to the outsourcing service level; retail supply chain service and service quality are categorized into the company's internal logistics service level; and environmental sustainability is an essential component of sustainability benefits. Therefore, after multiple rounds of discussions among experts, we summarized and sorted out all influencing factors, and finally extracted seven specific factors affecting the resource optimization of logistics companies, as shown in Table 3.

Table 3. List of influencing factors logistics companies in self-operation and outsourcing mode.

Factor	Description
Resource management level (F1)	Efficient allocation and management of resources, including capital, equipment and information, to achieve high-efficiency supply chain management.
Logistics service level (F2)	The quality and efficiency of cargo transportation and logistics services provided by logistics companies, covering delivery punctuality, safety, tracking visibility, and customer satisfaction.
Market competition (F3)	Advantages gained by logistics companies via superior service, cost control, and technological innovation in the continuous competition for customers, market share, and competitive edge.
Risk factor (F4)	Various risks encountered by logistics companies during operation, such as market, operational management, and competitive risk.
Outsourcing service level (F5)	The service quality and efficiency delivered by external partners when logistics companies outsource specific supply chain functions to third-party contractors.
Operational costs (F6)	Expenses incurred by companies in logistics operations and supply chain management, including procurement, warehousing, transportation, inventory management, human resources, and equipment maintenance.
Sustainability benefits (F7)	Positive multi-dimensional gains brought about by logistics companies' operations, covering environmental improvement, economic contribution, and social welfare promotion, which reflect comprehensive sustainable value from environmental, economic, and social perspectives.

4.2. TISM Analysis

A ten-member expert panel was formed for this study. The panel consisted of domestic and overseas scholars: two experts from Denmark, two from India, and six from China. Experts affiliated with research institutions specializing in logistics and supply chain management were selected to guarantee the authority and representativeness of their viewpoints. It was assumed that the experts' judgments were free from the interference of external factors during the decision-making process. Following the steps outlined in Section 3.2, we applied TISM to construct an interpretive logic knowledge base (see Table 4) to analyze the relationships between influencing factors. The structural self-interaction matrix and adjacency matrix of influencing factors are presented in Tables 5 and 6. Inter-rater reliability was verified via Fleiss's Kappa test, yielding a coefficient of 0.6021, which indicates favorable consistency among expert ratings.

Table 4. Interpretive logic knowledge base.

Factor	Paired Comparison of Factors	Ways in Which a Factor May Influence/Enhance Another Factor
F1	F1–F2	Improvements in resource management capabilities can directly influence and enhance logistics service performance through effective inventory management, supply chain visibility, human resource management, and resource allocation and optimization.
	F1–F6	A high level of resource management capability can help firms reduce inventory costs, decrease empty-load rates, and improve operational efficiency.
	F1–F7	By reducing energy consumption, improving traffic flow, lowering costs, and enhancing service quality, resource management increases social benefits and contributes to the achievement of sustainable development.
F2	F2–F1	By improving supply chain visibility, delivery reliability, and customer satisfaction, logistics service performance can directly enhance firms' resource management capabilities, facilitating the effective allocation and utilization of resources to achieve higher levels of performance.
	F2–F3	By expanding market reach through efficient service provision, firms can offer more competitive prices and attract a larger customer base.
	F2–F6	Improvements in logistics service performance can reduce transportation and inventory costs while simultaneously increasing investment costs associated with human resources and technology.
	F2–F7	By reducing cargo dwell time, shortening transportation distances, and optimizing transportation routes, logistics service performance can reduce fuel consumption and emissions, thereby mitigating negative environmental impacts.
F3	F3–F2	Market competition can motivate logistics firms to continuously innovate and improve their service quality standards.
	F3–F4	Market competition creates new challenges and opportunities for firms in terms of cost management, customer loyalty, technological innovation, supply chain complexity, and supply chain visibility. Firms need to develop effective risk management strategies to address the challenges arising from market competition and ensure sustainability.
	F3–F5	Resource service providers can withstand competitive pressure by continuously improving their outsourcing services, including enhancing transportation efficiency, reducing costs, and providing faster delivery, thereby improving overall service performance.

Table 4. Cont.

