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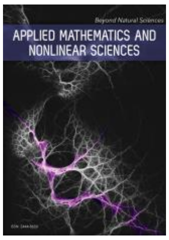

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Innovative Strategies and Practical Effects of Supply Chain Management of Business Enterprises under the Framework of Smart City

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Abstract

The change in modern information technology has brought new development opportunities to all walks of life, and the supply chain management mode of industrial and commercial enterprises has gradually shifted from management based on historical experience to management relying on information data. This paper combines the problems of inventory cost optimization and vehicle route scheduling optimization in the supply chain management of industrial and commercial enterprises and develops the supply chain innovation management system of industrial and commercial enterprises under the framework of a smart city. The proposed DES_RSA hybrid encryption method is proposed to ensure the timeliness and security of the information transmission process of the smart supply chain management system. During the interface test of the purchase order paging request, the system test revealed that the supply chain management system had a 0.00% error rate. The results of the application practice of Company H show that after the application of the supply chain innovation management system, the growth rate of Company H's operating costs continued to decline, the expense margin rose by 8.50% in two years, and the trend of customer satisfaction also shows a significant increase. The application value of the business enterprise supply chain management system designed in this paper is high, which can achieve efficient management of the business enterprise supply chain.

Keywords: Inventory cost; Vehicle route scheduling; DES_RSA method; Business enterprise; Supply chain management.
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1 Introduction

The core objective of enterprise business management is to achieve effective organization and deployment of resources to ensure the long-term sustainable development of enterprises. In this process, the efficient operation of decision-making, supply chain management, marketing, and customer service is particularly important [1-2]. The traditional management mode faces problems such as insufficient information acquisition and lagging decision-making, which leads to the failure of enterprises to fully grasp the market trend of change, and the overall level of industrial and commercial management is relatively low [3]. Based on the current situation of digital change, enterprises need to deeply understand and apply big data technology through the collection and analysis of huge data sets to formulate a more accurate market development strategy, to achieve personalized marketing on the basis of strengthening safety management, and to realize the transformation from traditional management to intelligent, data-driven management mode [4-6].

Under the framework of the smart city, all enterprises need to face an increasingly fierce competitive environment, and the competition between supply chains has naturally become the most influential and even decisive competitive dimension. The current business environment faced by enterprises is changing dramatically, and enterprises need to carry out reforms in various fields such as production, marketing, management, and logistics, and form an agile management and operation mode so as to be able to effectively respond to the challenges [7-9]. Innovative supply chain management can promote enterprises to effectively integrate the various nodes of the industrial chain in which they are located, to form a precise and effective understanding of market demand, and to be able to quickly and agilely adjust themselves according to the market changes, in order to strive for competitive advantages [10-12]. The quality of supply chain management has a significant impact on whether enterprises can effectively face cruel competition and is the core source of enterprise competitiveness [13-14].

In the field of enterprise management, supply chain management is a very valuable link. Rajeev, A. et al. comprehensively and exhaustively describe the current situation in the field of sustainable supply chain management development and put forward corresponding recommendations to promote its further development and improvement only through joint efforts to promote the implementation of the concept of sustainable development at multiple levels, and actively participate in each of these links can be truly realized. It is believed that only through joint efforts to promote the implementation of the concept of sustainable development at multiple levels and active participation in every aspect of the process can we truly achieve a good balance between industrialization and nature conservation [15]. Attaran, M believes that artificial intelligence and robotics, cloud computing, 3D printing, advanced analytics, blockchain, augmented reality, and other technologies have brought new opportunities and challenges for supply chain management in the digital era only by keeping up with the trend of technological development and flexibly applying the relevant technological means, enterprises will be able to maintain a competitive advantage in the highly competitive market and achieve the goal of sustainable development [16]. Rejeb, A. et al. dig deeper into the opportunities and challenges brought about by the mutually reinforcing development between the Internet of Things and blockchain technology in order to promote the wider and deeper integration and use of these two in the supply chain field and to make positive contributions to the construction of an intelligent, efficient supply system with a good trust mechanism [17].

