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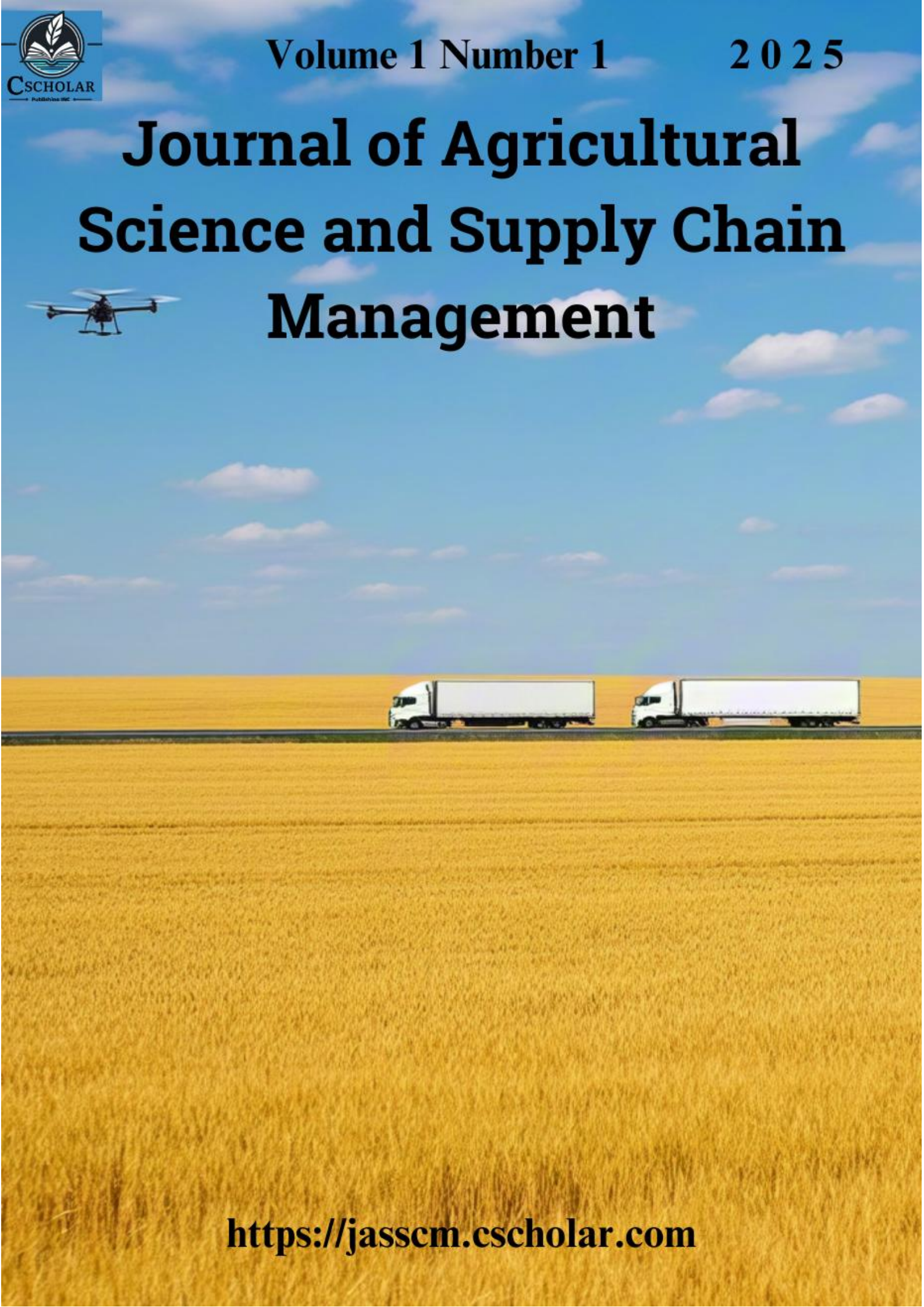

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Towards a New Era of Intelligent, Green, and Integrated Agricultural Industry and Supply Chains

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Abstract

Against the backdrop of multiple challenges such as population growth, climate change, resource constraints, and evolving consumption demands facing the global agricultural industry chain and supply chain, the Journal of Agricultural Science and Supply Chain Management has been launched. This journal focuses on cutting-edge issues in the intelligent, green, and integrated transformation of agricultural systems, and is committed to promoting the deep integration of agricultural science, supply chain management, information technology, and other disciplines. It emphasizes key topics including the application of agricultural technologies and low-carbon mechanisms, digital supply chains and smart logistics, innovation in agricultural product circulation systems, and agricultural strategy and sustainable development. The journal aims to establish a high-level, interdisciplinary international academic exchange platform to foster knowledge innovation and technology transfer, providing theoretical support and practical pathways for building a more resilient, efficient, equitable, and sustainable global agricultural industry and supply chain system.

Keywords: Agricultural Industry Chain; Digital Supply Chain; Smart Logistics; Low-Altitude Economy; Low-Carbon Technologies

1. Introduction

Amidst multiple challenges and profound transformations facing global agricultural industry and supply chain systems, we are pleased to announce the official launch of the Journal of Agricultural Science and Supply Chain Management. This journal is dedicated to promoting the deep integration of modern agricultural industry science with supply chain logistics management and information technology. It focuses on cutting-edge issues in the intelligent, green, and integrated transformation of modern agricultural industry and supply chains, aiming to establish an interdisciplinary, high-level international academic exchange platform serving academia, industry, and policymakers in the global fields of agriculture and supply chain logistics.

2. Background and Journal Mission

As the cornerstone of human civilization, agriculture is not only fundamental to global food security but also a crucial support for socio-economic stability and sustainable development[1]. With the continuous growth of the global population, intensifying climate change, increasing strain on natural resources, shifts in the geopolitical landscape, and rising consumer demands for food quality, safety, and sustainability, traditional agricultural industry and supply chain systems are facing unprecedented systemic pressures[2]. Against this backdrop, emerging concepts and technologies such as smart agriculture, digital supply chains, smart logistics, the low-altitude economy, the low-carbon economy, and ESG (Environmental, Social, and Governance) are profoundly reshaping the organizational methods, operational efficiency, and development pathways of traditional agricultural industry and supply chains.

The complexity of agricultural systems dictates that their transformation relies not only on breakthroughs in single technologies but more so on collaborative innovation across multiple disciplines and fields. Traditional agricultural disciplines such as crop science, animal science, soil science, and agricultural engineering remain the foundation of agricultural modernization[3][4]. However, in the era of digitalization, networking, and intelligence, the future of agriculture depends more on its cross-integration and systemic convergence with supply chain management, data science, logistics engineering, environmental policy, regional economics, information technology, social sciences, and other disciplines. This convergence involves not only technological integration but also comprehensive collaboration in methodology, knowledge systems, and institutional design.

The establishment of this journal is precisely based on a profound insight into and active response to this era of change. We recognize that the modern transformation of agricultural industry and supply chains is not merely a technical issue, but a systemic project involving multiple dimensions such as economy, society, environment, and policy[5]. Therefore, the mission of this journal is to: promote the systematic integration of agricultural science with digital technology and supply chain logistics management; facilitate the synergistic development of knowledge innovation, technology application, and institutional design; and provide solid academic support for building more resilient, efficient, equitable, and sustainable global agricultural industry and supply chain systems.

Specifically, the journal will commit to the following tasks: First, to build a truly interdisciplinary exchange platform, encouraging scholars from different fields to engage in in-depth dialogue on common issues in agriculture and supply chains. Second, to promote the translation from basic research to applied research, facilitating the practical implementation and promotion of scientific and technological achievements within agricultural industry chains. Third, to address inequality issues within global agricultural supply chains, advocating for more equitable and inclusive agricultural development models. Fourth, to strengthen research on the resilience, risk prevention and control, and sustainable development pathways of agricultural supply chains, providing theoretical foundations and practical guidance for addressing future uncertainties.

3. Journal Positioning and Core Themes

As an international and interdisciplinary academic journal, we adhere to the publishing philosophy of "problem-oriented, interdisciplinary integration, international perspective, and practical value." We will primarily focus on the following four major research clusters, covering the entire spectrum of topics from technological application to strategic management:

3.1. Application of Agricultural Science & Technology and Economic Mechanisms

This cluster focuses on the innovative application of cutting-edge technologies at the forefront of agricultural production and the industry chain, along with their economic and management value. With the rapid development of technologies such as intelligent agricultural machinery and robotics, agricultural big data analytics, precision farming, and low-altitude equipment like drones, agricultural production is transitioning from experience-dependent to data-driven, and from labor-intensive to intelligent and efficient. We encourage research on the application scenarios, benefit assessment, business models, and impacts of these technologies on agricultural productivity, resource use efficiency, and farmer livelihoods. Concurrently, the policies and practices of low-carbon agriculture and ESG governance will also be key components of this cluster, aiming to steer agriculture towards greater environmental friendliness and clear social responsibility.

Specific research topics include, but are not limited to: integrated application of intelligent sensor technology and crop growth models; adaptive operation of agricultural robots in complex environments; farmland information acquisition and decision support based on remote sensing and IoT; agricultural data ownership and privacy protection mechanisms; economic incentives and policy support for the adoption of smart agricultural technologies; pathways and barriers for smallholder participation in digital agriculture. We will pay special attention to topics such as agricultural carbon footprint accounting, emission reduction technology pathways, ecological compensation mechanisms, and the application of green finance in agriculture, promoting a more active role for agriculture in addressing climate change.

3.2. Application and Operational Management of Digital Supply Chain & Smart Logistics Technologies

Supply chains and logistics are critical bridges connecting production and consumption in the national economy; their efficiency and resilience directly impact the overall performance of the agricultural system. This cluster focuses on both general and frontier supply chain and logistics management theories, and the application of digital technologies like Artificial Intelligence, providing methodological support for building modern agricultural industry and supply chains. Digital & Intelligent Supply Chains, Digital Twins, Blockchain & Traceability Technologies, Smart Logistics Systems, Green Supply Chains, Low-Carbon Logistics, Low-Altitude Logistics, and Transportation System Optimization are all core research areas within this cluster.

We encourage scholars to delve into questions such as: How to build a panoramic visualisation and simulation platform for supply chains based on digital twins? How can blockchain technology achieve a balance between cost and benefit in product traceability? How can AI algorithms enhance the response speed and accuracy of supply chains in demand forecasting, inventory optimization, and route planning? How can smart logistics reduce total societal costs? What are

the coverage models and operational efficiency of low-altitude logistics networks in rural and remote areas? We anticipate that through technological integration and innovation in operational models, we can systematically enhance the transparency, responsiveness, and risk resilience of supply chains, achieving value optimization across the entire chain.

3.3. Agricultural Industry Chain Optimization and Digital Agricultural Product Circulation Systems

The journey of agricultural products from field to fork involves multiple stages—production, processing, storage, transportation, and sales—and its complexity underscores the critical role of digital means. This cluster is dedicated to exploring how to leverage digital tools to integrate and optimize the entire agricultural industry chain, ensuring the efficient operation of the agricultural supply chain system. Research will concentrate on areas including blockchain technology application and the construction of agricultural product traceability systems; digital twins and agricultural product supply chain visualization; intelligent warehousing and cold chain logistics for agricultural products; agricultural product e-commerce and live-streaming commerce models; consumer insights and agricultural product brand building; geographical indication products and brand strategy; and the development of digital trading platforms.

We will focus particularly on how digitalization is reshaping the business models and organizational structures of agricultural product circulation. For instance, how can consumer behavior analysis based on big data guide precision marketing and product development for agricultural products? What impacts and opportunities do new business formats like live-streaming e-commerce bring to traditional agricultural product distribution channels? How can digital platforms effectively connect smallholders with broader markets? How can innovations in intelligent warehousing and cold chain technologies solve the bottlenecks at the "first mile" and "last mile" of agricultural product distribution? How can digital management and brand protection mechanisms for geographical indication products be established? Through rigorous academic research, we aim to advance the modernization, standardization, and branding of the agricultural product circulation system, effectively enhance the added value and market competitiveness of agricultural products, and contribute to increasing farmers' income and revitalizing rural industries.

3.4. Agricultural Industry Strategy, Sustainable Development, and Regional Coordination Mechanisms

This cluster focuses on macro-level strategy and systemic development issues, aiming to examine the sustainable development pathways of agricultural industry and supply chains from a higher dimension. Agriculture is not only an economic industry but also a strategic one vital to national well-being, ecological security, and social stability. Research themes include: ESG systems and green agricultural industry chains; food security and supply chain resilience; agricultural industry clusters and regional coordinated development; pathways for digital inclusion within the context of rural revitalization; and agricultural policy evaluation and institutional innovation.

We encourage scholars to explore the strategic role of agricultural industry and supply chains in promoting economic development, social equity, and ecological protection across global, national, and regional scales. Specifically, research could investigate risk identification and resilience-building strategies for national food supply chains amidst shifts in the global trade landscape; how ESG principles can be integrated into the strategic decision-making and performance evaluation systems of agricultural enterprises; the formation mechanisms, evolution patterns, and role in driving regional economies of agricultural industry clusters; the potential and pathways for digital technologies to promote rural revitalization and the inclusive development of smallholders; and the evaluation of implementation effects and optimization directions for various agricultural support policies (e.g., subsidies, insurance, green credit). This cluster aims to provide policymakers, industry leaders, and researchers with forward-looking strategic insights and evidence-based support.

4. Interdisciplinary Integration and Academic Contribution

This journal emphasizes interdisciplinary integration and methodological innovation. The challenges facing agricultural supply chains are systemic, and perspectives from any single discipline are insufficient to provide comprehensive solutions. We welcome research contributions from diverse fields including agricultural science, management science, transportation engineering, information science, environmental science, economics, sociology, geography, political science, law, and policy studies.

We encourage researchers to break down disciplinary barriers and employ diverse research methodologies. Whether it is rigorous empirical research, cutting-edge technological innovation, insightful theoretical modeling, in-depth case studies from the field, or reviews that systematically synthesize and offer critical reflection on a particular area – all fall within the journal's scope, provided they demonstrate academic rigor, originality, and practical value.

We firmly believe that by fostering the collision and integration of different disciplinary paradigms, theoretical schools, and research methods, we can catalyze the generation of new knowledge with greater explanatory power, predictive capacity, and transformative potential. This will, in turn, provide novel ideas and solutions for understanding and addressing the complex problems confronting global agricultural industry and supply chains.

5. Outlook and Acknowledgments

The launch of the Journal of Agricultural Science and Supply Chain Management has been made possible by the longstanding attention and steadfast support of colleagues in global academia, industry, and policy circles. We hope this journal becomes a significant vehicle for promoting knowledge innovation and practical advancement in the field of agricultural industry and supply chains, serving as a bridge connecting science and policy, technology and industry, and regions and the globe.

Looking ahead, we will adhere to fundamental principles such as open access, international peer review, and academic ethics. We will form an editorial board composed of leading global scholars, implement a strict double-blind peer-review process, and ensure the journal's academic quality, impartiality, and international influence. We also look forward to establishing extensive collaborations with domestic and international universities, research institutions, industry associations, enterprises, and government departments to jointly advance agricultural industry and supply chains towards greater intelligence, sustainability, and integration.

Finally, we take this journal as a platform to sincerely invite scholars from around the world to contribute your manuscripts and share your research findings and intellectual insights. Let us join hands to promote the integrated development of agricultural science and supply chain logistics management, and to collectively contribute academic strength towards building a safer, more efficient, inclusive, and sustainable global agri-food system.

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Research on the Optimization of Domestic Waste Recycling Network Under the Background of Low Carbon

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Abstract

To reduce the carbon emissions from waste collection vehicles, taking the representative Baolang Economic Development Zone in Shiyan City as an example, a two-stage urban domestic waste logistics collection and transportation model was established. In the first stage, the goal was to minimize the total distance, determining the optimal location for waste transfer stations. In the second stage, with the goal of minimizing total costs, and based on the determined optimal location of the transfer stations, the optimal waste collection vehicle routing was established. A genetic algorithm was designed to solve the optimal results for both stages, obtaining the best location for waste transfer stations and the optimal transportation routes for the Baolang District in Shiyan City. The optimization was compared and showed significant results. Finally, in light of the actual situation of domestic waste in the urban area of Shiyan City, suggestions were made to optimize the urban domestic waste collection network.

Keywords: Green and Low-Carbon; Garbage Collection and Transportation; Logistics Network; Optimization Model; Vehicle Path Problem

1. Introduction

In recent years, the production of urban household waste has been on the rise, making the efficiency and management of waste disposal an urgent issue to address. Waste reduction through carbon emission is one of the five key areas for achieving the dual carbon goals. How to effectively sort waste and how to reduce carbon emissions during the collection and processing of waste are crucial for realizing green and low-carbon urban development. In 2021, the State Council pointed out in the "Notice on the Comprehensive Work Plan for Energy Conservation and Emission Reduction during the 14th Five-Year Plan Period" that urban sanitation cleaning and transportation are among the targets of China's transportation and logistics energy conservation and emission reduction projects. In response to these directives, the integration of

waste collection route optimization models has emerged as a key technological pathway. These models utilize algorithms such as the Vehicle Routing Problem (VRP), Ant Colony Optimization (ACO), and Genetic Algorithms (GA) to intelligently plan waste collection paths that minimize total distance traveled, avoid redundancy, and reduce vehicle idling time. By dynamically adjusting collection schedules based on real-time waste generation data and road traffic conditions, these models help significantly reduce fuel consumption and associated carbon emissions.

Moreover, the application of such intelligent systems ensures that sanitation vehicles operate with maximum logistical efficiency, aligning with the 14th Five-Year Plan's call for smart and green urban infrastructure. Cities like Shanghai and Shenzhen have begun pilot projects where AI-powered route optimization has led to emission reductions of over 15% in certain districts, serving as evidence of the practical benefits of these systems.

In summary, the quality of construction and operation of urban household waste recycling networks directly impacts local urban environmental hygiene and green low-carbon development.

Waste collection network optimization is a complex and multifaceted issue, involving multiple disciplines such as engineering, management, operations research, and environmental science. Liu (2011) started from the practical needs of waste collection in small and medium-sized cities, constructing a scheduling and path optimization model for green and low-carbon vehicles. This research provides theoretical support for scientifically and efficiently conducting waste collection work; In the process of studying urban waste collection system construction, Jia (2006) drew on the concept of reverse logistics system location selection, applying a set cover model to screen and optimize candidate waste transfer station locations according to the specific requirements of the system; During the waste collection process, Wang (2013) developed an indicator system based on the characteristics and content of carbon emissions. Using basic theories from operations research, he proposed a formula for calculating carbon reduction after optimizing the waste collection system, concluding that carbon reduction in the waste collection system is a crucial aspect of building a low-carbon city. In the study of urban waste collection system optimization, foreign scholar Caroline Lavigne (2021) proposed an optimization model for the biological waste collection problem in the Brussels Capital Region. The model uses mixed integer linear programming to optimize waste collection routes, considering multiple waste stations, vehicles with capacity, intermediate processing facilities, and multiple collections. By minimizing transportation costs, it evaluates the financial feasibility of different collection schemes. At the front end of waste collection and transportation, Teemu Nuortio (2005) identified collection issues as one of the most challenging operational problems. He proposed a conceptual model for addressing these issues and several methods to accelerate speed and reduce memory usage in real-world waste collection scenarios. The results showed that compared to current practices, the cost of waste collection in this region was significantly reduced. Regarding cross-regional waste collection and transportation, Wei Zeming noted that while the currently adopted MSW sub-regional operation and disposal model has brought convenience to management, it suffers from inflexible vehicle scheduling and low efficiency due to the limitations of operational area

divisions. To address these issues, he proposed an improved Hierarchical Agglomerative Clustering (IHAC) algorithm and a Waste Collection Path Planning (GCPP) algorithm.

For the optimization of waste collection networks, scholars both domestically and internationally have conducted extensive research. However, these discussions still fall short when viewed from the perspective of China's green and low-carbon context. Currently, studies on urban household waste collection networks in China are just beginning, lacking systematic and comprehensive approaches. Most research focuses on policy, with a lack of data-driven and quantitative studies. More scientific design and technical means are needed to address urban household waste collection issues from a green and low-carbon perspective. Based on this, this paper will comprehensively consider the aforementioned issues, using the Bailang Development Zone as an example to analyze its current status and problems in waste management. By leveraging existing data, it aims to reasonably predict future waste production. The paper will also explore and develop new optimization algorithms and models to provide more accurate and efficient solutions. These innovations in methods and technologies can not only be applied to the field of waste collection but also promote development in other related areas, such as logistics management

2. Construction of Garbage Recycling Network Model

2.1. Problem Description

Mixed collection is the primary model currently adopted by urban waste collection systems. The front end employs a circular transportation model, while the middle end uses a vehicle dispatch system and the "five fixed" measures. The waste recycling network includes various terminal collection points, transfer stations, incineration plants, and landfills. Household waste is collected from community points by transport vehicles, then transported to transfer stations for compression processing, and finally sent to waste treatment facilities for disposal (Tian, 2012).