Factor	Paired Comparison of Factors	Ways in Which a Factor May Influence/Enhance Another Factor
F4	F4–F6	Risk factors can directly influence or increase the operational costs of logistics firms through various channels, including traffic disruptions, supply chain disruptions, and trust-related risks. Firms need effective risk management strategies to mitigate the adverse cost impacts of these risks and ensure business sustainability and profitability.
F5	F5–F3	Outsourcing services have a direct impact on the reputation and customer satisfaction of logistics firms. High-quality outsourcing services enable firms to meet customer needs while focusing on their core business activities, thereby enhancing their core competitiveness in the market.
	F5–F6	The implementation of efficient and cost-effective outsourcing services can help logistics firms reduce their operational costs.
F7	F7–F6	Pursuing sustainability benefits, including energy conservation, emission reduction, green operation and corporate social responsibility, directly raise operational costs. Extra upfront investment and continuous operating expenditure are required for purchasing high-efficiency vehicles, constructing eco-friendly warehouses and implementing social responsibility projects.

Table 5. Structural self-interaction matrix.

Factor	F7	F6	F5	F4	F3	F2	F1
F1	V	V	O	O	O	X	-
F2	V	V	O	O	X	-	
F3	O	O	X	V	-		
F4	O	V	O	-			
F5	O	V	-				
F6	A	-					
F7	-						

Table 6. Adjacency matrix.

Factor	F1	F2	F3	F4	F5	F6	F7
F1	1	1	0	0	0	1	1
F2	1	1	1	0	0	1	1
F3	0	1	1	1	1	0	0
F4	0	0	0	1	0	1	0
F5	0	0	1	0	1	1	0
F6	0	0	0	0	0	1	0
F7	0	0	0	0	0	1	1

The reachability matrix is used to represent the direct and indirect relationships between influencing factors, and it is generated through power iteration analysis based on the adjacency matrix [70]. When the power iteration satisfies the equation $R = (A + I)^{b+1} = (A + I)^b \neq (A + I)^{b-1} \neq \dots \neq (A + I)^2 \neq (A + I)^1$ ($b > 1$), the matrix R is obtained. Using MATLAB R2019a software, the reachability matrices for the seven influencing factors were obtained, as shown in Table 7.

Table 7. Final reachability matrix.

Factor	F1	F2	F3	F4	F5	F6	F7
F1	1	1	1	1	1	1	1
F2	1	1	1	1	1	1	1
F3	1	1	1	1	1	1	1
F4	0	0	0	1	0	1	0
F5	1	1	1	1	1	1	1
F6	0	0	0	0	0	1	0
F7	0	0	0	0	0	1	1

Subsequently, hierarchical divisions were performed by identifying the reachability set, antecedent set, and intersection of the reachability matrix. The reachability set of an influencing factor consists of itself and other factors influenced by it, while the antecedent set comprises the influencing factor itself and other factors that may influence it. The intersection is formed by the common factors in the reachable set and antecedent set. In accordance with the principle of ISM, the top-level position is assigned to the influencing factor that achieves the same reachability set and intersection set first [59]. The results of the level partition are presented in Table 8. As shown in Table 8, three levels of driving factors influencing the operational development of logistics companies in the self-operation and outsourcing cooperation mode were obtained: L1 = (F6), L2 = (F4, F7), L3 = (F1, F2, F3, F4).

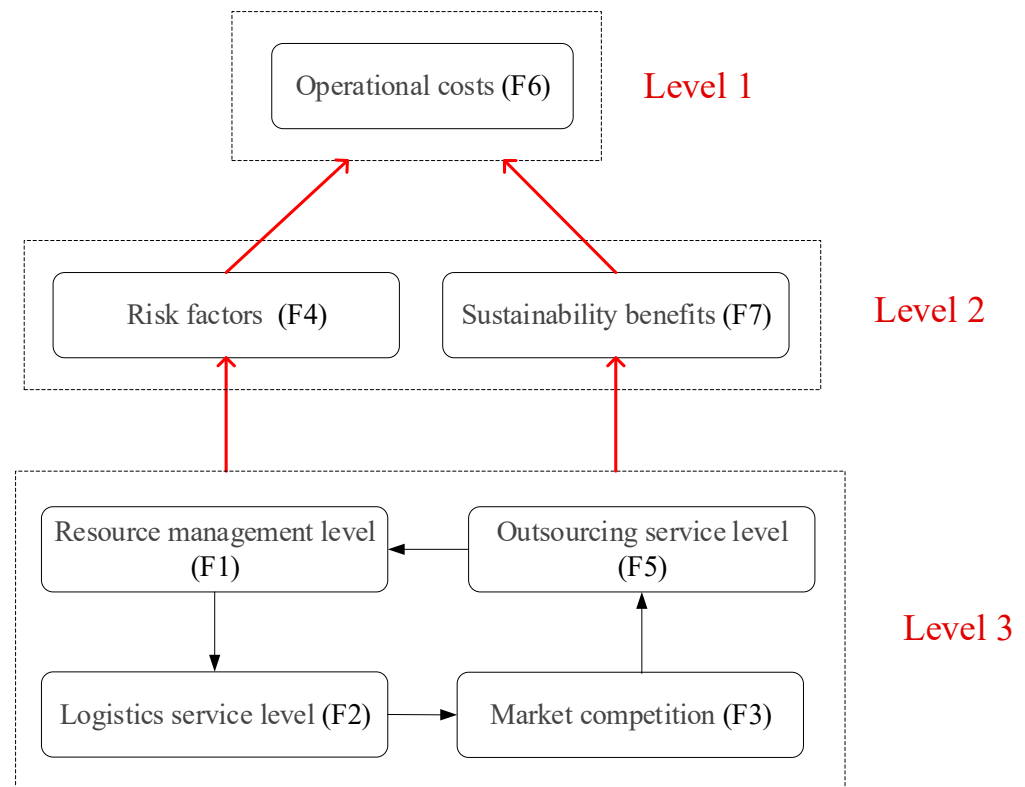
Table 8. Level partitioning.