In addition, Toorajipour, R et al. systematically analyzed and synthesized the relevant literature and discussed the current problems and future development prospects of artificial intelligence in supply chain management from different perspectives, which provides valuable references for the relevant practitioners and promotes the better integration of scientific research and practical experience in this field, and facilitates the whole supply chain system to move towards a more efficient and sustainable development[18]. Dzhuguryan, T. et al. worked to address waste management issues in urban multi-story manufacturing clusters and to promote resource recycling and energy conservation through the design of smart supply chain solutions to reduce emissions, which will help to improve the quality of the urban environment, conserve natural resources, and promote sustainable economic and social development [19]. Liu, W et al. established a theoretical framework to explore the correlation mechanism between smart technology level (STL) and smart supply chain innovation performance (SSCIP) and verified the feasibility and validity of the framework in Chinese physical Internet enterprises through multi-case studies and these findings will help global enterprises to better utilize smart technologies to promote their competitiveness and achieve better economic benefits [20].

This paper proposes an optimal strategy for managing inventory costs in industrial and commercial enterprises' supply chains by combining the variables of demand, supply, and supply speed. Then, by setting constraints on vehicle route scheduling in supply chain management, it optimizes vehicle routes in the supply chain management of industrial and commercial enterprises and improves logistics and transportation efficiency. Based on this, the supply chain management innovation system of commercial and industrial enterprises under the framework of a smart city is proposed to realize the intelligent collaborative management of commercial and industrial enterprises' supply chains through the perception layer, network layer, platform layer, and decision-making layer. Meanwhile, DES_RSA hybrid encryption technology is adopted to realize the security of sensitive information transmission and storage in the supply chain management system. After the performance test of the system, Company H is taken as the research object, and the current situation of the company's supply chain management development is sorted out and analyzed, pointing out the existing problems of the company. Then, the supply chain innovation management system is applied to Company H, and analyzed from the aspects of cost management and customer satisfaction to explore the practical effects of the supply chain management system.

2 Method

2.1 Optimization Model Establishment of Inventory Costs in Business Enterprises

2.1.1 Model assumptions

Assume that the product demand rate D in the supply chain management of a business enterprise is constant. Let the supply be continuous and uniform, i.e., the supply rate P is constant. At the same time, $P > 0$. The cost per unit of storage is C_1, the cost per unit of out-of-stock is C_2, and the cost of ordering is C_3. $[0,t]$ is an inventory cycle. The supply starts at time t_1 and ends at time $t3$. Inventory is zero at time $\left[0,t_2\right]$, and the maximum stock-out quantity B is reached at time t_1. Output at time $\left[t_1,t_2\right]$ meets demand at speed D on the one hand and makes up for the stock-out at time $\left[0,t_1\right]$ at speed $\left(P-D\right)$ on the other. The shortage is replenished up to the t_2 th hour. At $\left[t_2,t_3\right]$ time production meets demand at speed D on the one hand and increases stock at speed $\left(P-D\right)$ on the other. To t_3 time, the maximum stock A is reached, and the supply is stopped. In $\left[t_3,t\right]$ time, the demand is met with stock, and the stock is reduced at D. By moment t storage is reduced to 0, and the next storage cycle is entered.

2.1.2 Modeling

Based on the model assumptions and the storage state, the average total cost (i.e., the cost function) over time $\left[0,t\right]$ is first derived, and then the optimal inventory strategy is determined.

From $\left[0,t_1\right]$, the maximum out-of-stock quantity $B=D\cdot t_1$. from $\left[0,t_1\right]$, the maximum out-of-stock quantity $B=\left(P-D\right)\left(t_2-t_1\right)$. Therefore $Dt_1=\left(P-D\right)\left(t_2-t_1\right)$, the solution:

$$t_1=\frac{\left(P-D\right)}{P}t_2 \tag{1}$$

From $\left[t_2,t_3\right]$, the maximum out-of-stock quantity is $A=\left(P-D\right)\cdot\left(t_3-t_2\right)$. From $\left[t_3,t\right]$, the maximum stock quantity is $A=D\left(t-t_3\right)$. Therefore, we have $\left(P-D\right)\left(t_3-t_2\right)=D\left(t-t_3\right)$, from which we solve:

$$t_3-t_2=\frac{D}{P}\left(t-t_2\right) \tag{2}$$

In time $\left[0,t\right]$, the storage cost is $\frac{A}{2}C_1\left(t-t2=\frac{1}{2}C_1\left(P-D\right)\left(t_3-t2\left(t-t_2\right)\right.\right.$ The shortage cost is $\frac{1}{2}C_2Dt_1t_2$. Therefore, the average total cost in time $\left[0,t\right]$ is $\frac{1}{t}\left[\frac{1}{2}C_1\left(P-D\right)\cdot\left(t_3-t_2\right)\left(t-t_2+\frac{1}{2}C_2Dt_1t_2+C_3\right.\right]$, which is collapsed:

$$C\left(t_1,t_2\right)=\frac{\left(P-D\right)D}{2P}\left[C_1t-2C_1t_2{}^2+\left(C_1+C_2\right)\frac{t_2^2}{t}\right]+\frac{C_3}{t} \tag{3}$$

Solve the system of equations $\begin{cases}\dfrac{\partial C\left(t,t_2\right)}{\partial t}=0\\ \dfrac{\partial C\left(t,t_2\right)}{\partial t_2}=0\end{cases}$ to get:

$$t^*=\sqrt{\frac{2C_3}{C_1D}}\cdot\sqrt{\frac{C_1+C_2}{C_2}}\cdot\sqrt{\frac{P}{P-D}} \tag{4}$$

$$t_2{}^*=\left(\frac{C_1}{C_1+C_2}\right)t^* \tag{5}$$

It is easy to prove that the cost $C\left(t^*,t_2^*\right)$ at this point is the minimum value of the cost function $C\left(t,t^2\right)$. Therefore, the optimal inventory cost strategy for each reference value of the inventory model in the supply chain management of business enterprises is as follows.

Optimal Inventory Cycle:

$$t^* = \sqrt{\frac{2C_3}{C_1 D}} \cdot \sqrt{\frac{C_1 + C_2}{C_2}} \cdot \sqrt{\frac{P}{P-D}} \tag{6}$$

Economic ordering lots:

$$Q^* = Dt^* = \sqrt{\frac{2DC_3}{C_1 D}} \cdot \sqrt{\frac{C_1 + C_2}{C_2}} \cdot \sqrt{\frac{P}{P-D}} \tag{7}$$

Out-of-stock make-up time:

$$t_2^* = \left(\frac{C_1}{C_1 + C_2}\right) t^* = \sqrt{\frac{2C_3}{C_1 D}} \cdot \sqrt{\frac{C_1}{C_1 + C_2}} \cdot \sqrt{\frac{P}{P-D}} \tag{8}$$

Start of supply time:

$$t_1^* = \frac{(P-D)}{P} t_2^* = \sqrt{\frac{2C_3}{C_1 D}} \cdot \sqrt{\frac{C_1}{C_1 + C_2}} \cdot \sqrt{\frac{P-D}{P}} \tag{9}$$

End of supply time:

$$t_3^* = \frac{D}{P} t * + \frac{(P-D)}{P} t_2^* \tag{10}$$

Maximum inventory:

$$A^* = D\left(t^* - t_3^*\right) \tag{11}$$

Maximum Out-of-Stock:

$$B^* = Dt_1^* \tag{12}$$

Average total cost:

$$C^* = \frac{1}{t}\Bigg[\frac{1}{2} C_1 (P-D) \Bigg(t_3 - t2 \quad \Bigg(t - t2 + \frac{1}{2} C_2 D t_1 t_2 + C_3 \Bigg] = \frac{2C_3}{t^*} \tag{13}$$

2.2 Vehicle Route Scheduling Model

Vehicle path scheduling problem (VVRP) [21] is the key to optimizing the distribution and transportation routes, reducing transportation costs, realize that transportation scheduling is scientific, intelligent, and automated. At the same time, it can save a lot of operating costs for industrial and commercial enterprises, and it has become a hot spot in the field of current supply chain management and combinatorial optimization.