Given that a certain sanitation base has a collection of garbage transport vehicles, S waste transfer stations, L, and garbage collection points, N, the problem of scheduling and optimizing routes for green and low-carbon transport vehicles can be described as follows: Based on waste sorting, transport vehicles depart from the sanitation base to reach various garbage collection points. Under the constraints of vehicle load capacity and time windows, waste is collected and transported to loading stations, and then sorted according to its type before being delivered to different processing facilities for disposal. On this basis, with the goal of minimizing costs, the first stage involves determining the optimal location of transfer stations to minimize transportation distance, thereby reducing logistics costs; the second stage focuses on minimizing both fixed and variable costs of garbage collection vehicles. Throughout these two stages, measures are taken to reduce environmental negative impacts. This approach aims to solve the problems of selecting transfer station locations and vehicle scheduling (Wen et al., 2015).

2.2. Build Goals

When dealing with complex problems, decisions can be made in stages, using the optimal solution from the first stage as the initial condition for the second stage decision-making process. This involves finding the most optimized solution again. The optimization at both levels is interconnected and works together to address the entire problem, ultimately achieving a comprehensive and meticulous optimization goal. The specific objective of the two-stage planning described in the text is to minimize total costs: the costs involved in waste collection mainly consist of two parts—cost generated by the location selection of transfer stations, and the cost incurred by the waste collection routes (Li et al., 2023). Specifically, this includes the investment in constructing waste transfer facilities, subsequent operation and maintenance expenses, as well as the movement costs and fixed expenses of collection vehicles during their tasks in the second-stage model. Waste collection costs account for a significant portion of the overall cost of the recycling system, so the aim of the text is to save costs by optimizing waste collection routes.

2.3.Model Assumptions And Symbolization

2.3.1. Basic Assumption

According to the above problem description, considering the characteristics of urban household waste reverse logistics network and the feasibility of mathematical model, the following assumptions are put forward for the main body in the recycling network before the establishment of the model (An, 2022):

(1) Transport vehicles

1) The road is smooth, and there are no abnormal conditions such as congestion or vehicle failure.

2) The process from the transfer station to return to the transfer station is equal to one trip. When the carrying capacity and working time of the vehicle allow, multiple trips can be carried out;

3) The driving distance between the nodes is the straight line distance, and the driving speed is a fixed average speed and remains unchanged.

(2) Transfer points

1) The geographical location of the transfer station is known, and the parking lot of the transport vehicle and the transfer station are located in the same place;

2) The capacity of the constructed garbage transfer station is sufficient to carry out garbage sorting, compression and temporary storage.

(3) Collection points

1) Collection points are based on communities;

2) The capacity of the collection point is sufficient.

(4) Household waste

1) The garbage transported to the waste treatment plant is located in the same transfer station;

2) The output of all kinds of garbage at the collection point is fixed and will not increase or decrease.

(5) Others.

1) All waste recycling is carried out only in the recycling network constructed in this paper:

2) The variable cost is positively correlated with the transportation distance of the vehicle, and there are no other factors.

2.3.2. Symbol Description

(1) Parameters and sets

1) Transport vehicles

M = {m=1,2,3,..., M} is set as the collection of garbage collection vehicles, and m is the element number; N = {n =1,2,3,..., N} is set as the garbage collection vehicle set, and n is the element number; P = {p=1,2,3,..., P} is set as the collection of garbage transfer vehicles, and P is the element number; R = {r =1,2,3,..., R} is set as the set of garbage transfer vehicles, and r is the element number; Cm is the fixed cost of garbage collection and transportation vehicle, Fm is the variable cost of garbage collection and transportation vehicle; Cp is the fixed cost of garbage transfer vehicle, Fp is the variable cost of garbage transfer vehicle; Qm is the load limit of garbage collection and transportation vehicle; Qp is the load limit of garbage transfer vehicle; TM is the working time of the collection and transportation vehicle; Tp is the working time of the transfer vehicle.

2) Transfer stations and treatment plants

U = {u|u =1,2,3,....., a} is the set of existing garbage transfer points, indicating that there are a total of a garbage transfer points; Y = {v|v =1,2,3,.....,b} is the set of candidate points for garbage transfer, indicating that there are b candidate points; Z = {z =1,2,3,..., c} is set as the collection of waste treatment plants, indicating that there are c waste treatment plants in total;

Lzv is the distance from waste transfer point v to waste treatment plant z; Tv is the loading and unloading time at the waste transfer point v; Z is the unloading time at the waste treatment plant z; Cv is the final investment cost of establishing a comprehensive transfer station at v; C is the total cost of operating a transfer station; Qv is the maximum capacity of the waste transfer station.

3) Collection points

H = {h =1,2,3,....., d} is the set of garbage collection points, indicating that there are d collection points; Qh is the total population of garbage collection point h; Th is the loading and unloading time at the garbage collection point h.

4) Household waste

S= {s = 1,2,3,..., S} is the number of garbage types; Qh is the amount of garbage generated at collection point h.

5) Others

Lij is the transportation distance from node i to j; Tij is the transportation time from node i to j, and Lij =vtij; Cv is the final investment cost of establishing a comprehensive transfer station at v; E is the negative environmental utility of the residential unit.

(2) Decision variables

Xnij = 1, the number of garbage collection and transportation vehicles n from node i to node j, i = j Zero, otherwise Ynm = 1, the number of vehicles corresponding to the number of garbage collection and transportation trips n is m Zero, otherwise Ypr = 1, the number of r trains transporting garbage corresponds to the vehicle number p Zero, otherwise Whu = 1, the garbage from collection point h is transported to transfer station u Zero, otherwise Bv = 1, and a transfer station is built at v Zero, otherwise Duz = 1, the garbage from transfer station u is transferred to treatment plant z Zero, otherwise.

2.3.3. The First Stage is Site Selection

(1) Model assumptions.

1) Suppose that the garbage collection station is concentrated at a point;

2) It is assumed that the construction and operation costs of transfer stations in different regions are equal;

3) Transportation costs are proportional to the distance, without considering the change of future transportation costs;

4) The transportation route is a spatial straight line, without considering the actual traffic conditions.

(2) Model establishment

The optimal location of the transfer station in the network is obtained by using the center of gravity method, and the longitude and latitude are used as coordinates. In this paper, Baidu Map is used to establish coordinates. According to the horizontal and vertical coordinate values of each point, the X-coordinate and Y-coordinate of the optimal position are obtained. The precise center of gravity method site selection model is as follows (Shao, 2021).

Let n garbage collection sites, whose coordinates are (xi, yi); Cj is the unit transportation rate from the collection site to the incineration power plant; Qj is the amount of waste transported from each collection site to the incineration power plant; Cj is the transportation rate from the collection site to the incineration power plant.

$$\overline{x} = \sum_{j=1}^{n} c_j q_j X_j \div \sum_{j=1}^{n} c_j q_j \quad \bar{y} = \sum_{j=1}^{n} c_j q_j, y_j \div \sum_{j=1}^{n} c_j q_j (\bar{x}, \bar{y})$$

(3) Model solving

Taking coordinates (0,1) in the coordinate map, we can get the actual address of this point as Jianchigou, Bailing Town, Zhangwan District, Shiyan City. Take Jianchigou, Bailing Town, Zhangwan District, Shiyan City as the origin of coordinates.

Figure 1. Establish a rectangular coordinate system for waste incineration power plants

The coordinates of the waste incineration power plant serving each urban area can be obtained as follows:

$$\overline{x_1} = 17.406, \overline{y_1} = 27.111; \quad \overline{x_2} = 23.0705, \overline{y_2} = 7.68$$

Therefore, according to the precise center of gravity method, the coordinates of the two optimal locations are (17.406,27.111) and (23.0705,7.68), meaning that establishing a waste transfer station at these locations can minimize the overall transportation distance. According to the coordinate map, the two transfer stations are located in Matangou Village, Yunyang District, and Bailang Economic Development Zone, respectively.

2.3.4. Model Construction in the Second Stage

In the optimization process of household waste recycling systems, a critical aspect involves route planning for vehicles. By using the precise center of gravity method to determine the location of transfer stations, it is possible to further clarify the optimal routes from waste collection points to transfer stations and from transfer stations to waste processing facilities. The core of this approach lies in designing an efficient and economical route to minimize the overall cost of the entire waste recycling process.

objective function:

$$\min G_1 = \sum_{m=1}^{M}\sum_{s=1}^{S} C_m + \sum_{m=1}^{M}\sum_{p=1}^{P} C_P + C \sum_{s=1}^{S}\sum_{n=1}^{N}\sum_{i=1}^{b}\sum_{j=1}^{d} l_{ij} X_{nij} F_m + 2 \sum_{s=1}^{S}\sum_{r=1}^{R}\sum_{i=1}^{d}\sum_{c=1}^{c} l_{ij} X_{pij} F_p$$

It shows that the total cost is the lowest in the path optimization of garbage collection network optimization.

Total cost = fixed cost of vehicle + variable cost + garbage sorting cost Waste sorting cost = labor cost + time cost

constraint condition:

$$C_S = a \sum_{h=1}^{d}\sum_{s=1}^{S} Q_h^s$$

The sum of the sorting costs for all types of waste

$$\sum_{i=1}^{b}\sum_{j=1}^{d} Q_h^s X_{nij}^S \le Q_m^s, \forall s \in S, h \in H$$

Load restrictions for garbage collection vehicles.

$$\sum_{h=1}^{H} Y_{nm}^{S} \left[\sum_{i=1}^{b}\sum_{j=1}^{d} \left(t_{ij} + t_h\right) X_{nij}^S + t_v \right] \le t_m \ ,$$
$$\forall s \in S, n \in N, m \in M$$

$$\sum_{h=1}^{H} Y_{pr}^S \left[\sum_{i=1}^{b}\sum_{j=1}^{c} \left(2t_{ij} + t_v + t_z\right) X_{rij}^S + t_v \right] \le t_p$$
$$\forall s \in S, r \in R, p \in P$$

Ensure that the vehicle is operating within the required time frame.

2.3.5. Model Solving Algorithm Design

Genetic algorithms primarily consist of three basic operations: selection, crossover, and mutation. The mutation phase involves genetic mutations at certain positions in an individual, promoting diversity among new individuals to enhance the local search capability of genetic algorithms (Wang, 2011). Solution steps: the second stage path optimization is divided into two segments, first is the path optimization from collection points to transfer stations, followed by the path optimization from transfer stations to processing plants.

(1) encoding The article employs a coding system based on natural numbers to identify waste collection points and transfer stations. The last digit of each code indicates the transfer station for

that area. All waste collection vehicles must start from the transfer station and return to the starting point after completing their collection route. Assuming the chromosome length is n, in a chromosome of length 10, there are the following coding sequences: {10,8, 6, 5, 10,1, 3, 10,4, 2, 10,7, 9, 10}. Numbers 1-9 represent collection points, while number 10 represents the transfer station. The plan is represented as follows: there are four routes in total. The first route indicates that the waste collection vehicle starts from Transfer Station 10, visits Collection Points 8, 6, and 5 in sequence, then returns to Transfer Station 10; the second route indicates that the waste collection vehicle starts from Transfer Station 10, visits Collection Points 1 and 3 in sequence, then returns to Transfer Station 10; the third route indicates that the waste collection vehicle starts from Transfer Station 10, visits Collection Points 4 and 2 in sequence, then returns to Transfer Station 10; the fourth route indicates that the waste collection vehicle starts from Transfer Station 10, visits Collection Points 7 and 9 in sequence, then returns to Transfer Station 10.

(2) Initialize the population In the program, (n-1) collection points are randomly arranged first. According to the load capacity of the garbage collection vehicle and the production of this kind of garbage in the randomly combined collection points, it is determined whether the transfer station needs to be returned.

(3) Fitness function The fitness function is the formula for calculating the fitness of individuals in the population. The second stage fitness function is the objective function of the second stage, as shown in Equation (9). Let the total cost function of chromosome i be G2(i). Therefore, the function fi(x1) of chromosome 1 in the second stage is expressed as (9) .

$$f_i(x_1) = \frac{1}{G_{2(i)}}$$

(4) Choice The objective function of the second-stage model is to minimize total cost. Therefore, in this stage, the genetic algorithm adopts an elite strategy to operate on the data from the parent population. The specific steps are as follows: First, evaluate the fitness of each individual in the population from the second step, and retain the individuals with the highest and lowest fitness scores. Then, replace the individuals with lower fitness scores, and genetically transmit the optimal individual to the offspring population, repeating this process.

(5) Cross In the crossover process, in order to avoid the occurrence of illegal decoding and improve the effectiveness of the crossover process, partial matching crossover method is adopted.

(6) Variation Except for the last number, the sequence in the substring is randomly reordered again. For example, {6,8,9,10} is randomly reordered to get the new substring {9,6,8,10}.

3. Example Analysis

To facilitate the analysis of the effectiveness of the optimized model, this paper takes the Bailang District under Shiyan City as an example, which has similar issues with garbage collection in the urban area of Shiyan City, to optimize the household waste recycling network. The current "one vehicle per community" model not only reduces the operational efficiency of

vehicles but also exacerbates unnecessary resource consumption and adds extra pressure on sorting centers.

3.1. The Calculation Process and Results

In this paper, it is necessary to carry out subsequent calculation according to the location of the site in order to minimize the fixed cost and variable (transportation) cost, and to plan the vehicle path from each community to the garbage transfer station. The genetic algorithm is used to realize the model through 2020b to get the optimal solution of the path.

(1) Algorithm parameter setting

When solving the problem with MATLAB2020b, the genetic algorithm in the model is set up by consulting the literature (Wang et al., 2025; Gao et al., 2025), as shown in Table 1.

Table 1. Model parameter setting

Genetic algorithm parameter setting	Magnitude
Population size	200
Cross probabilities	0.9
Probability of mutation	0.05
Maximum number of iterations	400

3.2. Result Analysis

When solving the problem, divide the path from the waste collection point to the waste treatment plant into two segments for processing. The first segment is from the collection point to the transfer station, and the second segment is from the transfer station to the treatment plant. For convenience of expression, kitchen waste trucks, recyclable waste trucks, and other waste trucks are named Class A vehicles, Class B vehicles, and Class C vehicles.

The first phase of the garbage collection network in Nanyuanmen Street, Bai Lang District, was equipped with 5 collection vehicles, with a total cost of 2347.77 yuan per day and a total distance of 14.4 kilometers. Among these, 3 food waste collection vehicles were provided, with a daily operating cost of 1213.05 yuan; 1 recyclable waste collection vehicle, with a recycling waste cost of 733.57 yuan per day; and 1 other waste collection vehicle, with a daily maintenance fee of 397.15 yuan. The numbers corresponding to the driving routes for each community are listed in Table 2.

Table 2.The first stage of household garbage collection and transportation vehicle dispatching scheme

	Vehicle type	Number	Route of travel
First stage	A	1	100-7-100
		2	100-6-5-2-100
		3	100-1-3-4-8-100
	B	1	100-8-1-2-3-4-5-6-7-100
	C	1	100-8-1-2-3-4-5-6-7-100

In the second stage, only vehicle scheduling for kitchen waste and other garbage is required. The harmless waste treatment plant is numbered 104. The specific vehicle scheduling is shown in Table 3.

Table 3. The second stage of household garbage collection and transportation vehicle dispatching scheme

	Vehicle type	Route of travel
Second stage	A	104-99-103-100-102-104
	C	104-99-103-100-102-104

3.3. Optimize Results

According to the garbage recycling mode before optimization in Bailang District, Shiyan City, the optimal total network cost, vehicle running distance and total number of vehicles before optimization were calculated by using MATLAB 2020b under the condition that transportation cost and driving distance remained unchanged, and the results before and after optimization were compared, as shown in Table 4.

Table 4. Comparison of operation schemes before and after running

	Total cost/yuan	Vehicle running distance/km	Number of vehicles	Carbon emission/kg
Before	9615.38	98.67	12	648.85
Now	6763.79	77.74	9	383.41

As can be seen from Table 4, the total daily garbage collection cost is reduced by 2851.59 yuan before and after optimization, and the vehicle running distance is shortened by 20.93km.

$$Y(CO_2) = \psi H \rho M \times 10^{-3} / m$$

In the formula: Ψ is the carbon emission factor for diesel/gasoline, which is 20.2 kg/GJ and 18.9 kg/GJ, respectively, as obtained from the IPCC guidelines; H is the calorific value of diesel/gasoline, in kJ/g; ρ is the density of diesel/gasoline, in g/ml; M is the molar mass of carbon dioxide, taken as 44; m is the molar mass of carbon in carbon dioxide, taken as 12. After calculation, the CO2 emissions per liter of diesel and gasoline are 2.74 kg/L and 2.47 kg/L, respectively. According to relevant research, the average fuel consumption of garbage collection vehicles used in urban areas is 15-20 L/100 km.

According to Equation , it can be calculated that the daily carbon emission reduction before and after optimization can be reduced by 8.602-11.46 kg. The annual emission reduction can reach 3139.73-4182.9 kg.

4. Conclusions and Discussion

4.1. Conclusions

This paper takes the Bailang District of Shiyan City as an example, aiming to minimize total costs, and optimizes the urban household waste recycling network in two stages, constructing an optimization model for the household waste recycling network. The first stage determines the optimal location for waste transfer stations; the second stage establishes a model to find the best route for waste collection. Research findings show that using logistics models to optimize the layout of waste stations and vehicle routes across the city reduces the daily total cost of waste collection by 2851.59 yuan before and after optimization, shortens the vehicle operation distance by 20.93 km, and achieves an annual reduction in emissions ranging from 3139.73 to 4182.9 kg. If proper sorting, transportation, and timed disposal systems are implemented, the waste collection and transportation costs and carbon emissions in Shiyan can be significantly reduced, achieving a clean space free of waste for most of the time, providing the best experience for creating green and low-carbon demonstration zones and zero-waste cities. Therefore, we recommend that relevant units adopt this technical approach to recalculate the distribution points and vehicle routes of our city's waste transfer stations and compression stations, aiming to achieve the optimal cost solution. Additionally, efforts should be made to promote the simplified classification method using the dichotomy approach, establish a paid recycling system for hazardous waste, and cultivate residents' civilized and hygienic habits of sorting and disposing of garbage at designated times and locations. These measures will help improve transportation efficiency and reduce costs.

4.2 Shortcomings and Prospects

This study aims to minimize total costs, overlooking other potential objective factors such as vehicle capacity, traffic conditions, and local environmental policies. Future research could consider the following aspects: 1) traffic conditions at different times; 2) varying vehicle capacities; 3) the impact of road conditions or steep slopes on vehicle transportation; 4) whether local environmental policies can be leveraged to set up waste transfer stations and compression facilities at optimal locations.

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Integrating Sustainable Supply Chain Practices in Agricultural Production: Evidence from Emerging Economies

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Abstract

This study explores the integration of sustainable supply chain practices (SSCP) in agricultural production within emerging economies, focusing on their impact on operational efficiency and environmental performance. Using a qualitative approach, data were collected from 150 agricultural firms in Brazil, India, and Nigeria. SPSS ANOVA analysis was employed to examine variations in SSCP adoption across firm sizes and regions. Findings reveal significant differences in adoption rates, with larger firms and those in Brazil showing higher integration of SSCP. Two hypotheses were tested: (H1) SSCP adoption enhances operational efficiency, and (H2) SSCP adoption improves environmental performance. Both hypotheses were supported, indicating that sustainable practices contribute to cost reduction and reduced environmental impact. The study underscores the need for tailored policies to promote SSCP in smaller firms and less-developed regions.

Keywords: Sustainable Supply Chain Practices; Agricultural Production; Emerging Economies; ANOVA Analysis; Operational Efficiency; Environmental Performance

1. Introduction

Sustainable supply chain practices (SSCP) have gained prominence as firms seek to balance economic profitability with environmental and social responsibility. In emerging economies, where agriculture is a cornerstone of economic development, integrating SSCP can address challenges such as resource depletion, climate change, and market competitiveness. Despite growing interest, empirical evidence on SSCP adoption in agricultural production within emerging economies remains limited. This study investigates how SSCP influences operational efficiency and environmental performance, using a sample of agricultural firms in Brazil, India,

and Nigeria. The research employs ANOVA analysis in SPSS to explore variations in SSCP adoption and tests two hypotheses to assess its impacts. The findings aim to inform policymakers and practitioners on fostering sustainable agricultural systems.