	Reachability Set	Antecedent Set	Intersection Set	Level
		Iteration 1		
F1	F1, F2, F3, F4, F5, F6, F7	F1, F2, F3, F5	F1, F2, F3, F5	I
F2	F1, F2, F3, F4, F5, F6, F7	F1, F2, F3, F5	F1, F2, F3, F5	
F3	F1, F2, F3, F4, F5, F6, F7	F1, F2, F3, F5	F1, F2, F3, F5	
F4	F4, F6	F1, F2, F3, F4, F5	F4	
F5	F1, F2, F3, F4, F5, F6, F7	F1, F2, F3, F5	F1, F2, F3, F5	
F6	F6	F1, F2, F3, F4, F5, F6, F7	F6	
F7	F6, F7	F1, F2, F3, F5, F7	F7	
		Iteration 2		
F1	F1, F2, F3, F4, F5, F7	F1, F2, F3, F5	F1, F2, F3, F5	II
F2	F1, F2, F3, F4, F5, F7	F1, F2, F3, F5	F1, F2, F3, F5	
F3	F1, F2, F3, F4, F5, F7	F1, F2, F3, F5	F1, F2, F3, F5	
F4	F4	F1, F2, F3, F4, F5	F4	
F5	F1, F2, F3, F4, F5, F7	F1, F2, F3, F5	F1, F2, F3, F5	
F7	F7	F1, F2, F3, F5, F7	F7	II
		Iteration 3		
F1	F1, F2, F3, F5	F1, F2, F3, F5	F1, F2, F3, F5	III
F2	F1, F2, F3, F5	F1, F2, F3, F5	F1, F2, F3, F5	III
F3	F1, F2, F3, F5	F1, F2, F3, F5	F1, F2, F3, F5	III
F5	F1, F2, F3, F5	F1, F2, F3, F5	F1, F2, F3, F5	III

Based on the information presented in Tables 8 and 9, a hierarchical structure based on TISM can be derived, representing the causal links between the seven identified influencing factors. As depicted in Figure 7, the interpretive structural model of key driving factors for the operational development of logistics companies in the self-operation and outsourcing cooperation mode consists of three levels.

Table 9. List of CSPs and their levels in TISM.

Factor	Description	Level in TISM
F1	Resource management level	III
F2	Logistics service level	III
F3	Market competition	III
F4	Risk factors	II
F5	Outsourcing service level	III
F6	Operational costs	I
F7	Sustainability benefits	II

**Figure 7.** Hierarchy structure diagram.

Operational costs (F6) reside in the first layer and represent the most direct outcome within the hierarchical structure, reflecting the cumulative effects of multiple factors on the development of logistics companies in the self-operation and outsourcing cooperation mode. Risk factors (F4) and sustainability benefits (F7) are positioned in the second layer as transitional factors that directly affect operational costs. The resource management level (F1), the logistics service level (F2), market competition (F3), and the outsourcing service level (F5) constitute the third layer as fundamental factors, forming an internal feedback loop within the hierarchical structure. Specifically, the outsourcing service level influences the market competitiveness of logistics companies, while superior logistics and outsourcing services contribute to customer retention, customer satisfaction, and competitive advantage. Enhanced market competitiveness further promotes improvements in logistics service capability and resource management. Through these intermediate transmission paths, the fundamental factors gradually influence transitional factors and ultimately affect operational costs and overall business performance. This hierarchical transmission mechanism reveals the underlying logic of factor interactions and provides a systematic explanation of how foundational drivers shape the development of logistics companies in the self-operation and outsourcing cooperation mode.