1) Principle of algorithm

VRPTW is based on VRP and adds a time window T for control. The time window T is the acceptable time limit for the customer to receive the goods and T is determined by the earliest time to receive the goods T_σ and the latest time to receive the goods T_I, beyond which the customer is unable to accept the time window.

2) Algorithm description

Let the customer $i(i \in v)$, the vehicle tb_i be k, $x_{ijk} = \begin{cases} 1, i\varepsilon(i,j) \\ 0, i \notin (i,j) \end{cases}$. Define the vehicle load as D and the customer demand as d_i. The service start time for customer i is and the end time is to_i. When $x_{ijk} = 1$, the vehicle k is from the customer $i \to j$, y_{ki} is the vehicle k is in the service i. The service time required for the customer i is ts_i, i.e., $ts_i = tb_i - to_i$. The travel time of the vehicle from the customer i to the customer j is t_{ij}, and the waiting time before the start of the service is is tw_i.

3) The constraints

$\sum_j d_i y_{ki} \le D_i \forall k$, denotes the total demand of the customer „ loads. $\Sigma_k y_{ki} = 1$, $i \in V$, denotes that each vehicle serves the customer only once.

$\sum_{jj} x_{ijk} = y_{ki}$, $j \in V$, $\forall k$, $\sum_j x_{ijk} = y_{ki}$, $j \in V$, $\forall k$, $\sum_{ies}\sum_{jes} x_{ijk} \le |S| - 1$, $s \subseteq V$, and mandatory transportation vehicles form a closed loop from company → customer → company, where s is the number of customers visited.

$to_i + t_{ij} \le tb_j$, $to_i \le tb_j$, indicates the existence of a more optimal transportation path.

$te_i \le tb_i \le tl_i$, $i \in V$, is a time window constraint [22], indicating that the service start time should be within the time window.

x_{ijk}, $y_{ki} \in \{0,1\}$, $i, j \in V$, $\forall k$ with a unique number of customer services and unique vehicle service customers.

4) Algorithm optimization

According to the optimization objective of VRPTW, i.e., minimum number of vehicles and total route length to complete all tasks, the following formula is obtained:

$$\min Z = \{\Sigma_i \Sigma_j \Sigma_k t_{ij} x_{ijk}, \Sigma_j \Sigma_k xo_{jk}\} \tag{14}$$

$\sum_i \sum_j \sum_{ik} t_{ij} x_{ijk}$ is the total time spent on the planned route with the load. The vehicle is constant, the speed is constant, t_{ij} and the route kilometers are proportional to the number of kilometers, so the shortest time and the shortest distance calculation results in the same. $\sum_j \sum_k xo_{jk}$ traverses the customer to send the smallest number.

2.3 Establishment of an intelligent supply chain innovation management system

2.3.1 Supply Chain Management System Architecture

Combined with the inventory cost and vehicle scheduling optimization model proposed in the previous section, this paper presents a smart supply chain innovation management system for industrial and commercial enterprises constructed under the framework of a smart city. The system structure is designed to be divided into three layers, which are the perception layer, network layer, platform layer, and decision-making layer, and the specific architecture of the supply chain management system is shown in Figure 1. The perception layer is equivalent to the human body's sensory organization through the integrated use of embedded technology, RFID [23], barcodes, sensors, video surveillance, and other perception technologies, a timely, accurate, and comprehensive collection of supply chain system in the basic level of relevant information, to achieve a comprehensive perception of the supply chain of each link, to achieve the supply chain operation of the whole process of visualization and traceability. The network layer is equivalent to the human body's nerve organization, and through the wireless short-distance communication technology, Internet, and mobile communication technology applied in the transmission layer, the basic information is safely and reliably transmitted to the data cloud storage center and the structural and non-structural data are stored in accordance with the preset rules for subsequent analysis and processing. The platform layer is similar to the human brain, in which the backend plays the role of data storage and analysis, and the front end is used as the operation and display of each participating body in the supply chain. The front end includes the three main systems of supplier management, customer relationship management, and internal production management, as well as two subsidiary subsystems of financial management and personnel management. Among them, the supplier management system and customer relationship management system need to be redeveloped, the internal production management module be upgraded on the basis of the ERP information system [24], and the financial management and personnel management systems only need to be directly interfaced with the corresponding system modules of ERP. The decision-making layer is the data information collected, transmitted, and stored in the perception layer, network layer, and platform layer, and the cleaning, processing, in-depth mining, and analysis of the data with the help of cloud computing, big data, artificial intelligence, and other technologies, so as to realize the whole supply chain visual traceability, element integration, intelligent collaboration, and intelligent decision-making.