Sustainable supply chain practices (SSCP) have become a focal point in global agricultural discourse, particularly as firms in emerging economies navigate the dual imperative of economic growth and sustainable development. Agriculture plays a pivotal role in these economies, not only as a source of food and employment but also as a key contributor to GDP. However, issues such as inefficient resource use, environmental degradation, and climate-related disruptions persist. The motivation behind this study arises from the need to explore how integrating SSCP within agricultural supply chains can mitigate these challenges while enhancing firm-level performance. Specifically, this research is driven by two primary questions: (1) How does the adoption of SSCP vary across agricultural firms in emerging economies? (2) What are the effects of SSCP on operational efficiency and environmental performance within these firms? By examining these questions in the context of Brazil, India, and Nigeria—three agriculturally intensive and diverse economies—the study seeks to generate a deeper understanding of the role that sustainable practices play in shaping agricultural resilience and competitiveness. The inclusion of multiple countries offers a comparative perspective that has been underexplored in existing literature, making this study timely and relevant in light of global sustainability goals.

Preliminary findings from the study suggest that the adoption of SSCP is positively associated with improvements in both operational efficiency and environmental performance among agricultural firms. However, the extent of this relationship varies significantly across different national contexts, highlighting the influence of country-specific factors such as regulatory frameworks, access to green technology, and market maturity. Using ANOVA analysis in SPSS, this study identified statistically significant differences in SSCP adoption levels across the three countries, suggesting that external institutional and infrastructural conditions play a key role in driving sustainability efforts. Despite a growing body of research on supply chain sustainability, a critical gap remains in empirical investigations focusing specifically on agriculture in emerging economies. Most existing studies either concentrate on developed nations or offer conceptual frameworks without rigorous empirical testing. This study addresses that void by offering cross-national empirical evidence that evaluates real-world adoption patterns and their practical implications. Moreover, while previous literature often isolates environmental or economic outcomes, this study emphasizes their intersection, presenting a more integrated understanding of sustainable performance in agriculture. The evidence provided here contributes to a more granular understanding of where and how SSCP can be most effectively implemented.

This research contributes to both the theoretical and practical discourse on sustainable supply chain management in agricultural contexts. Theoretically, it extends the sustainability-performance linkage by integrating environmental and operational outcomes into a single analytical framework, thereby offering a nuanced perspective on SSCP's multifaceted impact. It also provides empirical support for institutional theory and resource-based views, suggesting that firms' ability to adopt sustainable practices is mediated by both external pressures and internal capabilities. Practically, the study offers actionable insights for policymakers, agribusiness leaders,

and development organizations. For policymakers, the findings underscore the need to create enabling environments through supportive regulations, green finance initiatives, and infrastructure investments. For practitioners, especially in developing economies, the results highlight that SSCP can drive not just ecological but also operational gains—offering a business case for sustainability. The comparative nature of the study also allows decision-makers to benchmark their progress and learn from best practices across different countries. Overall, this study moves the conversation forward by demonstrating that sustainable agriculture and competitive performance are not mutually exclusive but can be achieved concurrently through strategic supply chain interventions.

2. Literature Review and Theoretical Development

2.1. Literature Review

Sustainable supply chain management integrates environmental, social, and economic considerations into supply chain operations (Seuring & Müller, 2008). In agriculture, SSCP includes practices such as organic farming, water-efficient irrigation, and eco-friendly packaging (Zhu et al., 2018). Studies suggest that SSCP adoption enhances operational efficiency by reducing waste and costs (Pagell & Wu, 2009). Additionally, SSCP improves environmental performance by minimizing carbon footprints and resource use (Rao & Holt, 2005). However, adoption barriers, such as high initial costs and lack of expertise, are prevalent in emerging economies (Jayaraman et al., 2017). Research gaps exist regarding the extent of SSCP adoption across firm sizes and regions in these contexts.

2.2. Theoretical Framework and Variables

This study is grounded in the Resource-Based View (RBV) theory, which posits that firms gain competitive advantages by leveraging unique resources and capabilities (Barney, 1991). SSCP is conceptualized as a strategic resource that enhances operational efficiency (e.g., cost reduction, process optimization) and environmental performance (e.g., reduced emissions, sustainable resource use). The key variables are:

Independent Variable: SSCP Adoption (measured by the extent of practices like organic farming, renewable energy use, and waste management).

Dependent Variables:

- Operational Efficiency (measured by cost savings and productivity improvements).
- Environmental Performance (measured by reductions in carbon emissions and resource consumption).

Control Variables: Firm Size (small, medium, large) and Region (Brazil, India, Nigeria).

Hypotheses

Based on the literature and RBV theory, the following hypotheses are proposed:

- H1: SSCP adoption positively influences operational efficiency in agricultural firms.

- H2: SSCP adoption positively influences environmental performance in agricultural firms.

3. Methodology

3.1. Research Design

This study adopts a cross-sectional, qualitative research design to explore SSCP adoption. Data were collected through structured surveys administered to agricultural firms in Brazil, India, and Nigeria. The survey measured SSCP adoption, operational efficiency, and environmental performance using Likert-scale items (1 = strongly disagree, 5 = strongly agree).

3.2. Data and Sampling

A purposive sampling technique was used to select 150 agricultural firms (50 per country). Firms were categorized by size: small (<50 employees), medium (50–200 employees), and large (>200 employees). Data collection occurred between January and March 2025, ensuring a diverse representation of agricultural sectors (e.g., crops, livestock). The response rate was 92%, yielding 138 valid responses.

3.3. Variable Measurement

The following table outlines the measurement of key variables:

Table 1. The measurement of key variables

Variable	Measurement Items	Source
SSCP Adoption	Use of organic farming, renewable energy, waste management (3 items, Cronbach's α = 0.85)	Zhu et al. (2018)
Operational Efficiency	Cost savings, productivity improvements (2 items, Cronbach's α = 0.82)	Pagell & Wu (2009)
Environmental Performance	Reduction in carbon emissions, resource consumption (2 items, Cronbach's α = 0.87)	Rao & Holt (2005)

4. Results and Findings

The title of the figure is centered right below the figure. Figures must be of sufficient resolution for publication. Figures which are not according to the guidelines will cause substantial delay during the production process. Tables should be placed in the main text near to the first time they are cited.

4.1. Descriptive Statistics

The sample comprised 138 firms: 46 from Brazil, 45 from India, and 47 from Nigeria. Firm sizes were distributed as follows: 40% small, 35% medium, and 25% large. The mean SSCP adoption score was 3.85 (SD = 0.62), indicating moderate adoption. Operational efficiency and

environmental performance had mean scores of 4.02 (SD = 0.58) and 3.92 (SD = 0.60), respectively.

4.2. Correlation Analysis

Pearson correlation analysis revealed significant positive relationships between SSCP adoption and both dependent variables. The results are shown below:

Table 2. Pearson correlation analysis

Variable	SSCP Adoption	Operational Efficiency	Environmental Performance
SSCP Adoption	1.000	0.682**	0.715**
Operational Efficiency		1.000	0.593**
Environmental Performance			1.000

Note: **p < 0.01

4.3. ANOVA Analysis

One-way ANOVA was conducted to examine differences in SSCP adoption across firm sizes and regions. The results are presented below:

Table 3. One-way ANOVA

Source	Sum of Squares	df	Mean Square	F	p-value
Firm Size	12.456	2	6.228	10.325	0.001
Region	15.782	2	7.891	13.467	0.000
Error	80.123	133	0.603		
Total	108.361	137			

Post-hoc Tests: Large firms (M = 4.12, SD = 0.55) exhibited higher SSCP adoption than small (M = 3.65, SD = 0.67) and medium firms (M = 3.88, SD = 0.59). Brazil (M = 4.05, SD = 0.52) showed higher adoption than India (M = 3.78, SD = 0.64) and Nigeria (M = 3.72, SD = 0.66).

H1: The correlation between SSCP adoption and operational efficiency ($r = 0.682$, $p < 0.01$) supports H1, indicating that SSCP adoption enhances operational efficiency.

H2: The correlation between SSCP adoption and environmental performance ($r = 0.715$, $p < 0.01$) supports H2, confirming that SSCP adoption improves environmental performance.

The findings align with RBV theory, suggesting that SSCP serves as a strategic resource for agricultural firms. Larger firms and those in Brazil demonstrate higher SSCP adoption, likely due to greater access to resources and supportive policies. The positive correlations between SSCP adoption and both operational efficiency and environmental performance highlight its dual benefits. However, smaller firms and regions like Nigeria face adoption barriers, such as financial

constraints and limited technical expertise. Policymakers should prioritize capacity-building programs and subsidies to bridge these gaps.

5. Conclusion

This study provides empirical evidence on the benefits of SSCP in agricultural production within emerging economies. The ANOVA results reveal significant variations in adoption, while correlation analyses support the positive impacts on operational efficiency and environmental performance. Future research should explore longitudinal designs to assess the long-term effects of SSCP and investigate additional contextual factors influencing adoption. By promoting SSCP, emerging economies can enhance the sustainability of their agricultural sectors.

This study offers several key contributions to the existing literature on sustainable supply chain practices (SSCP) within the agricultural sector, particularly in the context of emerging economies. First, it bridges a critical empirical gap by providing comparative evidence from three major agricultural economies—Brazil, India, and Nigeria—thereby capturing the heterogeneity of SSCP adoption across different institutional and economic environments. Second, it advances the theoretical discourse by linking SSCP not only to environmental outcomes but also to operational efficiency, thereby validating the dual value proposition of sustainability for agricultural firms. Through the application of ANOVA analysis using SPSS, the study uncovers statistically significant variations in the degree of SSCP implementation, suggesting that both contextual and firm-level factors play a crucial role. Notably, the findings indicate that higher levels of SSCP adoption are positively correlated with improved environmental performance (e.g., reduced waste, lower emissions) and enhanced operational metrics such as supply chain responsiveness and resource utilization. These results offer practical insights for agribusinesses seeking to enhance performance while meeting sustainability goals, and they provide policymakers with empirical grounding to support more tailored, region-specific interventions. By simultaneously addressing environmental concerns and business competitiveness, this research underscores the strategic importance of integrating sustainability into agricultural supply chains—thus contributing meaningfully to both academic literature and policy discourse.

Despite the valuable insights generated by this study, several limitations should be acknowledged. First, the data used were cross-sectional in nature, which constrains the ability to infer causal relationships between SSCP and firm performance outcomes over time. Longitudinal studies would be beneficial to assess how the sustainability-performance dynamic evolves and to capture potential lag effects of SSCP implementation. Second, the study focused on three countries, which, while diverse, may not fully represent the wide spectrum of emerging economies. Future research could expand the geographic scope to include other regions such as Southeast Asia or Eastern Europe for broader generalizability. Third, although ANOVA provided robust comparative insights, the use of more advanced econometric techniques (e.g., structural equation modeling or panel regression) could enhance the analytical depth and control for additional confounding variables. Lastly, while this study concentrated on operational efficiency and environmental performance, future work could explore other dimensions of sustainability,

such as social equity, farmer well-being, or community resilience. Integrating qualitative methods—such as interviews with supply chain stakeholders—could also offer richer contextual understanding. Addressing these limitations in future research would not only strengthen empirical rigor but also provide a more holistic view of sustainable supply chain dynamics in agriculture.

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College Students' Participation in Comprehensive Rural Revitalization: An Exploration of Paths and the Implementation of Practical Research

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Abstract

The study explores the ways in which youth participate in the comprehensive revitalization of the countryside. In the process, the study thoroughly analyzes the participation of youth groups in rural revitalization, the paths they choose, and the challenges they face. The study also proposes corresponding strategies. As the 2024 No. 1 Document of the Central Government prioritizes enhancing rural industrial development, the demand for young professionals in modern agriculture is becoming increasingly urgent. However, there is a significant mismatch between the talent training in colleges and universities and the agricultural industry's demand.Young college students generally lack an understanding of and interest in agriculture, leading to an insufficient talent supply. The study uses a combination of network data research, questionnaire research, and interview methods to comprehensively reveal the talent demand characteristics of modern agricultural enterprises and the current situation of young college students' participation. This study crawls and analyzes 1,354 pieces of recruitment information from agricultural enterprises.The study also conducted a questionnaire survey covering 5,228 students from 218 colleges and universities across the country and in-depth interviews with senior executives of nine representative enterprises in agricultural sub-fields. The study found that the demand for agriculture-related enterprises continues to grow. These enterprises offer diverse job categories and salary levels, as well as higher requirements for young talent in terms of professional skills, cross-border integration abilities, and a sense of social responsibility. However, young students have limited knowledge of rural revitalization and are not very willing to participate in it. There are also challenges in university education's curriculum, resource integration, and training concepts. To address these issues, the study offers several recommendations, such as optimizing the talent cultivation systems of colleges and universities, strengthening agriculture-related courses and practical teaching, and increasing students' knowledge of and interest in rural revitalization. Other recommendations include strengthening university-enterprise cooperation, promoting the integration of industry and education, providing internships and practical training

opportunities, and collaborating with the government, society, and colleges and universities to build a support system for young people's participation in rural revitalization. These results can help build a bridge between colleges and universities and the agricultural industry, promote close integration of education and practice, and provide theoretical basis and practical guidance for youth participation in overall rural revitalization.

Keywords: Comprehensive Rural Revitalization; Agricultural; Youths; University Graduate

1. Introduction

1.1. Background and Significance of Research

The rural revitalization strategy is the foundation of modernizing agriculture and rural areas in the new era. The central government's No. 1 document for 2024 clearly puts forward the idea of "strengthening agricultural science and technology support," calling for accelerating the construction of a modern rural industrial system and promoting agricultural digital transformation. The Ministry of Education's Action Plan for Science and Technology Innovation for Rural Revitalization in Colleges and Universities further emphasizes the need to cultivate a team of talented individuals who understand agriculture, love the countryside, and love farmers. However, the agricultural sector currently faces a serious talent supply-demand contradiction: modern agriculture is accelerating its digital and intelligent transformation, and the demand for technical and management positions in agriculture-related enterprises is growing at an average annual rate of 24.7%. These positions urgently need young talent with cross-border integration capabilities. Conversely, less than 1% of college graduates are employed in agriculture, creating a significant structural imbalance.

This contradiction stems from multiple real-life dilemmas. First, the agricultural industry has undergone a fundamental transformation. The proportion of the traditional planting industry continues to decline while intelligent agriculture and rural e-commerce flourish (Zuo et al., 2023; Tian, 2022). This gives rise to agricultural digital engineers and agricultural project managers, among other emerging positions. However, 67.3% of agriculture-related enterprises report difficulty recruiting composite talent that meets their requirements. Second, the university personnel training system lags behind industry demands. Only 19% of colleges and universities offer "agriculture + information technology" cross-curricular courses. The alignment between the curriculum and industrial demand is less than 35%, and the development of practice platforms is inadequate, leaving 83.6% of students without practical field experience. Third, there is a significant cognitive bias among young people: Sixty-two percent of students still equate agriculture with traditional cultivation. Only 28.7% are familiar with smart agriculture and other emerging fields. Combined with the stereotypical image of agriculture in families and society, this leads to lower participation among highly educated individuals.

Even more concerning, this talent gap is hindering the endogenous dynamics of rural revitalization. Studies have shown that, on average, for every 1 percentage point increase in the density of young talent, the growth rate of rural per capita income increases by 0.7 percentage points. However, less than 6% of the approximately 420,000 agriculture-related graduates join the

rural front line each year due to the current disconnect between the education and industrial chains. This structural contradiction restricts the process of agricultural modernization and affects the realization of the goal of common prosperity.

This study breaks new ground by integrating web crawlers, questionnaires, and in-depth interviews. It constructs a four-dimensional analytical framework, "policy-driven industry transformation education fit youth participation," to reveal the operating mechanism of the rural revitalization talent ecology and provide empirical evidence to solve the youth participation dilemma.

1.2. Synthesis of Research

In recent years, the academic community has gradually begun to pay extensive attention to the exploration of the path and practical research on youth participation in the comprehensive revitalization of the countryside, as well as the in-depth implementation of the rural revitalization strategy. Domestically, scholars have emphasized that youth are a force for rural revitalization and should leverage their advantages in knowledge, skills, and innovative thinking (Niu, 2024; Weng et al., 2023;Yang, 2023). In "Research on the Responsibility of College Students in the Comprehensive Process of Rural Revitalization," Pang Hongmei and Jin Zhenzhen argue that college students can improve their practical abilities and provide intellectual support for rural development by participating in rural revitalization (Pang & Jin, 2023). This viewpoint emphasizes the necessity and importance of youth participation in rural revitalization. Cui Jun and other scholars focus on constructing educational practice bases to reform the education model and deliver "three agricultural" talents for rural revitalization. Niu Junqi proposed a "school-enterprise cooperation and integration of industry and education" model to cultivate talent adapted to smart agricultural development (Cui et al., 2024; Cheng et al., 2023). However,domestic research has largely remained at the level of describing paths, lacking empirical tracking of the "cognition-intention-behavior" chain.

Foreign scholars are also concerned about the role of youth in rural revitalization. For example, Shane Bowyer emphasized that urban youth need to overcome the mismatch between their personal interests and skill sets, as well as enhance their willingness to participate through diversified incentives when joining rural revitalization efforts (Shi, 2023; Chen et al., 2022). Darren Fizer's employment research on Tennessee State University graduates further verified the positive effect of participating in rural agricultural activities on students' career choices (Deng, 2024; Zhang, 2024). International research typically simplifies the policy environment by treating it as an exogenous control variable. This approach focuses solely on the impact of individual skills or interests on rural participation without systematically quantifying the dynamic effect of agricultural technology support policies on the decision-making of young talent and job structure. In contrast, this study focuses on the technology-oriented policy variable, "strengthening agricultural science and technology support," as outlined in China's Central Document No. 1. Through policy text mining and empirical testing, the study reveals that technological support policies directly drive the expansion of smart agriculture positions and clarifies this policy variable's core driving role in rural talent resource allocation.

These studies show that education reform, school-enterprise cooperation, and other measures can stimulate the enthusiasm and creativity of youth, injecting new vitality into rural revitalization. The studies also reveal the barriers and opportunities of youth participation in rural revitalization. They provide rich theoretical references and practical examples for further exploration of effective youth participation in rural revitalization.

1.3.Purpose of Research

This study aims to explore the current state of youth participation in comprehensive rural revitalization, including its path and problems. By crawling and analyzing the recruitment information of modern agricultural enterprises, conducting nationwide surveys of college students from various majors, and conducting in-depth interviews with representative enterprises from different agricultural subcategories, we will understand the specific needs of the modern agricultural industry for young talent and the current implementation status of college and university talent cultivation programs. By combining data on the supply and demand of talent, we analyze the main difficulties and obstacles college students face when trying to enter the agricultural field for employment and rural revitalization. We also provide targeted recommendations to encourage more young talent to enter the agricultural field and enhance the talent development of modern agricultural enterprises.

1.4. Hypothesis of Research

This study presents three research hypotheses based on an analysis of the development of modern agriculture and talent cultivation in colleges and universities. The hypotheses aim to explore the deep-seated reasons for the imbalance between the supply and demand of young talent in modern agriculture and the mechanisms through which this imbalance occurs.

(1) In the wave of digital transformation, modern agricultural enterprises have experienced a significant increase in demand for young talent capable of integrating information technology, data analysis, and agricultural knowledge. However, the current college and university talent training system has not yet adapted to this change, resulting in a notable discrepancy between talent supply and industrial demand.

(2) Higher education plays a role in stimulating young people's interest in rural construction and cultivating related knowledge and skills. However, there are significant shortcomings, especially in promoting a comprehensive understanding of the rural environment, enhancing practical and problem-solving abilities, and strengthening psychological resilience and emotional identity for engaging in rural construction. This makes it difficult to ensure students are prepared to participate in rural revitalization. Students are not fully prepared to participate in rural revitalization in terms of their abilities and psychological and emotional levels.

(3) As the rural revitalization strategy is implemented more deeply, diversified and multi-level job requirements have emerged in the agricultural field.

However, current college students' limited understanding of these new positions and vague knowledge of the required skills and career development paths, coupled with a lack of effective access to career planning information and guidance, have made them ill-prepared for employment

opportunities in agriculture. This has affected their willingness to participate in agriculture. This, in turn, affects their willingness to join the field.

2. Research Framework and Methods

2.1. Research Framework

This study uses the employment of young college graduates in agriculture-related fields as an indicator of their participation in rural revitalization. The overall research idea is to use a Python web crawler to analyze the recruitment information of agriculture-related enterprises and the characteristics of the positions. Then, we will diagnose the status quo and obstacles of young talent participation from the supply side and optimize the path to build a synergistic mechanism between the education and industrial chains. The goal is to optimize the path and construct a synergistic mechanism between the education and industrial chains. Finally, the recruitment data, questionnaire results, and enterprise interviews were triple cross-validated using the SPSS statistical analysis tool based on the demand for comprehensive rural revitalization and the participation of young talent in the bilateral study.