In addition, a sensitivity analysis was conducted to further examine the robustness of the TISM results. Specifically, two experts were randomly excluded from the expert panel, and the reachability matrix as well as the hierarchical structure were recalculated based on the remaining evaluations. The results indicated that the overall hierarchical structure remained stable, with no changes observed in the level classification of the influencing factors. The recalculated reachability matrix and hierarchical structure are presented in Appendix B (Tables A3 and A4) and are fully consistent with the original TISM hierarchy. This suggests that the model results are not overly sensitive to the judgments of individual experts. Furthermore, Fleiss's Kappa coefficient after sample adjustment was 0.6725, indicating a substantial level of agreement among the experts. Collectively, these findings provide additional evidence supporting the robustness and reliability of both the identified factor system and its hierarchical structure.

4.3. SNA Analysis

Based on the adjacency matrix of influencing factors obtained in Section 4.2, a visualized network was constructed via the SNA software Ucinet 6.236 and Netdraw to intuitively present the complicated correlation among factors, as shown in Figure 8. In the network diagram, nodes denote individual influencing factors, lines between nodes represent their interactive relationships, and arrows indicate the transmission direction of impacts. A larger size of the blue rectangular node implies a closer position to the network center and stronger correlations with other factors.

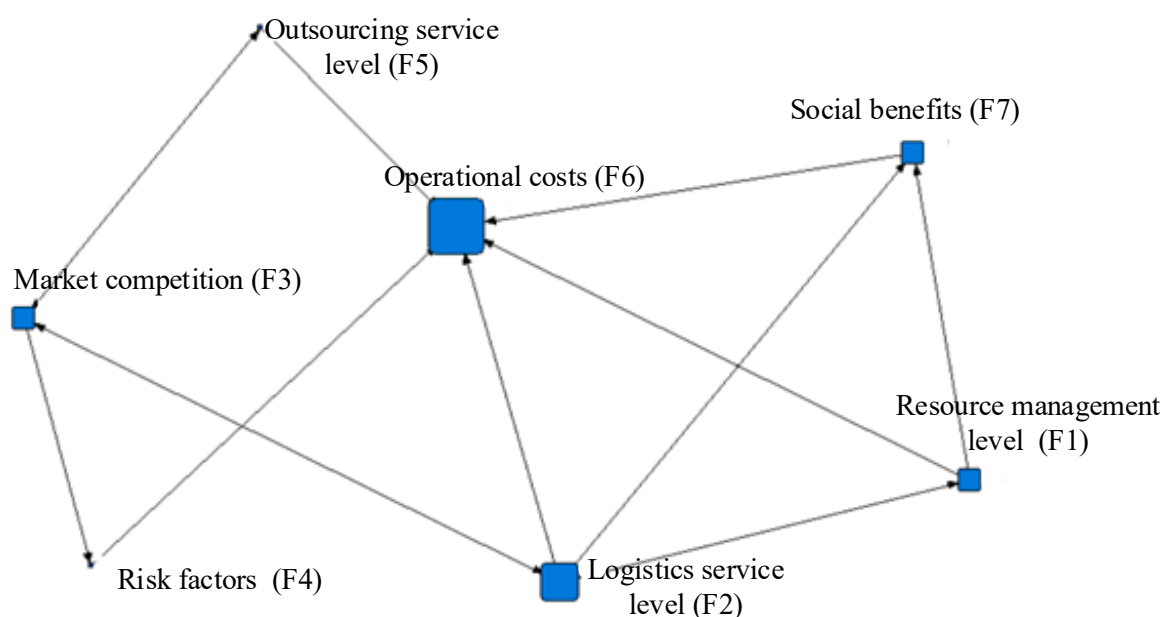


Figure 8. Network structure diagram of influencing factors correlation.

Figure 8 demonstrates that operational cost and the logistics service level rank as the top two in terms of rectangular area. Operational cost is located at the core of the network and presents strong correlations with other factors, demonstrating its dominant position within the factor network for company resource optimization.

The values of degree centrality, betweenness centrality, and closeness centrality were calculated following the path of “Network → Centrality → Multiple Measures” with the SNA software Ucinet. Meanwhile, the out-degree and in-degree were obtained via the operation “Network → Centrality → Degree”, and all statistical results are listed in Table 10.

Table 10. Centrality analysis of influencing factors correlation network.

Factor	Out-Degree	In-Degree	Point Centrality	Closeness Centrality (Inward/Outward)	Betweenness Centrality
F1	3	1	50.000	66.667 (22.222/54.545)	0.000
F2	4	2	66.667	75.000 (24.000/75.000)	15.556
F3	3	2	50.000	66.667 (24.000/66.667)	10.000
F4	1	1	33.333	60.000 (27.273/16.667)	2.222
F5	2	1	33.333	60.000 (22.222/50.000)	2.222
F6	0	5	83.333	85.714 (85.714/14.286)	36.667
F7	1	2	50.000	66.667 (28.571/16.667)	0.000
Mean	2	2	52.381	68.673 (33.429/41.976)	9.524

(1) Degree centrality analysis

From the node perspective, the degree centrality values of the logistics service level (F2) and operational cost (F6) are higher than the network average. This indicates that these two factors occupy central positions within the network and maintain direct connections with a larger number of factors. Therefore, they play important roles in the interaction and influence structure of the system.

(2) Closeness centrality analysis

The closeness centrality values of the logistics service level (F2) and operational cost (F6) exceed the network average, highlighting their prominent positions in the overall network. Operational cost (F6) exhibits relatively high inward closeness centrality, indicating that it is highly sensitive to changes in other factors and can be readily affected by fluctuations throughout the system. In contrast, the resource management level (F1), the logistics service level (F2), market competition (F3), and the outsourcing service level (F5) demonstrate relatively high outward closeness centrality, suggesting that they can effectively influence other factors through shorter transmission paths. Therefore, improvements in these factors are likely to generate broader impacts across the network and contribute to the overall optimization of logistics company operations.

(3) Betweenness centrality analysis

The betweenness centrality values of the logistics service level (F2), market competition (F3), and operational cost (F6) are higher than the network average, indicating that these factors occupy key intermediary positions within the network. As important bridges in the transmission of influence, they facilitate interactions among different factors and play a crucial role in the diffusion of effects throughout the system. Changes in these factors are therefore more likely to affect the overall network structure and influence transmission process.

Table 10 also reports the calculated out-degree and in-degree results. The out-degree refers to the number of paths through which a given node imposes influences on others, whereas the in-degree represents the quantity of influence paths directed from other nodes toward the target node. In social network analysis, the out-degree and in-degree carry distinct implications: a high out-degree suggests the factor exerts prominent driving impacts and tends to trigger fluctuations of other factors; a high in-degree means the factor is vulnerable to external disturbances and changes passively under the influence of other variables.

According to analytical findings, F1, F2, F3 and F5 feature a high out-degree yet low in-degree. As causal factors, they produce substantial shocks and fluctuations across the entire network. F6 and F7 have a larger in-degree than out-degree; they respond passively to external changes and function as outcome factors affected by network perturbations. F4

has an equal out-degree and in-degree, with strong information transmission capability to both affect and be affected by other factors, thus serving as an intermediate node at a pivotal network position.

4.4. Managerial Implications

(1) In the self-operation and outsourcing cooperation mode, the resource management level, the logistics service level, market competition, and the outsourcing service level are identified as fundamental influencing factors of logistics company performance and development. The results suggest that improving the resource management level is a critical prerequisite for enhancing overall operational effectiveness. This involves strategic logistics resource planning, investment in advanced equipment and technologies, and effective financial management. Efficient resource allocation contributes to improvements in the logistics service level, enabling firms to better meet customer expectations and service requirements. A higher logistics service level further strengthens market competition by attracting customers and business partners, thereby mitigating uncertainty-related risks. Moreover, collaboration with outsourcing partners can improve operational efficiency and reinforce competitive advantages.

(2) The findings further suggest that strengthening the management of risk factors is essential for enhancing organizational resilience and long-term viability while reducing the adverse impacts of uncertainties on operational costs. In addition, sustainability benefits represent an important consideration in logistics management. As sustainability has become an increasingly important dimension of competitive advantage, market demand for environmentally responsible logistics solutions continues to grow. Customers are increasingly inclined to engage with firms that demonstrate strong sustainability performance. Consequently, integrating sustainability-oriented practices into operational and strategic decision-making can generate both environmental and economic benefits, contributing to long-term organizational success.