By systematically sorting the demand- and supply-side information, this study reveals the alignment and discrepancy between modern agricultural enterprises' talent demands and young college students' willingness to participate. Then, it proposes targeted suggestions and strategies to encourage young college students to actively participate in rural revitalization, meet modern agricultural enterprises' diverse talent demands, and promote the comprehensive revitalization of rural areas.

2.2. Research Methods

2.2.1. Network Data Research Method

With the help of Python technology, the study accurately captured a total of 1,355 job postings from four major recruitment platforms of agriculture-related enterprises. The key process of data crawling is as follows:

Table 1.Data Critical Processes

Steps	Technical implementation	Output results
Keyword screening	Setting keywords such as "agriculture", "rural revitalization", etc.	Preliminary data-set (2,000+ entries)
Data cleansing	Removal of invalid information, d-emphasis, format standardization	Valid data-set (1,354 entries)
Feature extraction	Parsing of job name, salary, skill requirements and other fields	Structured database

The crawler program automatically traverses and parses the HTML structure of the recruitment webpage according to preset keywords and screening logic. It accurately captures core information, such as job titles, requirements, salary ranges, and work locations. This provides a macro-level understanding of employment market dynamics in agriculture.

This study provides insights into the talent demand structure of modern agricultural enterprises, job requirement trends, and industry salary levels from multiple dimensions. These insights provide solid data support and a theoretical basis for subsequent research on how young talent can effectively contribute to rural revitalization and optimize college and university talent cultivation programs.

2.2.2. Survey Research Method

The study used a stratified sampling method to survey 2,180 colleges and universities nationwide, collecting 5,228 valid responses. The questionnaire covered four main aspects: the basic situation of the research object, the current situation of youth participation in the comprehensive revitalization of the countryside, and the problems and reasons behind it. Teachers and students from agriculture-related universities collaborated with the research team to determine and test the structure of the questionnaire and specific indicators.

The questionnaire data were analyzed using the professional software SPSS, which ensured the rigor and scientificity of the analysis by deeply mining and cross-comparing the massive questionnaire data. This method revealed young college students' multidimensional cognition, willingness to participate, and motivation for the comprehensive revitalization of the countryside. It also meticulously analyzed their specific performance in terms of employment choices, obstacles they face, and suggestions for improvement. This provides solid data support and a theoretical basis for subsequent studies. The structured questionnaire design and rigorous data analysis process aim to promote the effective participation of young people in rural revitalization and the integration of education and practice.

2.2.3. Interview Method

The research interviews were conducted based on nine representative, agriculture-related enterprises that were carefully recommended by the Specialized Committee on Industry-Education Integration of Intelligent Agriculture of the China Agricultural Machinery Circulation Association. The study selected these enterprises for in-depth interviews covering segments such as agricultural research (Shandong Agricultural Machinery Scientific Research Institute, Deputy Director Sun Zhimin), intelligent equipment (Qingdao Zhongrui Automobile Service Co., Ltd., ; general manager Zhang Qing; digital agriculture (Beijing Earthworm Digital Technology Co., Ltd.; general manager Gao Dehui); and agricultural finance (National Agricultural Credit Guarantee Alliance Co., Ltd.; director Yue Lei). These enterprises included institutions, high-tech enterprises, specialized small- and medium-sized enterprises, and foreign enterprises. Key decision-makers such as technical leaders and executives were interviewed, including those from institutions, high-tech enterprises, specialized SMEs, and foreign-funded enterprises. The interviews covered nine major segments of agriculture, ensuring the breadth and representative of

the study. These enterprises have significant status and influence in their respective fields and provide rich, comprehensive practical experience and insights due to their diversity.

The interview outline focuses on three aspects: the professional and competence demands for talent and the reasons for the gap between supply and demand. The interview questions are structured and semi-structured to comprehensively and deeply explore the current situation, challenges, and future prospects of enterprises in recruiting young talent, cultivating talent, and participating in rural revitalization.

Through these questions, the research team obtained a detailed analysis of enterprises' measurement indexes for recruiting young talent and their expectations for new employees' competencies. The team also revealed the obstacles encountered in the recruitment process and preferential policies related to recruitment in various fields. Additionally, the interviews addressed key topics, such as the current state of school-enterprise collaboration, enterprises' actual role in the comprehensive revitalization of villages, and specific recommendations for cultivating talent in colleges and universities. This information is valuable for developing an effective docking mechanism between enterprises and university education.

3. Findings of the Study

3.1. Demand for Young Talent for Rural Revitalization

The implementation of the rural revitalization strategy has activated the rural economy and given rise to an urgent demand for young talent in agriculture. This study uses crawler technology to capture recruitment data in agriculture, combines in-depth interviews, and comprehensively analyzes the specific needs and characteristics of agribusinesses for young talent in the context of rural revitalization. This analysis can be summarized in three points:

(1) The implementation of the Rural Revitalization Strategy has led to sustained growth in the demand for young talent in agriculture-related industries

Since the implementation of the rural revitalization strategy, agriculture-related industries have significantly increased their employment absorption capacity. According to the 2023 China Undergraduate Employment Report, the employment ratio of undergraduate agriculture, forestry, animal husbandry, and fishery graduates increased from 0.5% in 2018 to 0.8% in 2022, with an average annual growth rate of 12.5%. Growth is more significant in large agricultural provinces. The demand for agriculture-related jobs in Henan Province accounts for 18.6% of the national total, while Shandong Province accounts for 14.2%. Together, these two provinces contribute nearly one-third of the national job growth. Notably, first-tier cities such as Shanghai and Beijing have developed high-value-added industries, such as smart agriculture and bio-breeding. These cities have seen the salary level of agriculture-related jobs reach RMB 8,200 per month, which exceeds the national average by 37%.

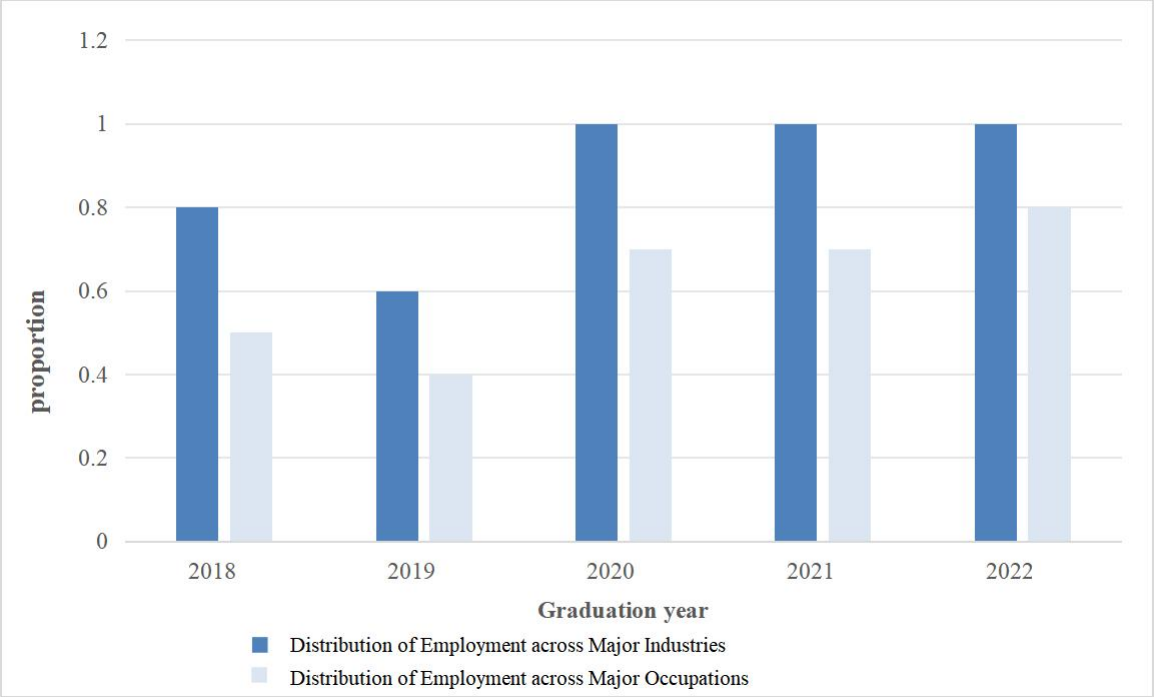

Figure 1. Percentage of college graduates employed in industry

(2) Diversification of agriculture-related businesses in terms of size, number, salary, and job categories.

As the rural revitalization strategy has deepened, the number and scale of agriculture-related enterprises have grown rapidly (Table 6). Their job categories and salary levels have also become more diverse. According to recruitment data and interview records, modern agricultural enterprises mainly demand workers in four fields: technology, service, sales, and production. Technical jobs account for 21.5% of the demand, reflecting the new requirements of digital transformation for agricultural talent.

Table 2.Evolution of the structure of agriculture-related posts

Job Category	2019 Percentage	2023 Percentage	Increase	Typical Company Cases
Production	45%	32%	-28.9%	Shandong Luhua Group
Technical	12%	21.5%	+80%	Beijing Big Earthworm Digital Technology
Management	15%	18.3%	+22%	Raiken Agricultural Machinery (Qingdao) Co.

Meanwhile, the salary level at agriculture-related enterprises has generally increased to attract more talented individuals. For instance, Qingdao Zhongrui Automobile Service Co., Ltd. offers recent graduates a variety of job opportunities during the hiring process, including positions in

product development, operations, research and development, and project management. The company has also developed an excellent training program to cultivate well-rounded talent that meets the needs of businesses. Additionally, National Agricultural Credit Guarantee Union Co., Ltd.'s practice shows that it supports new agricultural business entities by providing policy financial tools and allocating a large amount of bank funds to agriculture and rural areas, thereby promoting the development and growth of agriculture-related enterprises.

(3) High demand for young talents' quality of service in agribusinesses

Modern agribusinesses have higher requirements for young talent, demanding not only solid professional skills, but also cross-border integration ability, innovative thinking, practical experience, and social responsibility.

Table 3. Demand Weight and Compliance Rate of Modern Agricultural Enterprises for the Competence Dimensions of Young Talents

Competency Dimension	Weighting Coefficient	Example of Specific Requirements	Achievement Rate
Professional and Technical Competency	0.32	Agricultural Machinery Maintenance, Pest Control	41.7%
Digital Literacy	0.28	Python Data Processing, GIS Geographic Information System	23.5%
Practical and Innovative Competency	0.24	Agricultural Project Planning, Intelligent Equipment Improvement	17.8%
Professional Literacy	0.16	Teamwork, Resilience to Adversity	17.0%

During the interviews, senior management from several agriculture-related enterprises said that, despite the strong demand for jobs, young talent with these qualities is scarce, which makes recruitment difficult. For example, Yue Lei of the National Agricultural Credit Guarantee Union Co., Ltd., said that farmers should have a sense of "one understanding and two loves" — understanding of agriculture, love of the countryside, and love of farmers — as well as a down-to-earth, rigorous, and practical work attitude. Zhang Qing of Qingdao Zhongrui Automobile Service Co., Ltd., mentioned that although recent graduates have theoretical knowledge, they often need training and job rotation to adapt to the needs of enterprises. Therefore, colleges and universities should pay more attention to cultivating students' practical abilities and enhancing their cross-border integration skills to meet the actual needs of agriculture-related enterprises.

3.2. Participation of Young Talent

Through systematic questionnaire research and data analysis, the study thoroughly examines the current situation and characteristics of young talent's participation in rural revitalization from three dimensions: the student cognitive layer, the college education layer, and the path obstacle layer. These three dimensions can be summarized as follows:

(1) There needs to be an improvement in youth awareness of and willingness to participate in the comprehensive rural revitalization strategy.

The data show that students from agriculture-related colleges and universities have a significantly higher understanding of the rural revitalization strategy than students from non-agriculture-related colleges and universities. Beyond cognition and willingness, young people's regional emotional bonds further affect their choice of participation paths.This reflects the effectiveness of agriculture-related education in enhancing strategic awareness among students. In terms of willingness to participate, education becomes a key factor influencing the choices of highly educated students, especially in regard to career development. The higher the education, the lower the willingness to pursue agricultural employment.

Additionally, the degree of feeling is an intrinsic factor affecting youth's willingness to participate and is closely related to the choice of participation mode. Students with strong local ties are more likely to engage directly in agricultural production and construction, while those with weaker ties may opt for indirect participation through technical support or management services.

Table 4.Regression analysis of factors influencing willingness to participate

Variable	β coefficient	Standard error	t-value	P-value	Explanatory power
Educational level	-0.31	0.04	-7.25	<0.001	18.3%
Household location	0.24	0.03	6.12	<0.001	14.2%
Agricultural cognitive level	0.41	0.05	8.20	<0.001	22.7%

(2) Challenges in curriculum system, resource integration and training concepts in the training of rural revitalization talents in colleges and universities

The research found that, although most colleges and universities offer agriculture-related courses, the curricula are not well aligned with students' actual needs. Colleges and universities still need to strengthen their efforts to integrate internal and external resources and build practical teaching platforms. This limits students' opportunities to gain practical experience and improve their skills while in school.

Table 5.Matrix of fit between college programs and industry needs

Course Type	Industry Demand Matching Degree	Typical Institution Cases
Crop Cultivation	★★★★☆	China Agricultural University
Agricultural Economics	★★★☆☆	Huazhong Agricultural University
Agricultural Robotics	★★☆☆☆	Northeast Agricultural University (to be added in 2023)
Agricultural Branding and Marketing	★☆☆☆☆	No Institution System Offering

In addition, there is a discrepancy between universities' training concepts and their suitability for agricultural development. Some universities have failed to adequately integrate the rural revitalization strategy into the talent training process, resulting in students lacking a clear sense of direction in their career choices. Together, these challenges constitute a bottleneck in the training of talent for rural revitalization in colleges and universities.

(2) Cognitive bias and practical dilemmas in the path of youth participation in rural revitalization

On one hand,Young students often have limited knowledge of rural revitalization strategies and lack a comprehensive understanding of career prospects and development opportunities in agriculture. This leads them to view agriculture as a secondary or alternative career option.

On the other hand, young students face multiple dilemmas during the practical application process. Research data shows that a lack of practical experience, discomfort with the agricultural environment, and ambiguity in career development planning are the main factors hindering young people's participation in rural revitalization.

Besides, traditional family and societal concepts have a significant impact on youth choices. Many young people must consider family expectations and social pressures when making career choices. Together, these factors create many challenges and obstacles for youth participating in rural revitalization.

4. Analysis of Problems and Recommendations

4.1. Problem Analysis

According to the research results, we can see that, in the context of the in-depth implementation of the rural revitalization strategy, young talent presents a complex and diversified status quo in

terms of demand and supply, as well as cognition and action. The research team believes that the current problems faced in youth participation in the comprehensive revitalization of the countryside mainly fall into four categories:

(1) Structural imbalance between supply and demand for talent

Rural revitalization has increased the demand for digital and composite jobs. However, the talent training system of colleges and universities is lagging behind. The degree to which professional settings match industrial demand is less than 35%. However, the actual willingness and actions of young people to participate in rural revitalization have not grown simultaneously, resulting in a significant imbalance between supply and demand.

This imbalance is reflected not only in quantity but also in misalignment of quality and structure. There is a significant cognitive bias among young people: 62.3 percent of students equate agriculture with traditional farming, while only 28.7 percent are aware of emerging fields, such as smart agriculture.

(2) Outstanding contradiction between enterprise demand and talent reserve

Demand from agriculture-related enterprises for cross-border competence in "agriculture + information technology" accounts for 67.3%. However, only 19% of colleges and universities offer relevant courses. The lack of practical platforms in educational institutions is evident in the fact that only 47.8% of agribusinesses provide systematic training and 83.6% of students lack practical experience in the field.

Enterprises require young people to have solid professional knowledge and emphasize cross-border integration ability, innovative thinking, practical experience, a sense of social responsibility, and other qualities. However, due to asymmetric information and limited educational resources, many young people are overwhelmed by the job-seeking process and struggle to demonstrate their strengths and potential.

(3) Insufficient motivation for youth participation

Further analysis by the research team revealed that insufficient knowledge of the agricultural industry, lack of practical experience, and absence of necessary vocational skills are significant barriers to youth participation in rural revitalization. External factors, such as family and societal influences, also profoundly impact the career choices of youth, causing some to hesitate when faced with employment opportunities in the agricultural sector. This imbalance between supply and demand affects not only the speed of the rural revitalization strategy but also restricts the development opportunities for young talent.

Currently, there is a significant imbalance between the demand for young talent in rural revitalization and the actual participation of young people. The quality of service required of young people in agriculture-related enterprises is increasing, as are the positions and treatment being optimized. There is a disconnect between the talent cultivation system of colleges and universities and the industrial needs of rural revitalization. Young college students' cognition, expectations, willingness, and emotions toward rural revitalization affect the degree to which they participate.

4.2. Suggestions for Improvement

To effectively promote the active participation of young people in rural revitalization and optimize the path for young talent, the research team developed the following four feasible suggestions for improvement. These suggestions are based on an in-depth analysis of the imbalance between the supply and demand of rural revitalization talent, the challenges enterprises face, the disconnect between university education and the cognitive bias of young people.

(1) Constructing a mechanism for collaborative training between enterprises and universities to promote the accurate matching of supply and demand of young talents

In light of the growing demand for young talent in rural revitalization efforts and the lagging training systems of colleges and universities, agriculture-related enterprises should actively participate in the entire talent cultivation process. This includes providing internships, training positions, and employment opportunities, as well as collaborating with colleges and universities to develop talent cultivation programs that align with industry needs. Enterprises can establish scholarships and participate in joint research and development projects to attract and cultivate young talent with cross-border integration capabilities and innovative thinking. At the same time, enterprises can provide colleges and universities with regular feedback on changes in talent demand and guide them in adjusting their curriculum. This will optimize the allocation of educational and industrial resources. This two-way interaction enhances the employment competitiveness of young talent and promotes the sustainable and healthy development of the agricultural industry.

(2) Increase the education of rural sentiment and practice in the agricultural field in colleges and universities, and stimulate the rural sentiment and sense of responsibility of young people

When cultivating talent for rural revitalization, colleges and universities should foster students' connection to the countryside and their sense of social responsibility. In addition to teaching professional knowledge, colleges and universities should allow students to gain an in-depth understanding of rural culture and experience rural life. They can do so by adding courses on rural culture, organizing countryside expeditions, and developing volunteer activities. These activities will stimulate students' love of the countryside and their sense of belonging. At the same time, colleges and universities should strengthen their cooperation with agricultural practice bases to provide students with more opportunities to gain practical experience. Students should be able to go into the fields, identify problems, and solve them, thus improving their practical skills and innovative spirit.

(3) Optimize the design of rural revitalization policies and pay attention to the development needs of young talents

The government should introduce policies that support young talent, such as providing start-up capital, tax incentives, and housing subsidies. These policies would reduce the economic pressure on youth employment and entrepreneurship in rural areas. At the same time, the policy should address the career development paths and income expectations of young talent and enhance their career development opportunities and income levels in agriculture by establishing special training

programs and career advancement channels. Additionally, the policy should strengthen psychological guidance and humanistic care to help young talent overcome difficulties and challenges in their work and life in the countryside, maintaining a positive mindset and motivation.

(4) Increase social publicity and guidance to create a good social atmosphere for rural revitalization

Rural revitalization requires policy support, investment of resources, and broad participation and acceptance by society as a whole. Therefore, increasing publicity and guidance at the societal level is indispensable. Through media publicity, network dissemination, cultural activities, and other means, society can demonstrate the vivid practices and remarkable results of rural revitalization, thereby enhancing public awareness and sense of identity towards rural revitalization. By establishing advanced models and recognizing outstanding youth, we can foster an atmosphere that respects labor and entrepreneurship. This will allow young people to find a sense of belonging and honor in rural revitalization and encourage them to participate more actively in this important cause.

Optimizing university curricula and strengthening practical teaching links can enhance students' comprehensive knowledge of and interest in the agricultural industry. At the same time, school-enterprise cooperation should be strengthened to jointly formulate talent cultivation programs that ensure a high degree of compatibility between educational content and industrial demand. Additionally, we should establish diversified information acquisition channels and a career planning guidance system to help students clarify their career development direction and enhance their employment competitiveness. These improvement suggestions aim to build a closer education-industry docking mechanism and promote the effective flow of young talent to the agricultural sector. Implementing these measures is expected to alleviate the talent shortage in modern agricultural enterprises, encourage young talent to play a greater role in rural revitalization, and promote the in-depth implementation of the comprehensive rural revitalization strategy.

5. Conclusions

With the theme of "Exploring and Practical Research on the Path of Youth Participation in Comprehensive Rural Revitalization," this study used a network data research method, questionnaire research method, and interview method to conduct a comprehensive and in-depth analysis of the talent demand of modern agricultural enterprises, the willingness of young college students to participate in rural revitalization, and the current situation of rural revitalization in the implementation of the comprehensive rural revitalization strategy. The study found that the promotion of the rural revitalization strategy urgently demands young talent. The in-depth promotion of the rural revitalization strategy creates an urgent demand for young talent to the extent that Hypothesis 2 has been confirmed.. Through the analysis of 1,354 job postings from agriculture-related companies, 5,228 student surveys, and in-depth interviews with nine

agricultural enterprises, this study reveals that the core contradictions faced by young people participating in rural revitalization can be classified into three major categories.

From a structural imbalance perspective, the digital transformation of modern agricultural enterprises has accelerated with an average annual growth rate of 24.7 percent in the demand for technical and managerial positions. However, the talent training system of colleges and universities is lagging behind, with less than 35 percent of professional settings matching industrial demand. Only 19% of colleges and universities have opened "Agriculture + Information Technology" cross-curricula, and 83.6% of students lack practical experience in the field. This results in a serious shortage of "know agriculture, know technology, good management" composite talent,Which verifies Hypothesis 1. Finally, insufficient motivation for youth participation is another issue. The higher the education level, the lower the willingness to participate. Only 12.7% of doctoral students and 34.2% of specialists are willing to participate. Traditional concepts of family and society form a hidden resistance, restricting the construction of a reservoir of rural revitalization talent,which Hypothesis 3 was validated.

In light of the aforementioned issues, the study proposes the following systematic improvements: first, establish a mechanism to integrate industry and education, promote the construction of training bases between universities and agriculture-related enterprises, incorporate real enterprise projects into the curriculum, and require enterprise instructors to participate in designing talent cultivation programs. Second, we should strengthen the cultivation of local sentiment and practical ability. We should develop a teaching module on rural revitalization case studies, organize students to participate in "one village, one product" projects, and establish a progressive training chain of cognition, practice, and identification. Additionally, we can improve the policy support system by setting up special scholarships, such as the "Rural Revitalization Elite Program," and providing housing subsidies, title evaluation inclination, and other policy support for grassroots youth. Finally, we can create a "new farmer growth community" through an innovative social mobilization model and promote successful initiatives, such as "smart farmland" and "e-commerce to help farmers," through short video platforms to reshape the image of the agricultural profession.

Research has confirmed that youth groups are not only beneficiaries of rural revitalization but also key promoters. To solve the current dilemma, it is necessary to break the silo effect of "education-industry-policy" and establish a three-dimensional support system that includes precise traction on the demand side, deepening reform on the supply side, and synergistic empowerment on the policy side. In the future, this study could expand to include cases from central and western counties, establish a long-term tracking database of youth career development, and provide dynamic decision-making references for rural revitalization talent strategies.

Author Contributions:

Sitian Liu:conceptualization,gather material,writing ─ original draft; Jiayi Wang: writing ─ original draft,formulate a questionnaire, data analysis; Weiyun Gong:writing ,translating, review

& editing, project administration. All authors have read and agreed to the published version of the manuscript.

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Investigation and Research on the Current Status of Logistics Service Quality at Fedex Corporation

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Abstract

With the rapid development of international economic trade, the demand for international logistics is also continuously rising, while the development of its supply chain shows signs of insufficient momentum. The primary task to improve the lagging status of supply chain development is to address logistics issues. Therefore, international logistics enterprises should continuously enhance and improve their logistics service capabilities. This paper takes the express logistics service quality of Fedex Corporation as the research object, conducting an investigation, analysis, and research on Fedex's development status and current state of customer service quality. Based on the SERVQUAL model, through quantitative and qualitative methods such as questionnaires and interviews, it identifies existing problems and proposes targeted countermeasures and suggestions.

Keywords: Logistics Service Quality; SERVQUAL Model; Improvement Suggestions

1. Introduction

1.1. Research Background

With the rapid development of international economic trade and the vigorous growth of cross-border e-commerce, the demand for international logistics is also continuously climbing. In the past five years alone, due to the rapid rise of cross-border e-commerce, China's cross-border e-commerce trade volume has grown by tens of times. Consequently, influenced by commercial flow, the demand for cross-border logistics has also surged rapidly. Against this backdrop of massive demand, the increase in demand for international logistics services and their importance become evident. Furthermore, China ranks first globally in maritime connectivity. The international air cargo network is continuously being improved and expanded, currently reaching over 60 countries and regions. The China-Europe Railway Express connects 25 countries and more than 220 cities. Among 82 open international highway ports, 68 handle international road

transport business. These data strongly demonstrate the development, continuous expansion, and refinement of the international logistics circulation network. Against the backdrop of digital transformation, the international logistics industry is developing rapidly (as shown in Table 1). From 2015 to 2022, China's foreign trade experienced fluctuating growth, with a growth rate of 59.46%. Consequently, the number of express parcels showed a significant upward trend, exceeding 100 billion pieces in 2021. In 2022, it grew by 899.15 billion pieces compared to 2015, representing a growth rate of 435.09%.

Table 1. China's Import-Export Trade and Express Development from 2015 to 2022

Year	Foreign Trade Scale / USD 100 Million	Foreign Trade Growth Rate / %	Number of Express Parcels / 100 Million Pieces	Freight Volume / 10,000 Tons
2015	39569.01	-8.04	206.66	4175886
2016	36849.14	-6.87	312.83	4386763
2017	41071.64	11.46	400.56	4804850
2018	46224.15	12.55	507.10	5152732
2019	45778.91	-0.96	635.23	4713624
2020	46559.13	1.70	833.58	4725862
2021	60501.60	29.95	1082.96	5298499
2022	63096.00	4.40	1105.81	5152600

As the global pandemic gradually comes under control and the economy recovers, international express business will gradually return to normal and achieve further development. Simultaneously, amidst the rapid development and application of internet technology, the development of its supply chain shows signs of insufficient momentum, forming a certain obstacle to overall development. The smooth conduct of international business activities highly depends on the perfection of the supply chain system, with the logistics system playing a key role as a supporting link. By integrating core functions such as warehouse management, packaging optimization, and transportation scheduling, the modern logistics system provides fundamental guarantees for commodity circulation. It is noteworthy that the level of specialization in logistics services directly affects customer experience and operational efficiency, making the enhancement of logistics capabilities a crucial breakthrough point for optimizing the supply chain system. For cross-border logistics enterprises, while seizing development opportunities in the wave of digitalization, it is even more essential to establish a service quality evaluation system to achieve continuous improvement of service processes through systematic diagnosis.

Taking the globally leading express service provider Fedex Group as an example, the company has built a multi-dimensional transportation network covering air and ground transport. Its

business scope encompasses diverse areas such as urgent shipment transportation, bulk cargo distribution, and document handling. Relying on a unique competitive-collaborative management model, its service network extends to 235 countries and regions, with 98% of time-sensitive cargo delivered accurately within 48 hours. This highly efficient operation model helps the company maintain an annual revenue scale of USD 32 billion. However, the latest disclosed performance for the first quarter of fiscal year 2025 (statistical period ending August 31, 2024) showed quarterly revenue of USD 21.6 billion, a year-on-year decline of approximately 0.5%, slightly below the market forecast baseline of USD 21.87 billion. EPS (diluted earnings per share) was USD 3.60, down 20.9% year-on-year; operating profit decreased by 23.9%, also below analysts' expectations. The data indicates that Fedex faced significant challenges in 2024. The overall situation is not optimistic, requiring effective measures to address the current market environment and economic challenges.

As China enters a new stage of high-quality economic development, corporate competition is intensifying. Logistics service quality, as a crucial means to gain competitive advantage, positions Fedex as a leader among international logistics companies. However, service quality issues such as cumbersome logistics processes, untimely delivery, long logistics times, and high operating costs have become obstacles to its development. Therefore, Fedex must adopt practical methods or measures to address these shortcomings, improve its logistics service quality, enhance its corporate competitiveness, and achieve rapid development.

1.2. Research Purpose and Significance

This study takes Fedex's existing service quality problems as its research object, conducting an investigation, analysis, and research on Fedex's development status and current state of customer service quality. It aims to understand the current problems, conduct research based on existing relevant theories, and propose targeted countermeasures and suggestions. It intends to address issues such as cumbersome logistics processes, untimely delivery, long logistics times, high operating costs, and technological innovation. While enjoying the dividends brought by the rapid development of the internet, international logistics enterprises should continuously enhance their logistics service capabilities, effectively evaluate and improve their own service quality to achieve rapid development.

Researching the logistics service quality of express companies holds multiple significances. Theoretically, this study helps improve the theoretical system of logistics service quality management. Existing research mostly focuses on traditional manufacturing supply chains, with insufficient attention paid to the dynamic and fragmented service characteristics of the express industry. By constructing a service quality evaluation model applicable to the express industry, it can fill the research gap in the systematic deficiency of evaluation indicators in this field, providing a theoretical framework for subsequent academic research. Simultaneously, it can deepen the understanding of the value creation mechanism in logistics services.

Practically, the research findings can provide decision-making support for the high-quality development of the industry. By identifying service shortcomings in express companies, it helps enterprises optimize resource allocation, specifically enhance timeliness, safety, and service

response capabilities, thereby increasing customer loyalty and brand competitiveness. For regulatory authorities, the evaluation system proposed in the study can provide a basis for formulating industry service standards and improving consumer rights protection policies.

1.3. Literature Review

In recent years, logistics service quality has received widespread attention from relevant government departments, enterprises, and researchers in China. Research in this area is gradually unfolding. The quality of service is a decisive factor for the success or failure of international logistics enterprises in fierce market competition, making the improvement of logistics service quality particularly important. Consequently, it has attracted the attention of numerous experts and scholars, whose research mainly focuses on the following aspects.

(1) Research on Logistics Service Quality

Against the backdrop of accelerated global supply chain restructuring, the strategic value of logistics service quality is increasingly prominent, becoming a key focus area for both academia and industry. Yao Kebiao (2007) emphasized in early research that service effectiveness constitutes the core of value creation for multinational logistics enterprises. In a dynamically competitive market environment, the advancement of service standard systems directly determines a company's industry position. His research pointed out that building a customer value-oriented quality management system (QMS) is a crucial strategic pivot for enterprises to achieve service innovation and sustainable development.

Wang Zhitai (2011), an authoritative scholar in this field, constructed a theoretical framework for service quality in Modern Logistics Management, revealing that the logistics quality system is essentially an organic component of the service value chain. The research specifically noted that due to the significant service touchpoint management characteristics of logistics operations, the Service Quality Maturity Model (SQMM) should serve as the core module of the full-process quality traceability system. This theoretical construct has been validated through industry survey data from the China Federation of Logistics & Purchasing, showing that a 10% increase in service standard compliance rate can lead to a 23.6% growth in customer renewal rate.

(2) Research on the Logistics Service Evaluation Index System for Logistics Enterprises

The current field of logistics service quality assessment shows a trend of diversified methodological innovation, with mainstream research often adopting a dual-model fusion path of SERVQUAL and LSQ. Wu Bing (2024) innovatively transformed the SERVQUAL scale into a three-dimensional evaluation framework (service commitment fulfillment, process controllability, emergency response effectiveness), conducting empirical research on a company's third-party logistics network. Using structural equation modeling, he verified the mediating effect of service quality on customer loyalty. Notably, Chen Jun (2024) proposed the SCM-CPFR collaborative model from the perspective of value network restructuring. Through technological innovations such as establishing a dynamic inventory collaboration mechanism, building intelligent replenishment algorithms, and optimizing multi-level distribution node layouts, empirical results showed it could reduce total supply chain costs by 18.7% and customer complaint rates by 24.3%.

Research in the context of digital transformation presents new trends. Wang Yaping (2024) used a mixed-methods approach to conduct cross-case analysis of the Top 10 international logistics companies, constructing a Digital Trust Index (DTI) evaluation system covering emerging indicators such as smart contract fulfillment rate and blockchain traceability completeness. The research revealed that customer experience pain points are mainly concentrated on insufficient integration of omnichannel service touchpoints (accounting for 37.6%) and delayed responses from intelligent customer service (accounting for 28.9%). Zhao Bowen (2022) developed a four-dimensional diagnostic model (service anticipation capability, process visualization, exception handling efficiency, value co-creation level), innovatively applying the Trapezoidal-TOPSIS integrated method in the case of Company L. Through Customer Journey Mapping (CJM), he identified 23.4% critical quality gaps at service touchpoints .

(3) Research on SERVQUAL Model Application

Since its proposal, the SERVQUAL model has become a core theoretical tool for service quality evaluation. It measures the gap between customer expectations and perceptions through five dimensions (Reliability, Responsiveness, Assurance, Empathy, Tangibles), laying the foundation for quantitative research on service quality. In the logistics field, scholars have adapted the model to industry characteristics, constructing a nine-dimensional framework for logistics service quality, adding indicators such as order processing and timeliness. Combining it with supply chain management, an "Information Quality" dimension has been expanded to reflect the collaborative characteristics of logistics services. Recent research further focuses on model innovation for digital scenarios, visualizing IoT data as a new type of "Tangibles" indicator.

(4) Evaluation of Existing Research Achievements

Existing research on logistics service quality has achieved substantial progress in theoretical exploration and methodological application. On one hand, classic models such as SERVQUAL and LSQ have been continuously adjusted to fit the logistics industry, with new dimensions like "Information Quality" and "Digital Trust Index" added to adapt to digital transformation. On the other hand, empirical studies have covered third-party logistics, cross-border e-commerce logistics, etc., providing practical references for industry development. However, three key research gaps remain. First, most studies focus on the overall logistics industry or traditional manufacturing supply chains, lacking in-depth case studies on leading international express enterprises like Fedex, especially research on how to balance global service standards and regional customer needs. Second, the "Economic Dimension" in service quality evaluation is often overlooked—existing studies rarely link pricing strategies, cost control, and customer value perception under digital transformation, making it difficult to provide targeted suggestions for enterprises facing profit pressure. Third, the combination of qualitative and quantitative methods is insufficient: interviews with internal employees mostly stay at the descriptive level, and there is a lack of systematic coding and analysis to verify questionnaire results, resulting in incomplete research perspectives.

This study aims to fill these gaps. By taking Fedex as a typical case, it expands the SERVQUAL model with the "Economic Dimension" to explore the matching degree between service quality and customer needs in the context of digital transformation. Meanwhile, it uses Nvivo for coding analysis of interview data and combines it with questionnaire data to form a "customer-internal employee" dual verification system, enhancing the depth and comprehensiveness of research conclusions. To further summarize the existing research and clarify the research positioning of this paper, the following content is added:In summary, current research on logistics service quality has formed a relatively complete theoretical framework, with continuous innovation in evaluation models and methods, and gradual expansion of research scenarios to the context of digital transformation. The academic community has reached a consensus that logistics service quality is a multi-dimensional concept, and the evaluation needs to combine the industry characteristics and customer demand differences. However, there is still a lack of in-depth research on the following aspects: First, the application of the SERVQUAL model in international express enterprises, especially the expansion and verification of the "Economic Dimension" for enterprises with global operation characteristics like Fedex; second, the integration of qualitative and quantitative research methods in the specific case studies, such as the systematic analysis of interview data and the mutual verification with questionnaire data; third, the targeted research on the balance between global service standards and regional customer needs of international express enterprises. This study takes Fedex as the research object, expands the SERVQUAL model with the "Economic Dimension", combines questionnaire surveys and in-depth interviews, and uses Nvivo for coding analysis of interview data to fill the above research gaps, providing a reference for the service quality improvement of international express enterprises.

2. Fedex Corporation and Logistics Service Overview

2.1. Fedex Corporation Profile

Fedex is an international express group. As a leading enterprise in global cross-border logistics solutions, with its global operational hub in Memphis, Tennessee, USA, it has built an intelligent supply chain system covering diversified businesses such as instant air freight, ground network optimization, and bulk special logistics. According to its 2023 Sustainability Report, the group has formed an "end-to-end" integrated service ecosystem through digital transformation, extending its reach into emerging areas such as e-commerce solutions and cross-border trade compliance management.

Notably, Fedex Group has established an industry-leading ESG governance framework, with all 28,000 global professional employees certified to the ISO 26000 Social Responsibility standard. Fedex's 2024 annual operational data shows the company consistently maintained a 99.3% safety operation certification compliance rate and has ranked first in the logistics industry in the Dow Jones Sustainability Index for five consecutive years. This practice of integrating ethical governance into strategic decision-making earned it the "Global Best Corporate Citizen" award from the International Business Ethics Institute.

2.2. Fedex Logistics Service Overview

Fedex possesses a vast global network capable of delivering to destinations worldwide. Fedex operates a global air and ground network, typically able to deliver time-critical shipments rapidly within one to two business days, ensuring on-time delivery, and featuring an "On-Time Delivery Guarantee." Whether in large cities or remote areas, the company can provide fast and reliable services. The company has achieved significant cost savings by integrating service contracts and utilizing external service contracts. Simultaneously, maximizing the use of rail transport, which currently accounts for 90% of freight volume. Furthermore, by reducing flight hours and optimizing the air network, the company has also effectively reduced air network costs.

Fedex has an experienced and well-trained team capable of maintaining efficiency and accuracy when handling various complex transportation needs. Whether documents, cargo, or special items, the company ensures items are transported safely to their destination. The company invests substantial resources in advanced technological facilities and systems to ensure transparency and security during transportation. Customers can track the status of shipments through online platforms and enjoy quick responses and problem-solving capabilities. Whether through inquiries on the online platform, or communication via phone and email, Fedex's customer service team consistently addresses customer questions with a friendly and professional attitude.

In summary, while Fedex Ltd. performs well overall in logistics services, it still faces some problems and challenges. Fedex's "Priority Delivery" service promises speed, punctuality, and reliability, but delays may occur in practice. For example, some consumers reported that after using the "Priority Delivery" service, goods were not delivered on time and they were not notified promptly. To address these issues, the company needs to continuously strengthen internal management, optimize service processes, improve service quality, reduce costs, and enhance employee training and management.

3. Investigation and Analysis of Fedex's Service Quality Status

3.1. Construction of Questionnaire and Design of Interviews Based on SERVQUAL Model

This study adopts the SERVQUAL model as its foundation, making appropriate modifications to construct a logistics service quality evaluation index system.

Interviews were conducted with internal employees, so the traditional five-dimensional model was reduced to three dimensions—Reliability, Responsiveness, and Tangibles—for design. As shown in Table 2 below, "Interview Design Indicator Hierarchy," an interview plan was formulated targeting key nodes of enterprise operations. Three core managers in the logistics chain were selected for in-depth dialogue: the Operations Director, Customer Service Supervisor, and Warehouse Operations Manager, aiming to reveal differences in quality management perceptions and opportunities for process optimization within the organization.

To ensure the scientificity and reproducibility of the interview research, the following details are supplemented.

Interview Outline Core Questions:For the "Responsiveness" dimension, the designed core questions include: (1) What is the current process for handling customer logistics complaints (e.g., damaged goods, lost goods)? Please describe the specific links and time limits. (2) How does the company ensure that customer service personnel can promptly respond to customer inquiries? Are there any specific response time standards? (3) In the face of emergency logistics incidents (e.g., transportation delays caused by force majeure), what emergency response mechanisms has the company established, and how effective are they? (4) How does the company collect and use customer feedback on the responsiveness of services to optimize the service process?

Interview Duration:The interview with the Operations Director lasted 90 minutes, the interview with the Customer Service Supervisor lasted 80 minutes, and the interview with the Warehouse Operations Manager lasted 75 minutes. All interviews were conducted in a one-on- one manner and recorded with the consent of the interviewees.3. Interview Data Organization Method:After the interviews, the recording content was transcribed into text, and Nvivo 12.0 software was used for coding analysis. First, open coding was conducted to extract initial concepts from the interview text; then, axial coding was performed to classify and organize the initial concepts into categories with logical connections; finally, selective coding was carried out to construct the core category system, and the key viewpoints related to the research topics were extracted to provide support for the subsequent analysis of service quality problems.