(3) Operational costs are positioned at the highest level within the hierarchical structure and are located at the core of the influencing-factor network, indicating potential interactions with other determinants. This finding highlights the central role of cost management in the self-operation and outsourcing cooperation mode. Therefore, logistics companies are encouraged to continuously optimize operational processes, improve resource utilization efficiency, control expenditures, and adopt prudent procurement strategies. Effective operational cost management enables firms to allocate resources more efficiently, improve profitability, and support sustainable development in an increasingly competitive market environment.

4.5. Theoretical Implications

A three-stage analytical framework, LDA–TISM–SNA, was developed in this study. The framework integrates LDA for factor identification, TISM for hierarchical relationship construction, and SNA for structural importance evaluation. By combining text mining, expert interpretation, and network analytics, the framework provides a multi-method approach for investigating complex interdependent systems in logistics and supply chain contexts.

First, the study contributes to methodological development in logistics and supply chain research by integrating data-driven topic modeling with interpretive structural modeling and network analysis. Compared with traditional single-method approaches, the proposed framework reduces reliance on purely subjective factor identification while enabling a more comprehensive representation of structural relationships among influencing

factors. This enhances the ability to capture both hierarchical dependencies and network interactions within complex systems.

Second, the findings extend the existing logistics outsourcing literature by revealing the hierarchical organization of influencing factors. While prior studies have typically examined variables such as resource management, logistics service capability, and outsourcing performance in isolation, this study demonstrates that these factors form a structured multi-level system. In particular, foundational drivers such as the resource management level, the logistics service level, market competition, and the outsourcing service level influence higher-level outcomes through multi-stage transmission pathways, offering a more integrated understanding of logistics enterprise development mechanisms.

Finally, compared with LDA–TISM and DEMATEL–TISM approaches, the proposed approach further incorporates SNA to capture the centrality and relational influence intensity of factors while also integrating data-driven factor discovery and expert-based structural modeling. The proposed framework also shifts the analytical perspective from process optimization to mechanism exploration compared with the Supply Chain Operations Reference (SCOR) model developed by the Association for Supply Chain Management (ASCM), which focuses on standardizing supply chain processes such as Plan, Source, Make, Deliver, and Return. Rather than describing operational activities, the LDA–TISM–SNA framework identifies latent influencing factors and reveals how they interact through hierarchical and network structures. The proposed framework therefore complements SCOR by providing an explanatory layer that captures the underlying causal structure driving logistics system performance, rather than replacing its process-oriented perspective.

4.6. Policy Implications

The findings of this study provide several important implications for policymakers seeking to improve the operational performance and long-term sustainability of logistics companies operating in the self-operation and outsourcing cooperation mode.

First, the results highlight the importance of strengthening resource integration and service capability development across the logistics industry. The TISM analysis identifies the resource management level, the logistics service level, market competition, and the outsourcing service level as fundamental driving factors that indirectly influence firm performance through multiple transmission paths. Therefore, policymakers should prioritize the development of digital logistics infrastructure, data-sharing platforms, and intelligent logistics systems that facilitate resource coordination among logistics firms, suppliers, and customers. Such initiatives can enhance supply chain visibility, improve resource allocation efficiency, and support the continuous improvement of logistics service quality.

Second, the study emphasizes the strategic role of outsourcing governance in modern logistics systems. This suggests that policymakers should establish more transparent standards for third-party logistics service providers, strengthen service quality certification mechanisms, and promote information disclosure practices within outsourcing markets. By improving the institutional environment for logistics outsourcing, governments can encourage more efficient collaboration between logistics companies and external service providers while reducing transaction uncertainty.

Third, the findings suggest that risk management and sustainability benefits function as critical transitional factors linking organizational capabilities to operational performance. Given the increasing complexity of global supply chains and the growing frequency of external disruptions, policymakers should support the establishment of industry-wide risk monitoring, early-warning, and emergency-response systems. At the same time, sustainability-oriented policies, including carbon reduction incentives, green transportation subsidies, and environmental performance assessment frameworks, can encourage logistics

firms to integrate sustainability objectives into operational decision-making. Such measures not only contribute to environmental protection but also enhance long-term supply chain resilience and competitiveness.

Finally, since operational costs are influenced by multiple factors, policy interventions should move beyond short-term cost reduction measures and instead focus on improving the structural conditions that shape cost performance. Investments in logistics infrastructure, digital transformation, market standardization, and sustainable technologies can generate system-wide efficiency gains, ultimately reducing logistics costs while supporting high-quality industry development.