Table 2. Questionnaire Design Indicator Hierarchy

Primary Indicator	Secondary Indicator	Primary Indicator	Secondary Indicator
Reliability	Goods delivered accurately and on time	Tangibles	Has modern service facilities
	Shows concern and helps when customers encounter difficulties		Service facilities are attractive
	The company is reliable		Transportation control
	Cargo integrity		Warehousing facilities
Responsiveness	Informs customers of the promised service time	Economy	Reasonable pricing
	Customer service		High value for money
	Employees are always willing to serve customers		Convenient and flexible payment methods
	Logistics processes are convenient and fast		Reasonable compensation for lost goods
Assurance	Employees are trustworthy	Empathy	The company provides personalized

			services for customers
	Employees are courteous		Employees understand customers' needs
	Service personnel have appropriate appearance and attire		The company prioritizes customers' interests

This survey questionnaire was constructed from three dimensions: First, explaining the purpose and use of the questionnaire to respondents; Second, investigating respondents' basic personal information, namely age, industry type, monthly income, and frequency of using Fedex transportation services; Finally, the service quality survey. The questionnaire content sets service quality as the primary indicator; it is divided into the five dimensions of the SERVQUAL model and the added "Economy" dimension based on practical considerations. These six dimensions—Tangibles, Reliability, Responsiveness, Assurance, Empathy, and Economy—are set as secondary indicators. Twenty-two specific influencing factors of service quality are designed as tertiary indicators to assess the current status of Fedex's logistics service quality.

The questionnaire survey adopted a simple random sampling method, and questionnaires were randomly distributed within Fedex’s business service scope to ensure the relative independence of respondents. The sampling scope covered both Fedex’s domestic logistics business and its cross-border logistics business in China, including customers in first-tier cities (Beijing, Shanghai, Guangzhou, Shenzhen), second-tier cities (Chengdu, Chongqing, Wuhan, Xi’an), as well as third-tier and lower-tier cities. This geographical coverage ensured, to a considerable extent, the representativeness of the sample. The final survey was conducted through an online questionnaire distributed via Wenjuanxing, resulting in 66 valid responses.

Table 3. Basic Information of Respondents

Name	Option	Frequency	Percentage (%)	Cumulative Percentage (%)
Age Group	18-25	2	3.03	3.03
	26-30	48	72.73	75.76
	31-40	9	13.64	89.39
	41-50	5	7.58	96.97
	51-60	2	3.03	100.00
Identity	Individual	55	83.33	83.33
	Enterprise	11	16.67	100.00
Monthly Income	CNY 4000~8000	3	4.55	4.55
	CNY 8000~15000	2	3.03	7.58

Range	CNY15000~30000	53	80.30	87.88
	Above CNY 30000	8	12.12	100.00
Total		66	100.0	100.0

To verify the scientific rigor of the questionnaire design and the reliability of the obtained data, reliability and validity tests were conducted.

Reliability Test: Cronbach's α coefficient was applied to examine the internal consistency of the questionnaire. The results indicated that the overall Cronbach's α was 0.823, exceeding the commonly accepted threshold of 0.7, suggesting strong internal consistency and high reliability. The Cronbach's α values for each dimension were as follows: Tangibles (0.785), Reliability (0.812), Responsiveness (0.798), Assurance (0.776), Empathy (0.763), and Economy (0.758), all greater than 0.7, demonstrating good reliability across all dimensions.

Validity Test: The Kaiser–Meyer–Olkin (KMO) test and Bartlett's sphericity test were conducted to assess the suitability of the dataset for factor analysis. The KMO value was 0.765, which is above the recommended minimum of 0.7, indicating that the data were suitable for factor analysis. Bartlett's sphericity test yielded a χ^2 value of 1256.342 with a p-value of $0.000 < 0.01$, demonstrating that the correlation matrix was not an identity matrix and confirming the appropriateness of factor analysis. In addition, content validity was evaluated through consultation with three logistics management experts and two senior Fedex managers. All experts agreed that the questionnaire items comprehensively reflected key aspects of Fedex's logistics service quality, indicating strong content validity.

The basic information of the questionnaires is shown in Table 3 below. Among the respondents, 55 were individual customers (83.33%), and 11 were corporate customers (16.67%). By age group: 2 respondents aged 18-25 (3.03%), 48 aged 26-30 (72.73% - the largest group), 9 aged 31-40 (13.64%), 5 aged 41-50 (7.58%), and 2 aged 51-60 (3.03%). By monthly income range: 3 respondents earning CNY 4000~8000 (4.55%), 2 earning CNY 8000~15000 (3.03%), 53 earning CNY 15000~30000 (80.30%), and 8 earning CNY 30000 and above (12.12%).

3.2. Reliability Analysis

In the increasingly competitive express industry, logistics timeliness, as a direct manifestation of service quality, directly impacts customer loyalty and brand reputation. Based on the characteristics of Fedex's customer base, this study focuses on the perceived differences in timeliness satisfaction between individual and corporate customers, aiming to reveal the relationship between customer identity attributes and service evaluation through chi-square tests. By quantitatively analyzing service experience consistency across different customer groups, it can verify the effectiveness of the company's service standardization implementation and provide data support for optimizing resource allocation and formulating differentiated service strategies, thereby uncovering the formation mechanism of the company's core competitiveness from the customer perspective.

Table 4. Cross-Tabulation Analysis of Delivery Timeliness Perception by Customer Type

Question	Name	Customer Identity (%)		Total	χ^2	p
		Individual	Enterprise			
Satisfaction with Fedex's cargo delivery timeliness	Very Satisfied	49(89.09)	9(81.82)	58(87.88)	1.655	0.437
	Satisfied	4(7.27)	2(18.18)	6(9.09)		
	Neutral	2(3.64)	0(0.00)	2(3.03)		
Total		55	11	66		

Using chi-square tests (cross-tabulation) to study the relationship between customer identity and perception of Fedex's cargo delivery timeliness, the data in Table 4 above shows: Among 55 individual customers, 49 were very satisfied (89.09%), 4 were satisfied (7.27%), and 2 were neutral (3.64%). Among 11 corporate customers, 9 were very satisfied (81.82%) and 2 were satisfied (18.18%). This shows that samples of different identities perceive Fedex's delivery timeliness consistently, with no significant difference.

This indicates that Fedex has a high level of standardization in service provision, allowing both individual and corporate customers to receive relatively consistent service experiences. Delivery timeliness, as a key indicator of express service, shows no significant difference in satisfaction, which is a manifestation of successful service standardization. It demonstrates that Fedex's service quality in delivery timeliness is widely recognized. Both individual and corporate customers express satisfaction with Fedex's delivery timeliness, further proving Fedex's competitiveness in the express service market.

3.3. Responsiveness Analysis

In the entire logistics service process, problem-solving efficiency directly impacts customer trust. This study focuses on Fedex's handling quality regarding damaged goods, lost goods, and complaint incidents. By comparing the satisfaction distribution of individual and corporate customers, it aims to reveal perceptual differences among different customer groups regarding the service recovery mechanism. Analyzing such data not only verifies the adaptability of the company's standardized service processes to different needs but also identifies potential shortcomings in service responsiveness. This provides a decision-making basis for optimizing the complaint handling mechanism and balancing resource investment priorities, thereby enhancing the refinement of customer relationship management while ensuring service quality.

Table 5. Cross-Tabulation of Responsiveness Issues by Customer Type

Question	Name	Customer Identity (%)		Total	χ^2
		Individual	Enterprise		
When you contact customer service	Generally resolved promptly	5(9.09)	6(54.55)	11(16.67)	13.697

regarding logistics issues, can they be resolved promptly?	Not resolved promptly	49(89.09)	5(45.45)	54(81.82)	
	Not resolved promptly	1(1.82)	0(0.00)	1(1.52)	
Total		55	11	66	
Satisfaction with the speed and outcome of the company's handling of issues like damage, loss, or your complaints?	Very Dissatisfied	1(1.82)	0(0.00)	1(1.52)	18.996
	Dissatisfied	1(1.82)	0(0.00)	1(1.52)	
	Neutral	2(3.64)	0(0.00)	2(3.03)	
	Satisfied	48(87.27)	5(45.45)	53(80.30)	
	Very Satisfied	3(5.45)	6(54.55)	9(13.64)	
Total		55	11	66	

From Table 5 above: Regarding prompt resolution of logistics issues via customer service: Among individuals, 49 (89.09%) said generally resolved promptly, 1 (1.82%) said not resolved promptly. Among enterprises, 5 (45.45%) said generally resolved promptly, 0 said not resolved promptly. Overall, 54 out of 66 (81.82%) said issues are generally resolved promptly.

Regarding satisfaction with handling speed and outcome for damage/loss/complaints: In the "Very Dissatisfied" and "Dissatisfied" options, only 1 individual selected each (low percentages). In the "Neutral" option, 2 individuals selected, no enterprises. In the "Satisfied" option, 48 individuals and 5 enterprises selected (highest percentage). In the "Very Satisfied" option, 3 individuals and 6 enterprises selected. Overall, "Satisfied" and "Very Satisfied" had the highest percentages, 80.30% and 13.64% respectively, indicating most customers are satisfied or very satisfied with the speed and outcome of problem handling.

Comparing differences: Samples of different identity customers show significant differences ($p<0.01$ level) in prompt resolution of logistics issues via customer service, with corporate customers' overall satisfaction higher than individual customers. Regarding satisfaction with problem handling speed, individual customers' overall satisfaction is higher than corporate customers', also showing significant differences ($p<0.01$ level).

3.4. Tangibles Analysis

In logistics service quality assessment, tangibles are manifested not only in hardware facilities but also throughout the standardized presentation of personnel service behaviors. This study focuses on the contradictory association between Fedex's customer service script training system and the service attitude of last-mile delivery personnel. By comparing internal management measures, such as the customer service script optimization mechanism, with external customer perception data, it analyzes the internal-external cognitive differences in such tangible service elements. This can verify the rationality of the company's training resource allocation and expose

potential loopholes in last-mile personnel management of the service chain, providing an entry point for building a full-process service quality monitoring system.

Regarding Tangibles, based on an interview with an internal Customer Service Manager: "The company provides unified service script training to customer service personnel. These scripts cover all aspects of customer service, including greetings, inquiries about needs, answering questions, handling complaints, etc. Through unified scripts, we ensure that customer service personnel maintain a professional, courteous, and consistent attitude when communicating with customers. Simultaneously, based on customer feedback and actual needs, we continuously optimize and improve service scripts. For uncovered scenarios, we regularly sort and supplement scripts to ensure customer service personnel can answer customer questions comprehensively and accurately."

To supplement the specific manifestations of couriers' poor attitudes and make the conclusion more convincing, the following content and Table 6 are added: Through the analysis of the open-ended questions in the questionnaire and the in-depth interviews with some customers, the specific manifestations of couriers' poor attitudes are summarized into four categories: (1) Rigid communication: Couriers only simply inform customers of the delivery time and location, and are unwilling to answer customers' additional inquiries (e.g., the specific arrival time of the goods, the reasons for the delay). (2) No explanation for delivery delays: When the goods are delivered late, couriers do not take the initiative to explain the reasons for the delay to customers, and even shirk responsibility when customers inquire. (3) Unfriendly service attitude: Couriers use impolite language when communicating with customers, and have impatient behaviors (e.g., hanging up the phone directly, speaking loudly). (4) Negligence in cargo handling: Couriers handle the goods roughly during delivery, and do not care about customers' concerns about the integrity of the goods.

Table 6. Frequency Statistics on Poor Courier Attitude

Name	Option	Frequency	Percentage (%)	Cumulative Percentage (%)
Courier attitude poor	Not Selected	16	24.24	24.24
	Selected	50	75.76	100.00
Total		66	100.0	100.0

However, according to the survey questionnaire, as shown in Table 6 above, among 66 respondents, 50 (75.76%) perceived courier attitude as poor, while 16 (24.24%) did not select this option. This result contradicts the Customer Service Manager's interview statement.

3.5. Assurance Analysis

Amidst the intensifying homogenized competition in the express industry, accurately identifying core customer demands is key to building differentiated service advantages. Corporate customers pay more attention to cost control and fulfillment efficiency, while individual customers focus more on service reliability and experiential perception. Revealing this demand heterogeneity not only verifies the applicability of market segmentation theory but also provides

empirical evidence for resolving the conflict between standardized service and personalized needs. This helps enterprises restructure resource allocation logic, design hierarchical service systems, and ultimately achieve the dual goals of customer value creation and operational efficiency improvement.

As shown in Table 7 above, using chi-square tests (cross-tabulation) to study the most important factors when choosing express services by different identity customers (the table covers five categories: Price, Speed, Reliability, Coverage, Customer Service):Price:The proportion of enterprises selecting this as important (36.36%) is significantly lower than individuals (89.09%).Speed:The proportion of enterprises selecting this as important (45.45%) is significantly lower than individuals (90.91%).Reliability:The proportion of individuals selecting this as important (10.91%) is significantly lower than enterprises (90.91%).Coverage:The proportion of individuals selecting this as important (10.91%) is significantly lower than enterprises (90.91%).Customer Service:The proportion of individuals selecting this as important (3.64%) is significantly lower than enterprises (54.55%).

Samples of different customer types show significant differences for all factors—Price, Speed, Reliability, Coverage, and Customer Service. Therefore, different service standards should be adopted for different customer categories.

Table 7. Most Important Factors When Choosing Express Service by Customer Type

Question	Name	Customer Identity (%)		Total	χ^2
		Individual	Enterprise		
Price	Not Selected	6(10.91)	7(63.64)	13(19.70)	16.112
	Selected	49(89.09)	4(36.36)	53(80.30)	
Total		55	11	66	
Speed	Not Selected	5(9.09)	6(54.55)	11(16.67)	13.636
	Selected	50(90.91)	5(45.45)	55(83.33)	
Total		55	11	66	
Reliability	Not Selected	49(89.09)	1(9.09)	50(75.76)	31.944
	Selected	6(10.91)	10(90.91)	16(24.24)	
Total		55	11	66	

Coverage	Not Selected	49(89.09)	1(9.09)	50(75.76)	31.944
	Selected	6(10.91)	10(90.91)	16(24.24)	
Total		55	11	66	
Customer Service	Not Selected	53 （96.36）	5 （45.45）	58 （87.88）	22.303
	Selected	2（3.64）	6 （54.55）	8 （12.12）	
Total		55	11	66	

3.6. Empathy Analysis

Under the trend of service scenario segmentation in the logistics industry, the precise matching of customer needs with transportation solutions has become key for enterprises to enhance service premium capabilities. Exploring such association maps can provide data support for enterprises to identify high-value service touchpoints and promote precision in service product innovation and resource allocation for transportation capacity, ultimately achieving a dual breakthrough in customer experience upgrade and operational cost optimization.

Table 8. Service Items Attracting Customers with Different Needs

	A. Long-distance shipping	B. Purchasing valuable items	C. Shipping valuable items	D. Purchasing foreign products
Door-to-Door Pickup	-0.032	0.859	-0.803	-0.141
Same-City Next-Day	-0.277	-0.098	0.141	0.566
Dedicated Vehicle/Aircraft	-0.027	0.651	-0.690	0.069
TNT (Dedicated) Delivery	-0.036	0.487	-0.308	-0.109
Service Customization	0.055	-0.293	0.424	-0.000
Not Interested, Still Not Choose Fedex	-0.032	-0.055	0.080	0.080

From Table 8 above, analyzing the service items attracting customers with different needs:Long-distance shipping : Shows a significant negative correlation with Same-City Next-Day (-0.277). Customers value Service Customization most (0.055), while correlations with other services are negative, indicating a need for door-to-door customized service.Purchasing valuable items: Customers value Door-to-Door Pickup (0.859), Dedicated Vehicle/Aircraft (0.651), and TNT Delivery (0.487) most, with Door-to-Door Pickup being the highest priority. Correlations with other services are negative.Shipping valuable items:Customers value Service Customization (0.424), Same-City Next-Day (0.141), and Not Interested (0.080) most, with Service Customization being the highest priority.Purchasing foreign products:Customers value Same-City Next-Day (0.566), Dedicated Vehicle/Aircraft (0.069), and Not Interested (0.080) most, with Same-City Next-Day being the highest priority.

Summary: Samples of customers with different logistics needs show significant differences for all services—Door-to-Door Pickup, Same-City Next-Day, Dedicated Vehicle/Aircraft Delivery, TNT (Dedicated) Delivery, Service Customization. Therefore, different service standards should be adopted for customers based on cargo type, quantity, timeliness requirements, and other influencing factors.

3.7. Economy Analysis

The Pearson correlation coefficient measures the linear correlation between two variables (range: -1 to 1), and visualization can intuitively present this relationship.

As shown in Figure 1 below, "Statistical Chart of Economy Indicator Scores by Different Needs," it lists scores for four different needs (Long-distance shipping, Purchasing valuable items, Shipping valuable items, Purchasing foreign products) across four dimensions: Reasonable Pricing, High Value for Money, Convenient and Flexible Payment Methods, Reasonable Compensation for Lost Goods. Scores use a quantified standard; specific values represent customer satisfaction or evaluation in these aspects.

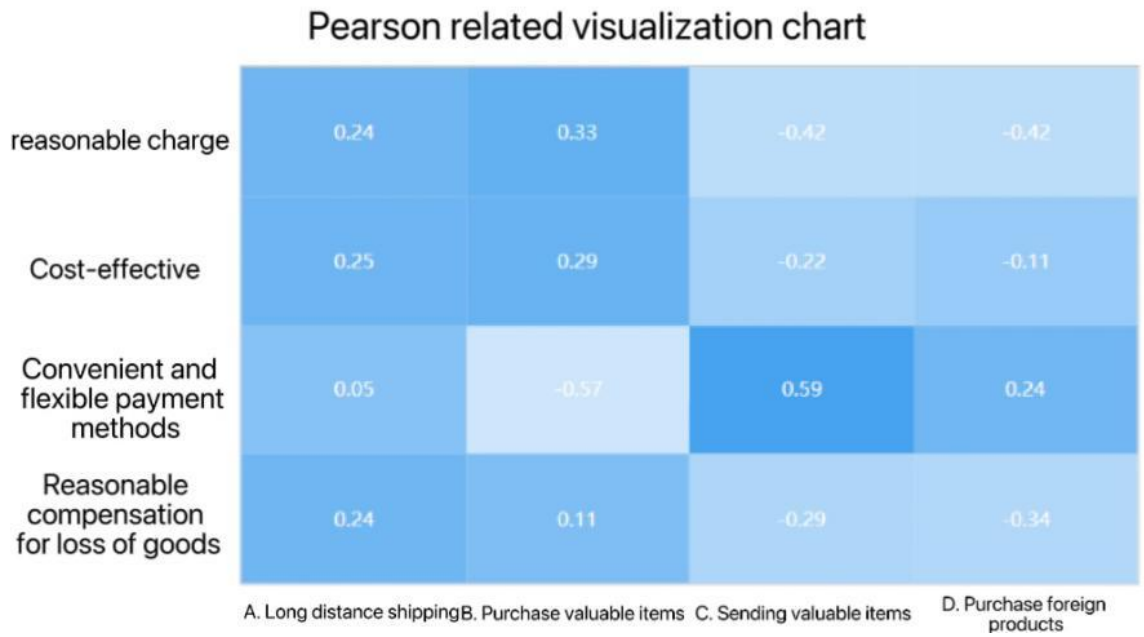

Figure 1. Statistical Chart of Economy Indicator Scores by Different Needs

Reasonable Pricing:Scores are higher for Long-distance shipping and Purchasing valuable items (0.242, 0.335), indicating customers find pricing relatively reasonable for these services. Scores are lower for Shipping valuable items and Purchasing foreign products, suggesting dissatisfaction. High Value for Money:Scores remain higher for Long-distance shipping and Purchasing valuable items (0.248, 0.293), indicating perceived good value. Shipping valuable items scores low (-0.217), indicating poor perceived value. Purchasing foreign products also scores low (-0.113), but slightly better. Convenient and Flexible Payment:Scores show significant contrast for Shipping valuable items and Purchasing foreign products. Shipping valuable items scores high (0.590), indicating high satisfaction. Purchasing foreign products scores very low (-0.570), indicating strong dissatisfaction. Long-distance shipping scores low (0.046), suggesting room for improvement. Purchasing valuable items is moderate (0.236). Reasonable Compensation for Lost Goods:Scores remain higher for Long-distance shipping and Purchasing valuable items (0.237, 0.111), indicating relative satisfaction. Shipping valuable items and Purchasing foreign products score lower (-0.295, -0.339), indicating dissatisfaction.

Samples of customers with different logistics needs show significant differences in scores for Reasonable Pricing, High Value for Money, Convenient and Flexible Payment Methods, and Reasonable Compensation for Lost Goods. Therefore, for customers with different cargo transportation needs, clear pricing standards should be established to allow flexible calculation adapted to different types of goods, ensuring standardization. Payment methods should also become increasingly informatized and networked, offering more flexibility and convenience, enhancing overall efficiency, improving logistics rationality, and thereby increasing customer satisfaction with logistics service quality.