5. Conclusions

The self-operation and outsourcing cooperation mode has emerged as an innovative development strategy for logistics companies to adapt to industry evolution and improve logistics resource utilization efficiency. Based on a comprehensive review of both the Chinese and international literature, as well as annual reports of logistics companies, this study proposes seven influencing factors: the resource management level, the logistics service level, market competition, the outsourcing service level, risk factors, operational costs, and sustainability benefits. A TISM approach was employed to investigate the hierarchical relationships and transmission paths among these factors. The results suggest that operational costs occupy the highest level of the hierarchical structure and represent the most critical factor influencing company development. In contrast, the resource management level, the logistics service level, market competition, and the outsourcing service level are located at the bottom of the hierarchy, serving as the fundamental driving forces behind the development of logistics companies. The SNAs of out-degree centrality and closeness centrality also suggest that the resource management level, the logistics service level, market competition, and the outsourcing service level exert substantial influence on other factors within the network. Consequently, fluctuations in these factors are more likely to generate cascading effects and disrupt the overall influencing-factor network. These factors are notably all positioned at the foundational level of the TISM structure. By comparison, operational costs are located at the center of the influencing-factor network and are highly susceptible to the impacts of other factors.

The proposed LDA–TISM–SNA analytical framework shows promising applicability for generalized use in various industrial scenarios. It enables practitioners and researchers to explore the underlying drivers of industry development from multiple perspectives and facilitates the identification of critical influencing factors affecting company development. The framework can consequently help decision-makers rapidly identify key operational bottlenecks and formulate targeted improvement strategies.

Nevertheless, several limitations should be acknowledged. First, both the influencing factors extracted via the LDA model and the constructed TISM model rely heavily on expert judgments, which may introduce subjectivity into the analytical results. Future research may adopt statistical and quantitative validation methods to further examine these influencing factors. Second, this study primarily provides a macro-level theoretical analysis and lacks empirical validation based on real-world company cases, which may limit the practical applicability and contextual specificity of the findings. Future studies are encouraged to conduct comparative case analyses involving representative logistics companies and develop more practice-oriented research frameworks to enhance the robustness and managerial relevance of the conclusions.

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Appendix A

Table A1. Preliminary “topic–word” matrix in English corpus.

Topic	Words
Topic 1	service, provider, party, customer, enterprise, quality, commerce, value, model, paper, competitive, satisfaction, business, market, important
Topic 2	performance, outsourcing, relationship, finding, research, firm, factor, purpose, effect, capability, limited, implication, knowledge, literature, publishing
Topic 3	company, management, process, industry, business, research, case, outsourcing, activity, operation, paper, organization, analysis, approach, framework
Topic 4	sustainable, transport, sustainability, environmental, springer, chapter, economic, nature, author, outsourcing, practice, offshoring, development, integration, challenge
Topic 5	global, production, firm, outsourcing, value, market, international, impact, economy, country, structure, economic, policy, social, right
Topic 6	China, food, agricultural, development, fresh, trade, blockchain, national, region, regional, Chinese, producer, country, product, consumption
Topic 7	data, carrier, digital, learning, energy, based, system, city, smart, job, user, architecture, IoT, thing, technology
Topic 8	model, cost, problem, distribution, transportation, proposed, time, based, order, demand, paper, algorithm, result, multi, solution
Topic 9	risk, management, strategy, information, control, cold, social, effective, public, technique, high, structural, key, challenge, action
Topic10	sourcing, warehouse, disruption, material, uncertainty, capacity, plant, shipping, recovery, transaction, strategy, resilience, picking, market, frequency
Topic 11	decision, criterion, selection, method, fuzzy, making, evaluation, approach, proposed, provider, based, multi, ahp, weight, process
Topic 12	delivery, freight, mechanism, financial, urban, driver, mile, center, pollution, run, fuel, province, grey, finance, footprint
Topic 13	procurement, pharmaceutical, fashion, south, power, organisation, brand, conflict, auction, acquisition, editorial, battery, African, Africa, electric
Topic 14	manufacturer, outsourcing, profit, strategy, decision, game, mode, price, product, production, enterprise, pricing, market, model, optimal
Topic 15	contract, retailer, product, cost, sharing, channel, quality, coordination, information, platform, online, decision, level, price, retail
Topic 16	emission, carbon, policy, remanufacturing, closed, government, container, loop, environmental, waste, recycling, low, impact, phone, trade