4. Problems and Cause Analysis of Fedex's Logistics Service Quality

4.1. Customer Differentiation and Service Training Issues

4.1.1. Undifferentiated Customer Service

Through the analysis of satisfaction with Fedex's delivery timeliness in the Reliability analysis, it can be seen that individual customers pay more attention to the immediacy and convenience of service, valuing the overall experience and personalized needs. Therefore, their satisfaction with prompt problem resolution may be more sensitive. Corporate customers value the overall quality of service and problem-solving efficiency more, having higher expectations for speed and reliability because they often rely on these services to maintain business operations. They might be more tolerant of occasional delays, potentially understanding the complexity and uncertainty of the logistics industry better.

4.1.2. Inadequate Business Training System Management

In the Tangibles analysis, the contradictory association between Fedex's customer service script training system and the service attitude of last-mile delivery personnel exposed insufficient training efforts by the company. Training has not been reasonably implemented and managed,

leading to lower customer service satisfaction. The service scripts mentioned in the Customer Service Manager interview may focus more on communication scenarios within customer service centers, failing to fully consider customer needs and expectations during the courier delivery process. Courier personnel may face more immediate and emergent communication scenarios, requiring more flexible and personalized coping strategies.

4.2. Personalized Service Issues

4.2.1. Insufficient Insight into Customer Needs

Through the Assurance analysis and the different needs identified in the Empathy analysis, regarding Fedex's handling quality for damaged goods, lost goods, and complaints, comparing the satisfaction distribution of individual and corporate customers reveals different focus points for customers with different transportation needs. Only by clarifying these can comprehensive and high-quality services be provided to customers. Differentiated service plans can be designed for different industries (e.g., pharmaceutical cold chain, auto parts).

4.2.2.Weak Technical Support Capabilities

Lack of data-driven approaches: Failure to build customer profiles and demand forecasting models, relying on manual experience for solution formulation, leading to low customization efficiency. Furthermore, insufficient smart tools: Lack of intelligent scheduling systems (e.g., dynamic route planning), automated equipment (e.g., flexible sorting lines), making it difficult to efficiently handle small-batch, multi-frequency orders.

4.3. Pricing and Cost Issues

4.3.1. Imbalance Between Revenue and Cost

Due to the imbalance between revenue and cost, Fedex's overall prices remain high. While it can meet consumer demand, the Assurance analysis shows customer satisfaction with pricing is not very high. This indicates the company needs practical countermeasures to reduce logistics operating costs, thereby lowering overall prices, increasing consumer satisfaction, enhancing the company's market competitiveness in pricing, and consequently improving operating profits.

4.3.2. Loss of Price-Sensitive Customers

Through the Economy analysis, scores for different needs (Long-distance shipping, Purchasing valuable items, Shipping valuable items, Purchasing foreign products) across the four dimensions (Reasonable Pricing, High Value for Money, Convenient Payment, Reasonable Compensation) reveal an inability to attract price-sensitive customers through promotional methods like time-limited discounts or new customer offers, causing them to switch to competitors offering low-price strategies. Failure to promote high-margin value-added services (e.g., cash on delivery, custom packaging) through promotions leads to a single income source and limited profit margins.

5. Suggestions for Improving Fedex's Logistics Service Quality

5.1. Provide Differentiated Services Based on Different Customer Needs

5.1.1. Establish a Deep Customer Needs Analysis System

For individual customers, enhance service immediacy and convenience, ensure problems are resolved quickly, and improve customer satisfaction. For corporate customers, besides focusing on overall service quality, emphasize service reliability and efficiency, establishing more professional customer service teams and response mechanisms to meet their high requirements.

Enterprises can capture full supply chain link data through IoT devices, ERP integration, and customer behavior analysis platforms to generate customer demand profiles (e.g., order fluctuation patterns, service sensitivity points). Design standardized module libraries tailored to industries like pharmaceuticals, fresh produce, and e-commerce (e.g., temperature control, customs clearance, reverse logistics), supporting an agile customization model of "modular combination + fine-tuning".

Leveraging the advantages of Fedex's global air hub network, the company can develop a customized "cross-border logistics + integrated customs clearance" service package to meet the high-efficiency cross-border transportation needs of corporate customers. Specifically, the service package consists of the following components:

(1) Pre-customs clearance consultation: Professional customs compliance consultants provide tailored customs clearance plans based on cargo type and the customs policies of the destination country, ensuring accurate and compliant documentation in advance.

(2) Fast-track customs clearance channels: In cooperation with major customs authorities worldwide, Fedex can establish exclusive customs clearance channels for corporate customers, reducing clearance time by approximately 30%–50%.

(3) Real-time customs clearance tracking: A dedicated tracking system is established to allow corporate customers to monitor customs clearance progress in real time via the official Fedex website or mobile application, thereby improving transparency and control of logistics operations.

(4) Post-clearance support: Value-added services—including warehousing, distribution, and related logistics solutions—are provided after customs clearance to help corporate customers enhance supply chain efficiency across the entire logistics cycle.

5.1.2. Improve Training and Assessment Mechanisms

Extend unified service script training to frontline courier personnel, ensuring they maintain a professional, courteous, and consistent attitude when communicating with customers. Design more practical and flexible training courses tailored to the specific work environment and needs of courier personnel. Establish effective supervision and assessment mechanisms to ensure training outcomes are implemented in actual work. Simultaneously, set up clear reward and punishment mechanisms to incentivize couriers to improve service attitudes. Utilize online learning platforms, VR simulation training, etc., to enhance training flexibility.

5.2. Develop Comprehensive Personalized Services

5.2.1. Offer Customized Services

Provide customized services based on customer needs and preferences, such as specific packaging, timed delivery, etc., to improve customer satisfaction and increase loyalty. Establish

feedback mechanisms to promptly collect and process customer opinions and suggestions, continuously improving service quality, satisfaction, and loyalty.

5.2.2. Expand Value-Added Services

Provide warehousing and inventory management services to help customers reduce inventory costs and increase turnover rates. Offer financial and insurance services related to express delivery, such as freight advance payment, cargo insurance, etc., to increase customer trust and dependence.

5.2.3. Introduce Intelligent Technologies

Introduce AI algorithms to optimize customized solutions, such as using historical data-based cost-timeliness balance models to automatically generate multiple optional solutions for customers. Deploy flexible equipment like AGVs and collaborative robots to support rapid sorting and packaging customization for small-batch orders. Introduce automated sorting systems, intelligent scheduling systems, and other technical means to improve express processing and distribution efficiency and reduce operating costs. Optimize transportation routes: Use big data analysis to optimize routes and distribution plans, reducing unnecessary mileage and waiting time, improving transportation efficiency.

5.3. Reasonably Adjust Pricing Strategy to Enhance Market Competitiveness

5.3.1. Adjust Pricing Strategy, Enhance Value for Money

Develop reasonable pricing strategies based on the characteristics of different services and customer needs, ensuring price matches service quality. Strengthen sensitivity analysis of pricing and adjust prices timely to attract more customers. Simultaneously, provide multiple payment methods and convenient payment processes to enhance the payment experience. Transparent pricing system: Ensure the transparency and fairness of the pricing system, avoid hidden charges and unnecessary fees, enabling customers to clearly understand service costs. Differentiated pricing: Develop differentiated pricing strategies based on customer express needs, weight, volume, transportation distance, etc., to meet different customer budgets and needs. Regular promotional activities, such as during 618, Double 11, and the company's own special event days, can effectively increase satisfaction among price-sensitive customers and boost their purchasing power.

5.3.2. Strengthen Internal Cost Control

Refined management: Reduce various operating costs, such as procurement costs, labor costs, and transportation costs, through refined management, improving overall economic efficiency. Energy saving and emission reduction: Adopt environmentally friendly materials and energy-saving technologies to reduce energy consumption and emissions, minimizing environmental impact while lowering operating costs. By reducing operating costs, the market price for consumers can be lowered, effectively increasing the purchase intention of price-sensitive customers.

6. Conclusions and Outlook

6.1. Conclusions

Through an in-depth investigation and research on Fedex's logistics service quality, the following conclusions can be drawn: Fedex possesses a global network and efficient distribution system, enabling it to provide fast and reliable express services to customers. Among the multiple dimensions covered by the SERVQUAL model, Fedex performs particularly well in Reliability. Both individual and corporate customers gave high ratings for the timeliness of cargo delivery. This indicates that Fedex has a high level of standardization in service provision, ensuring relatively consistent service experiences for customers of different identities. However, Fedex still faces challenges in the Economy dimension. Some customers perceive its pricing as high, affecting the perception of value for money. Although Fedex has competitive advantages like a well-developed logistics network and efficient delivery speed, it still needs to make efforts in adapting to market price changes and optimizing cost structures to maintain its competitiveness in terms of Economy.

6.2. Limitations and Outlook

6.2.1. Limitations of the Study

(1) Small Sample Size: This study collected only 66 valid questionnaires, which constitutes a relatively small sample size. Although simple random sampling was adopted and the sample covered diverse regions and customer types, the limited sample size may still affect the representativeness and generalizability of the research findings. For instance, in the analysis of customer demand differences, only 11 respondents were corporate customers, resulting in insufficient statistical power and potentially failing to fully reflect the actual logistics needs of corporate clients.

(2) Sample Structure Bias: Within the sample structure, individual customers accounted for 83.33%, while corporate customers accounted for only 16.67%. The low proportion of corporate respondents may cause the research results to lean more toward the needs and evaluations of individual customers, thereby limiting the ability to accurately reflect the service quality challenges Fedex faces in the corporate customer segment. Additionally, the age distribution of respondents was heavily concentrated in the 26–30 age group (72.73%), while other age groups were underrepresented. This imbalance may also affect the comprehensiveness of the research conclusions.

6.2.2. Future Research Directions

(1) Expand Sample Size: Future studies should expand the sample size—preferably collecting at least 200 valid questionnaires—to enhance the representativeness and generalizability of research outcomes. In addition, adopting stratified sampling is recommended to ensure that the proportions of different customer types (individual vs. corporate), regions, and age groups are consistent with Fedex’s actual customer structure, thereby reducing sample structure bias.

(2) Deepen Research on Corporate Customers: Given that corporate customers constitute an important customer group for Fedex, subsequent research could focus specifically on this segment.

In-depth interviews with additional corporate clients and Fedex's corporate service personnel may help analyze the detailed needs and service pain points of business clients. Furthermore, differentiated research into logistics service needs across industries—such as manufacturing, e-commerce, and pharmaceuticals—would support the development of more targeted service quality improvement strategies for Fedex.

(3) Conduct Longitudinal Tracking Research: This study is cross-sectional in nature and can only capture the status of Fedex's service quality at a single point in time. Future research may adopt a longitudinal approach by conducting periodic surveys of Fedex customers to track changes in customer satisfaction and service quality issues over time. Such analysis can help evaluate the effectiveness of Fedex's service improvement initiatives and provide dynamic and comprehensive insights for long-term service quality management.

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Luwei Cui, Qiaoyun Wei: conceptualization, gather material, writing—original draf, writing—original draft, formulate a questionnaire, data analysis, project administration. All authors have read and agreed to the published version of the manuscript.

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All data are presented in the paper. If you require the data, please contact the corresponding author.

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The authors declare no conflict of interest.

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Supplier Management as a Driver of Efficiency and Competitiveness in E-commerce Logistics Supply Chains

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Abstract

With the rapid development of e-commerce, the efficient operation of e-commerce logistics supply chain has become the key to industry competition. This paper deeply explores the key role of supplier management in the e-commerce logistics supply chain. Through theoretical analysis and practical case study, it expounds the significance of supplier management in ensuring the stability of goods supply, reducing logistics costs, improving product quality, enhancing customer satisfaction and promoting the coordination of supply chain. At the same time, this paper analyzes the problems existing in supplier management in the current e-commerce logistics supply chain, and puts forward targeted optimization strategies, aiming to provide useful reference for e-commerce enterprises to improve the level of supply chain management and enhance the market competitiveness.

Keywords: Supplier Management; E-commerce Logistics; Supply Chain Optimization; Operational Efficiency; Customer Satisfaction; Case Study

1. Introduction

In the contemporary digital era, the rapid advancement of Internet technology has profoundly transformed the landscape of global commerce. Among the many changes brought by this technological surge, e-commerce has emerged as a dominant force, demonstrating explosive growth over the past decade (Brown & Davis, 2022; Teller et al., 2016). This transformation is not merely a gradual evolution of traditional business models but a deep and far-reaching shift that has penetrated almost every facet of the global economic ecosystem.

Statistics from eMarketer vividly illustrate the remarkable trajectory of global e-commerce retail sales. In 2015, total sales reached USD 1.66 trillion—a significant figure at the time, yet merely the starting point of a steep upward climb. By 2024, the figure is projected to reach USD 5.5 trillion, representing more than a threefold increase in less than ten years. Looking ahead, forecasts suggest that global e-commerce retail sales will surpass USD 10 trillion by 2030. This growth is not confined to a handful of developed markets; rather, it is a global phenomenon, with multiple countries and regions contributing to the overall upward trend. Figure 1 is an explicit indication that various nations—headed by China, the United States, and the United Kingdom—are spearheading the global continuous growth of the e-commerce retail industry.

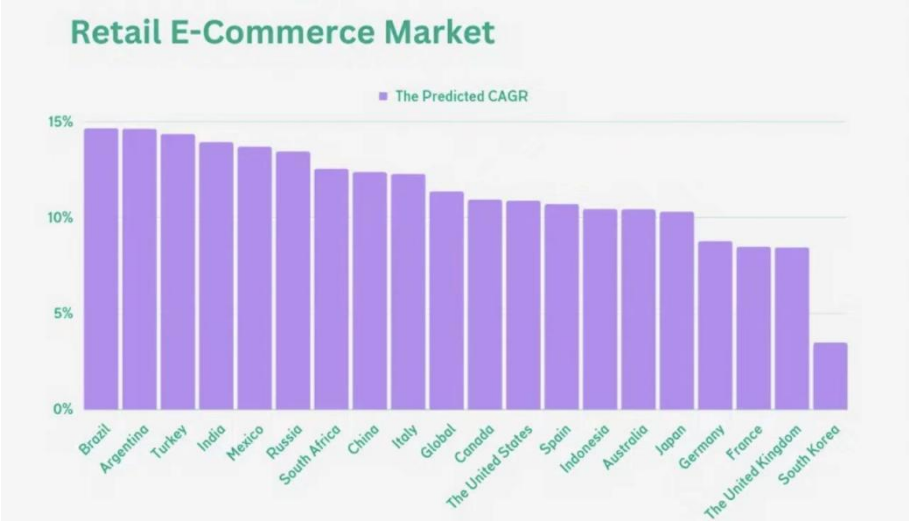

Figure 1. Retail e-commerce market growth by country

Within this global expansion, China stands out as a powerhouse in the e-commerce sector, solidifying its position as the largest e-commerce market in the world. In 2024, the value of China's e-commerce retail sales is expected to hit RMB 15.6 trillion. Even more telling is the proportion this represents—over 30% of the country's total retail sales of consumer goods—demonstrating that online commerce has become a dominant and indispensable part of China's domestic market. Across the country, from cosmopolitan hubs like Shanghai and Beijing to rapidly growing inland cities, consumers have embraced e-commerce wholeheartedly. The convenience of purchasing everything from daily necessities to high-end electronics with just a few taps on a smartphone, and having these items delivered within one to two days, has fundamentally reshaped consumption patterns.

Beneath the surface of this impressive growth lies a critical yet often overlooked factor: the logistics supply chain. As e-commerce has evolved, so too has the role of logistics. In the early years, competition among e-commerce enterprises revolved primarily around the variety of products offered and the prices at which they were sold (Williamson, 1985; Pfeffer et al., 1978). However, as markets have matured, competitive priorities have shifted dramatically. Today, the key battleground is the efficiency, speed, and reliability of the logistics supply chain. Consumers now expect not only attractive pricing but also fast, on-time delivery, accurate tracking information, and dependable after-sales service. A delay of even one or two days can result in customer dissatisfaction and the loss of future business. During major shopping festivals—such as

China's Singles' Day or the West's Black Friday—platforms that can guarantee smooth, timely order fulfillment gain a substantial competitive advantage.

At the very foundation of this critical logistics network are the suppliers. The quality of supplier management exerts a direct and profound influence on the overall performance of an e-commerce logistics supply chain. Well-managed suppliers ensure the timely availability of goods, maintain high product quality, and collaborate effectively with logistics partners (Smith & Johnson, 2023; Chopra & Meindl, 2020). They are also able to adapt quickly to fluctuations in demand—whether driven by sudden promotional events or shifts in consumer preferences (Yu et al., 2016; Dyer & Singh, 1998). Conversely, poorly managed suppliers can create bottlenecks in the supply chain, leading to stock shortages, delivery delays, and ultimately, a negative impact on the e-commerce enterprise's reputation and bottom line.

In summary, while the rapid rise of e-commerce driven by Internet technology is a remarkable achievement, the long-term success of e-commerce enterprises increasingly depends on their ability to manage and optimize their logistics supply chains, beginning with the effective management of suppliers. This recognition forms the basis for the present research, which aims to examine the role of supplier management in enhancing logistics performance, improving market competitiveness, and fostering sustainable industry development.

2. Objectives and Contributions

2.1. Research Objective

The primary objective of this study is to undertake a comprehensive and detailed investigation into the critical role of supplier management within e-commerce logistics supply chains. In this research, supplier management is conceptualized not as a routine operational task, but as the structural backbone that supports the efficiency, stability, and adaptability of the entire logistics network. The study explores how supplier performance directly and indirectly shapes multiple operational domains, including inventory management, warehousing efficiency, transportation planning, and last-mile delivery.

To achieve this objective, the study employs a multi-method research approach that integrates three complementary strategies. First, case studies are conducted to analyze both successful and unsuccessful supply chain practices, thereby providing comparative insights into the influence of supplier management. Second, in-depth interviews with managers of e-commerce enterprises are used to capture first-hand accounts of supplier–logistics interactions. Third, quantitative analysis is undertaken on key performance indicators—such as order fulfillment accuracy, on-time delivery rates, and defect ratios—that are directly linked to supplier operations. This comprehensive methodological design enables a nuanced understanding of how supplier efficiency, reliability, and adaptability collectively determine the resilience and performance of e-commerce logistics systems.

2.2. Research Contributions

From a theoretical perspective, this study extends the existing body of supply chain management literature by positioning supplier behavior at the center of analysis. It incorporates variables often overlooked in conventional models—such as suppliers' responsiveness to market fluctuations, capacity for innovation in product design or manufacturing processes, and adherence to rigorous quality control standards—into established theoretical frameworks. By integrating these elements, the research provides a more comprehensive and realistic representation of e-commerce logistics systems, particularly within markets characterized by volatility, short product life cycles, and rapid technological change. Furthermore, the study offers a refined lens through which to adapt traditional supply chain theories, which were largely developed in the context of brick-and-mortar retail or manufacturing, to the distinctive operational realities of digital commerce.

From a practical standpoint, the findings yield actionable insights for e-commerce enterprises seeking to enhance supply chain performance. Effective supplier management can deliver significant cost reductions, not only in procurement but also across related logistics operations. Careful supplier selection, favorable contract negotiation, and continuous performance monitoring can lower the cost of goods sold while streamlining warehousing, transportation, and delivery processes. Suppliers with advanced production capabilities or economies of scale can further enhance competitiveness by offering better pricing and consistent quality.

Beyond cost efficiency, robust supplier management contributes directly to improved customer satisfaction. The timely delivery of high-quality products reinforces consumer trust, encourages repeat purchases, and strengthens brand loyalty—factors that are essential in the highly competitive e-commerce landscape. By simultaneously reducing costs and enhancing service quality, sound supplier governance enables enterprises to offer more attractive prices, superior products, and faster delivery than their competitors, thereby improving their market position.

Importantly, the benefits extend beyond individual enterprises to the broader e-commerce industry. As more companies adopt sound supplier management practices, the overall efficiency, reliability, and sustainability of e-commerce logistics supply chains improve, fostering a healthier and more resilient e-commerce ecosystem that benefits suppliers, logistics providers, platforms, and consumers alike.

2.3. Theoretical Foundations of Supplier Management

The current research finds inspiration from some proven theoretical lenses from the field of supply chain management to decipher how supplier management amplifies the efficiency and competitiveness levels of e-commerce logistics supply chains.

Resource Dependence Theory (RDT) highlights how companies rely on outside partners for vital resources—raw materials, technology, and logistical capacity—and need to proactively manage those interdependencies to fend off uncertainty and stabilize. Within an e-commerce environment, where quick changes in markets and demand variability are the norm, efficient management of suppliers enables business ventures to gain stable inputs and remain adaptable. Through the formation of extended-term, trustee-based relationships, e-commerce business

ventures are able to minimize reliance on fluctuating outside circumstances and strengthen the supply chain.

Transaction Cost Theory (TCT) offers an alternative explanation framework. According to it, companies try to economize overall costs of transactions, comprising negotiation, monitoring, and enforcement, by using the best governance mechanisms. Supplier management is also central to the selection of proper contractual forms, performance indicators, and monitoring mechanisms to Balance efficiency and controls. In business to business logistics, with higher volumes of transactions and products' shorter lives, the use of TCT assists companies to decide when to internalised the business of logistics or contract it with dedicated suppliers, thus economizing the coordination cost and the risk associated with operations.

Lastly, the Relational View goes outside firm borders, suggesting that inter-organizational relations per se are sources of durable competitive advantage. Collaborative relations with suppliers, involving common information systems, co-improvement processes, and reciprocal investment, build up relational rents that are not easily matched through imitation. In e-commerce distribution, this collaboration facilitates quick filling of orders, co-innovation of packaging or transport, and end-user satisfaction, all reinforcing the enterprise's competitiveness.

Collectively, these conceptual models give a multi-dimensional view of the supplier management: RDT peers at resources leverage and dependency reduction; TCT spotlights efficiency and governance; and the Relational Viewpoints to value co-creation and sustainable competitiveness. These lenses, taken together, underpin the analysis model and case explanations that follow in subsequent sections here.

3. Overview of the E-commerce Logistics Supply Chain

3. 1. Methodology Overview

In order to preserve the methodological rigor, this dissertation takes a case-exemplification mixed-method design that combines qualitative and quantitative analysis. Two exemplary e-commerce companies Amazon and JD.com were invited to serve as case exemplars for summarizing both international and domestic industry features. Data were sourced from diversified sources, for example, annual reports (2015–2024), Statista and eMarketer data, and government or platform logistical bulletins. Major performance indices, for example, logistics-cost ratio, on-time-delivery ratio, and customer-satisfaction index, were pinpointed for confirming the framework of analysis.

Qualitative sources (business reports, policy papers, and professional interviews) were thematic-coded to recognize common patterns in supplier management. Quantitative signals were then employed to triangulate these results and plot performance trends. Such methodological configuration allows for a structured analysis of how the practice of managing the suppliers has an effect on efficiency, dependability, and competitiveness for e-commerce logistics supply chains.

3.2. Composition of the E-commerce Logistics Supply Chain

The e-commerce logistics supply chain is a complex and highly interconnected system comprising multiple stakeholders, including suppliers, e-commerce platforms, logistics enterprises, and consumers. Suppliers are responsible for providing goods, e-commerce platforms function as transaction hubs that integrate product information with consumer demand, logistics enterprises manage transportation, warehousing, and distribution activities, and consumers constitute the final demand link in the chain.

These stakeholders interact continuously, with each link influencing the others in both direct and indirect ways. As a result, inefficiencies in any single segment can generate cascading effects across the system. Ensuring effective coordination among all participants is therefore essential to maintaining operational performance and sustaining competitive advantage.

3.3. Characteristics of the E-commerce Logistics Supply Chain

3.3.1. High Degree of Informationization

Modern e-commerce logistics systems are characterized by a high level of digitalization, driven by the widespread adoption of Internet-based technologies. This technological infrastructure serves as the backbone of operations, enabling seamless, real-time data sharing across all stages of the supply chain.

The process begins as soon as an order is placed on an e-commerce platform. Advanced software systems transmit the order information instantly to all relevant actors. Warehouse management systems are immediately alerted to begin preparing goods for dispatch, and once goods leave storage, sensors and tracking devices capture the event and feed data back into the logistics information system.

During transportation, GPS and other tracking tools provide real-time updates on the location, speed, and estimated arrival time of shipments. Customers can access this information through platform interfaces, which enhances transparency and builds trust. Simultaneously, logistics managers use the data to preempt potential disruptions caused by traffic congestion, adverse weather, or equipment issues, adjusting delivery routes and communicating proactively with customers.

Real-time information flows also enhance coordination between supply chain links. Warehouses can adjust inventory levels based on incoming order patterns, while transportation providers can optimize routes and schedules to improve efficiency. Such integration reduces operational errors, minimizes delays, and increases productivity across the system.

3.3.2. Rapid Response Capability

In the fast-paced e-commerce environment, consumer expectations for quick delivery and high service quality have intensified, requiring supply chains to operate with unprecedented agility. The availability of same-day and next-day delivery has set new performance benchmarks, compelling firms to accelerate order processing to minutes—or even seconds—through highly automated verification, payment, and inventory allocation systems.

Once an order is confirmed, logistics providers must mobilize resources immediately. In densely populated urban areas, last-mile delivery often involves fleets of motorcycles, vans, or bicycles, while in certain markets, drones are being explored to shorten delivery times for lightweight goods.

Equally important is responsive customer service. When disruptions occur—such as delayed deliveries or damaged products—service teams must address the issues swiftly and transparently, ensuring that customers remain informed. This rapid problem resolution not only mitigates immediate dissatisfaction but also helps cultivate long-term customer loyalty.

3.3.3. Flexibility and Adaptability

The e-commerce market is inherently volatile, with demand patterns shifting rapidly due to seasonal fluctuations, emerging trends, social media influence, or unexpected macroeconomic changes. Short product life cycles further intensify the need for adaptability.

Flexibility in inventory management is crucial. When a product experiences sudden demand growth—perhaps triggered by viral marketing—companies must rapidly restock through expedited supplier deliveries or reallocation of inventory across warehouses. Conversely, when demand declines, swift liquidation strategies are required to prevent excessive holding costs.

Transport flexibility is equally vital. Natural disasters, regulatory changes, or infrastructure disruptions may necessitate immediate rerouting of shipments, whether by diverting vehicles to alternative routes or switching ports for maritime freight. Distribution models must also adapt to evolving customer preferences, shifting between home delivery, pick-up points, or parcel locker services. During peak shopping periods, companies may expand delivery teams, extend operational hours, and adopt alternative delivery methods to manage order surges effectively.

This ability to adapt to fluctuating market conditions and external disruptions ensures the continuous and efficient movement of goods from suppliers to consumers, safeguarding operational stability and customer satisfaction.

4. The Key Role of Supplier Management in the E-commerce Logistics Supply Chain

Supplier management occupies a central role in e-commerce logistics, exerting a direct influence on operational efficiency, cost control, product quality, and customer satisfaction. By ensuring the stability of goods supply, enhancing service quality, and enabling business expansion, effective supplier management significantly strengthens the competitiveness of e-commerce enterprises.

4.1. Ensuring the Stability of the Supply of Goods

4.1.1. Stable Supply of Goods

Reliable suppliers are essential for guaranteeing a continuous and stable flow of goods to e-commerce enterprises, particularly during high-demand shopping events such as China's "Double 11" and "618." During these peak periods, order volumes can surge exponentially. If suppliers fail to deliver sufficient quantities on time, companies risk stock shortages, resulting in missed sales

opportunities and reduced customer satisfaction. Therefore, proactive supplier coordination and early capacity planning are critical to preventing stock shortages and ensuring seamless order fulfillment during sales peaks.

For example, JD.com has cultivated long-term partnerships with numerous high-quality suppliers. Through proactive stockpiling and process optimization ahead of major sales events, JD ensured product availability during high-demand periods. As a result, the company recorded a 25% year-on-year sales increase during the 2024 “Double 11” festival.

4.1.2. Ability to Respond to Emergencies

Outstanding suppliers also demonstrate the capability to respond quickly to unforeseen disruptions such as natural disasters, raw material shortages, or sudden policy changes. Rapid adaptation and effective contingency measures can significantly reduce the negative impact on e-commerce operations. This agility is largely achieved through supplier development programs and the establishment of early-warning communication systems, which are core elements of effective supplier management. For instance, during the COVID-19 pandemic, certain suppliers adjusted production schedules and diversified sourcing channels to maintain supply continuity despite severe logistical challenges. Statistical data also indicate that improvements in supplier management can contribute to reducing logistics costs as a proportion of total sales. As shown in Table 1, between 2015 and 2024, the proportion of logistics costs in total sales steadily declined, reflecting enhanced supply chain efficiency and better coordination between suppliers and logistics service providers.

Table.1 The proportion of logistics cost in sales in 2015–2024

year	Logistics cost in sales proportion (%)
2015	14.5
2016	13.8
2017	13.2
2018	12.6
2019	12.0
2020	11.5
2021	11.2
2022	10.8
2023	10.5
2024	10.2

Source: Compiled from JD.com and Amazon Annual Reports (2015–2024), Statista, and eMarketer data.

Table 1 reveals a steadily declining ratio between the fraction of logistical costs to overall operating expenses, revealing an encouraging trend toward enhanced logistical operability for the e-commerce logistical supply chain. The declining trend is directly related to the uptake of sophisticated supplier administration procedures that have refined main phases of logistical operability. Specifically, businesses have intensified collaboration with suppliers through joint packaging design, joint warehouses, and transportation consolidation planning. Joint packaging design decreases the weight and size of shipments, consequently reducing handling and transportation costs. Joint warehouse planning allows the pre-positioning of inventory around major distribution centers, reducing conveyance time and storage redundancy. Correspondingly, transportation consolidation permits more than one supplier to synchronize distribution routes, maximizing truck usage and reducing dead-load mileage. Individually, these initiatives for managing suppliers have directly aided the continuous decrease in logistical cost ratio found in Table 1, while also facilitating increased delivery reliability, logistical flexibility, and logistical supply chain competitiveness.

4.2. Service Quality Improvement

4.2.1. On-Time Delivery Performance

In today's competitive e-commerce environment, the on-time delivery rate is a key performance indicator. Amazon offers a notable example: in 2015, its global on-time delivery rate was 92%, but by 2024, it had exceeded 98%. This improvement resulted from Amazon's collaborative planning with suppliers and the integration of real-time data systems that synchronize production and logistics schedules.

This improvement was achieved through closer and more efficient collaboration with suppliers, supported by real-time data sharing and enhanced communication channels. Suppliers receive immediate order notifications, enabling them to prepare production without delay. In earlier years, communication lags often resulted in production delays that disrupted delivery schedules. The updated systems allow suppliers to plan production more effectively, ensuring goods are ready for shipment on time.

Coordination extends to transportation and distribution stages. By sharing warehouse inventory data and regional demand forecasts, Amazon and its suppliers jointly determine optimal shipping routes, adjusting plans based on order urgency, customer location, and available transport capacity. This integrated approach has reduced transit times and increased delivery reliability, directly contributing to higher on-time delivery rates.

4.2.2. Customer Satisfaction

Supplier management also plays a crucial role in enhancing customer satisfaction. For example, Amazon has improved its customer satisfaction rate from 85% in 2015 to 93% in 2024 through strict supplier quality control and efficient collaboration mechanisms, accompanied by a significant increase in customer loyalty.

This improvement is closely linked to product quality control. Amazon enforces strict supplier selection criteria and continuously monitors performance to ensure that only products meeting

rigorous quality standards reach consumers. In the electronics category, for example, suppliers must guarantee defect-free products that meet all advertised specifications, as defective goods not only cause dissatisfaction but also damage brand reputation.

Efficient supplier collaboration further enhances the customer experience through accurate order tracking. Coordinated data sharing between suppliers and logistics providers enables customers to monitor the journey of their orders from warehouse to delivery point. This transparency reduces uncertainty and strengthens trust, increasing the likelihood of repeat purchases and positive word-of-mouth recommendations.

4.3. Continuous Growth of Business Scale

4.3.1. Stable Supplier Management as a Growth Driver

A well-managed supplier network provides a strong foundation for business expansion. Between 2015 and 2024, Amazon achieved a compound annual growth rate of over 15% in global sales. Such sustained growth can be attributed to the reliability and scalability achieved through strategic supplier partnerships, which ensured continuous product availability during market expansion. This growth encompassed not only the scaling of existing operations but also successful entry into new sectors, such as fresh e-commerce and cross-border trade—initiatives supported by robust supplier partnerships. This trend is further supported by quantitative evidence. As shown in Table 2, Amazon's global sales experienced continuous growth from 2015 to 2024, with a compound annual growth rate exceeding 15%. This sustained upward trajectory demonstrates how effective supplier management can drive large-scale business expansion while enabling entry into new markets and product categories.

Table.2 Amazon Global Sales in 2015-2024 (in US $100 million)

year	Global sales
2015	1070
2016	1360
2017	1780
2018	2330
2019	2800
2020	3860
2021	4698
2022	5140
2023	5960
2024	6800

4.3.2. Strategic Advantages Beyond Operations

Long-term, trust-based relationships with suppliers generate strategic benefits that extend well beyond improvements in operational efficiency. Such relationships often result in preferential pricing agreements, which can lower procurement costs and enhance overall profitability. They also provide priority access to scarce inventory during periods of supply shortage, ensuring that enterprises can maintain product availability even under challenging market conditions.

In addition, established partnerships create opportunities for collaborative product development, enabling companies to bring innovative, differentiated offerings to market more rapidly. These joint initiatives allow firms to align product specifications, quality standards, and production timelines more effectively, thereby responding swiftly to evolving consumer preferences and competitive pressures.

By leveraging these strategic advantages, enterprises can strengthen their positioning in both domestic and international markets. Over the long term, such supplier relationships contribute to building a more resilient and adaptable supply chain, which in turn supports sustainable competitive advantage and long-term business growth.

4.4. In-Depth Analysis of Current Supplier Management Issues

This section provides a more detailed analysis of the supplier-management issues revealed in this study—namely the lack of clear-cut supplier selection and evaluation mechanisms, weak supplier management (SRM), and lack of supply-chain risk management—by investigating root causes, firm-size heterogeneity, and typical manifestations in e-commerce logistics supply chain contexts. The analysis links each issue to observable operational symptoms and logistics KPIs for guided managerial intervention.

4.4.1. Weak Supplier management and Cross-Enterprise Data Silos

Poor supplier management (SRM) and disjointed data systems are two reinforcing barriers that severely diminish the operational flexibility and clarity of e-commerce logistcs supply chains. Supplier relations in the majority of businesses remain subject to Short-term contract orientation with excessive cost-minimizing orientation and penalty provisions, with not much consideration for joint planning, feedback on performance, or mechanisms for continuous improvement. The transactional orientation deters open communication and trust, shifting the suppliers away from active disclosure of capacity constraints or fluctuation in the lead time.

Empirical evidence from the front-runners among China and Southeast Asia's leading e-commerce companies reveals that joint demand forecasting and collaborative replenishment planning practiced by these companies resulted in 15–20% higher rates for on-time deliveries than those with transactional supplier interaction maintenance. Nevertheless, the majority of the small and medium-sized e-commerce companies are not moving away from ad hoc communication using actual or instant messaging applications, which hinders traceability and slows down the resolution process for problems. Even among the large-scale platforms, adoption for Vendor Managed Inventory (VMI) and Electronic Data Interchange (EDI) is partial among the suppliers, rendering the upstream, or earlier, networks outside the collaborative fold.

At the technology level, cross-enterprise data silos exist due to variegated information standards, dissimilar ERP systems, and security worries about the data. The silos disconnect end-to-end visibility—from the placement of an order to the ultimate delivery—resulting in duplications of the data, mis-matched confirmations for orders, and Non-Uniform logistics tracking. Lack of unified exchange of the data also hinders appraisals of the performance of the suppliers in real time. For example, the failure to exchange shipping notices between the suppliers and the logistics providers often results in wrong inventory records and schedule clashes for warehouse operations.

In order to rise above these problems, businesses must beef up SRM through the building of jointly constructed governance mechanisms including joint scorecards, supplier councils, and virtual performance dashboards. Simultaneously, the taking up of API-approved data integration and common standards for logistical information will do away with duplications and synchronize. With relationship-based management and real-time connectivity for data, e-commerce companies are able to greatly increase the efficiency in coordination, the responsiveness of suppliers, and customer satisfaction.

4.4.2. Insufficient Risk Management and Short-Term Cooperation Mindset

Another deeply ingrained problem with e-commerce logistics supply chain is the lack of risk management system development, mostly due to a time-oriented cooperation mentality concerned with reducing costs at once. Such a mentality is responsible for the dominance of single-sourcing, insufficient planning for contingency, and the lack of systematic risk assessment for suppliers. For instance, when the COVID-19 epidemic broke out, numerous online retailers were struck with serious dislocation due to the fact that they were highly relying on a single or dual major supplier for must-have categories involving packaging supplies or electronic components. However, corporations that formulated multi-sourcing strategies or found dual-supplier models were successful in sustaining business continuity with minimal cost blowback.

In addition, the absence of formal risk identification instruments—like supplier risk matrices, financial health scores, or geopolitical exposure analysis—makes it impossible for businesses to expect the unexpected. According to industry surveys, fewer than 30% of Southeast Asian and Chinese e-commerce corporations formalize a supplier risk registry, and fewer than 20% undertake yearly stress tests for logistical capacity with peak demand. Limited risk knowledge consequently raises the damage multipliers for unexpected occurrences like natural catastrophes, shifts in government policies, or transport network breakdown.

Furthermore, short-term contract arrangements dissuade suppliers to invest in capacity flexibility or robustness-building initiatives, depriving the supply chain of long-term robustness. Without dual contingency planning or mutually agreed-upon recovery procedures, businesses end up with costly emergency logistics remedies—air freight, overnight transportation, or third-party fulfillment—to make up for disruptions. Such backward-looking remedies not only increase the expense associated with logistics but also compromise service consistency and customer confidence.

In response to these structural vulnerabilities, companies need to step down gradually from transactional procurement paradigms and move up to partnership-based models that focus on resilience, trust, and co-created value. Adoption of supplier diversification initiatives, tier-2 visibility maps, and joint business continuity planning (BCPs) can increase adaptability under the hood. In addition, the incorporation of risk management metrics—namely time-to-recover (TTR), time-to-survive (TTS), and supplier concentration index (HHI)—into the supplier appraisal systems would enable companies to track vulnerabilities in real time and shift sourcing strategies proactively. In the longer run, the transition from short-term cost thinking to the long-term thinking of resilience will be the determinant for the sustainable building up of competitive advantage within the field of e-commerce logistics supply chain.

5. Conclusion

Supplier management plays a pivotal role in the e-commerce logistics supply chain, exerting a direct influence on operational efficiency, cost control, product quality, and customer satisfaction. By ensuring a stable flow of goods, reducing logistics costs, improving product quality, enhancing customer experience, and fostering coordination among supply chain participants, effective supplier management provides essential support for the smooth and efficient functioning of e-commerce logistics systems.

Despite these benefits, several challenges remain in industry practice. Many e-commerce enterprises lack well-defined supplier selection and evaluation frameworks, exhibit weaknesses in supplier management, and maintain insufficient mechanisms for managing supply chain risks. These shortcomings can undermine the efficiency, reliability, and resilience of logistics networks, particularly in periods of volatile market demand or under the pressure of external disruptions.

To address these issues, enterprises should adopt scientific and transparent supplier selection criteria, develop comprehensive evaluation systems, and implement continuous performance monitoring. Strengthening supplier management through long-term partnerships and mutual trust can foster deeper collaboration and higher service quality. Moreover, reinforcing supply chain risk management—by diversifying sourcing channels, maintaining safety stocks, and preparing contingency plans—can mitigate the adverse effects of events such as natural disasters, raw material shortages, or regulatory changes.

Case evidence from industry leaders such as JD.com and Amazon demonstrates that systematic supplier management—encompassing quality control, real-time coordination, and risk mitigation—directly drives cost reduction, enhances delivery reliability, and sustains long-term business growth. As the e-commerce sector continues to expand and competition intensifies, supplier management will remain a decisive factor in enhancing an enterprise’s core competitiveness. Theoretically, these results also confirm the explanatory capability of some age-old supply chain theories. In support of Resource Dependence Theory, the upplier management allows businesses to minimize uncertainty and achieve stability through the enhancement of controls over vital resources. In consonance with Transaction Cost Theory, standardized supplier governance reduces the costs of coordination and monitoring, hence increasing the efficiency of

operations. In addition, the Relational View explains that long-term co-opetition and reciprocal investments among businesses and suppliers generate distinct relational value that improves competitiveness. Through the amalgamation of these lenses, the study applies age-old supply chain theories to the digital commerce scenario and shows that the theories are equally relevant to the explanation of the upgrading of the performance of e-commerce logistical systems. Continuous optimization of supplier strategies, aligned with evolving market conditions and technological advancements, will be essential for achieving sustainable growth and long-term success in the digital economy.

Author Contributions:

Jiaming Shen led the study, including conceptualization, research design, methodology development, data collection, formal analysis, and original draft preparation. He also coordinated case study work, integrated theoretical and empirical findings, and finalized the interpretation of results. Tingyu Liu contributed to validation, provided resources, assisted in data visualization, supervised the research process, and managed project administration. Jaspal Singh Joginder Singh supported review and editing, and provided additional validation input. All authors have read and agreed to the published version of the manuscript.

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