Table A1. *Cont.*

Topic	Words
Topic 17	network, collaborative, collaboration, design, resource, information, sharing, fourth, truck, flow, hub, algorithm, node, graph, optimization
Topic 18	problem, vehicle, routing, shipper, scale, instance, route, search, linguistic, location, time, fleet, tax, solved, interval
Topic 19	technology, green, review, research, scm, cloud, lsps, practice, management, literature, adoption, future, paper, innovation, industry
Topic 20	supplier, manufacturing, outsourcing, design, reverse, product, construction, group, component, cluster, buyer, attribute, vendor, trust, security

Table A2. Preliminary “topic–word” matrix in Chinese corpus.

Topic	Words
Topic 1	service, conduct, coordination, system, production, demand, network, selection, food, third party, model, this paper, based on, propose, customer
Topic 2	mode, reverse, e-commerce, third party, development, conduct, platform, selection, logistics distribution, construction, problem, B2C, e-commerce, operation, government
Topic 3	relationship, third party, influence, performance, cooperation, theory, conduct, integration, mode, this paper, quality, through, effect, capability, operation
Topic 4	supply chain, retailer, decision, profit, third party, mode, influence, service, cost, supplier, coordination, model, system, strategy, revenue
Topic 5	financing, third party, supply chain, cost, disassembly, vegetable, vaccine, can, influence, fund, credit, mode, bank, guarantee, realization
Topic 6	development, manufacturing, logistics, industry, China, linkage, service, economy, level, coordination, promotion, sector, two industries, propose, this paper
Topic 7	distribution, e-commerce, mode, chain, logistics distribution, cost, supermarket, shopping, selection, demand, route, problem, product, vehicle, influence
Topic 8	procurement, 3PL, system, profit, cluster, retailer, supply chain, region, management, influence, third party, resource, demand, improvement, model
Topic 9	supply chain, manufacturer, dominance, service, recycling, mode, strategy, self-operated, seller, selection, influence, closed-loop, cost, retailer, third party
Topic10	company, selection, evaluation, service provider, conduct, supplier, management, indicator, service, this paper, business, theory, synthesis, indicator system, through
Topic 11	risk, conduct, outsourcing, evaluation, factor, propose, through, business, this paper, process, model, selection, transportation, assessment, mode
Topic 12	business, control, mode, performance, influence, decision, model, outsourcing, home appliance, conduct, small and medium enterprise, society, retail industry, management control, third party
Topic 13	risk, manufacturing, distribution, 3PL, outsourcing, equipment, time, contract, conduct, outsourcer, risk management, 4PL, optimal, process, effort
Topic 14	distribution, mode, e-commerce, selection, cost, platform, agricultural products, O2O, conduct, problem, pricing, center, self-operated, through, model
Topic 15	linkage, development, two industries, logistics industry, conduct, forecast, data, model, supply chain, mode, manufacturing, platform, integration, through, propose
Topic 16	management, cost, company, problem, development, business, conduct, outsourcing, control, this paper, supply chain, existence, through, propose, project

Table A2. Cont.

Topic	Words
Topic 17	risk, manpower, outsourcing, human resources, resource management, conduct, implementation, evaluation, response, identification, theory, company, China, competition, customer
Topic 18	third party, supplier, supply chain, fourth party, development, problem, incentive, service, conduct, selection, model, theory, through, agency, emission reduction
Topic 19	transportation, model, customer, algorithm, problem, service, cost, conduct, demand, route, solution, satisfaction, outsourcing, optimization, selection
Topic 20	cross-border, third-party, development, mode, e-commerce, China, railway, service, conduct, e-commerce, efficiency, trade, influence, training, management

Appendix B

Table A3. Final reachability matrix (8 experts).

Factor	F1	F2	F3	F4	F5	F6	F7
F1	1	1	1	1	1	1	1
F2	1	1	1	1	1	1	1
F3	1	1	1	1	1	1	1
F4	0	0	0	1	0	1	0
F5	1	1	1	1	1	1	1
F6	0	0	0	0	0	1	0
F7	0	0	0	0	0	1	1

Table A4. List of CSPs and their levels in TISM (8 experts).

Factor	Description	Level in TISM
F1	Resource management level	III
F2	Logistics service level	III
F3	Market competition	III
F4	Risk factors	II
F5	Outsourcing service level	III
F6	Operational costs	I
F7	Sustainability benefits	II

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