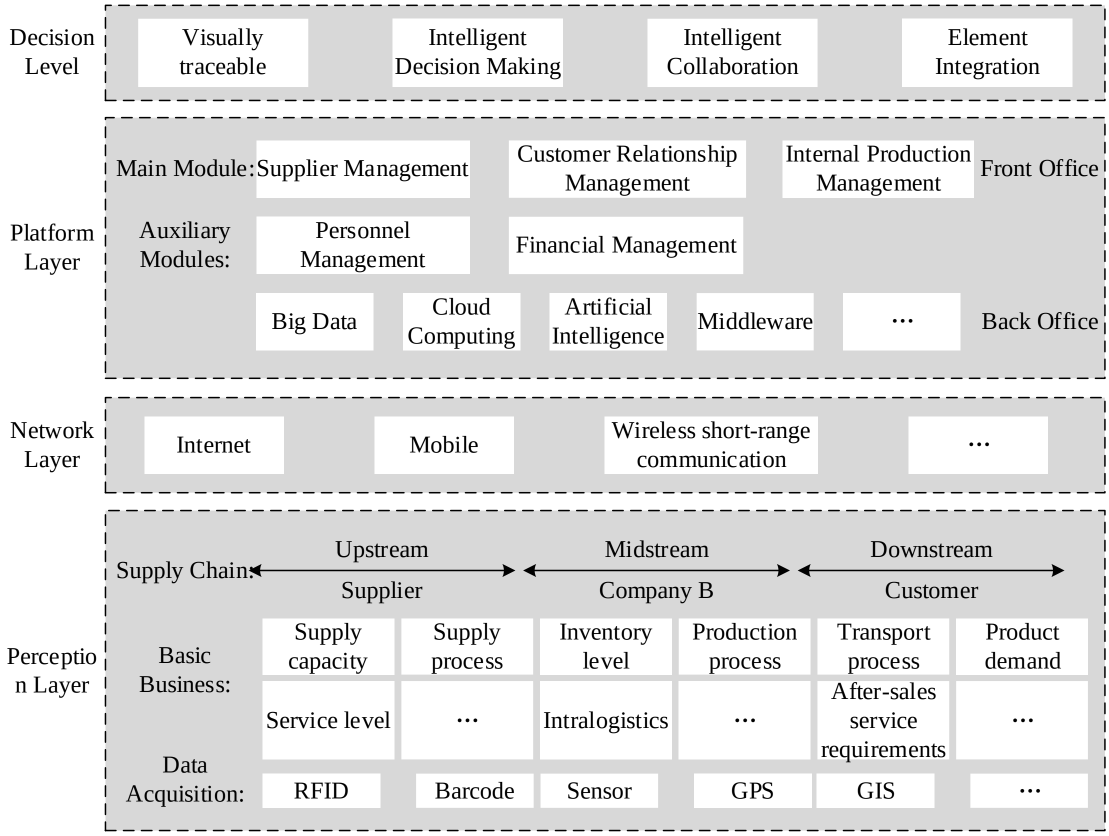

Figure 1. Intelligent supply chain innovation management architecture diagram

2.3.2 Supply Chain Management Information Encryption Methods

Information encryption uses DES_RSA hybrid encryption technology to provide security for the transmission and storage of sensitive information of each member of the supply chain while conserving the corresponding encryption application interface. The reason for adopting a hybrid encryption algorithm is that a symmetric encryption algorithm is fast but has low security, while an asymmetric encryption algorithm makes up for the poor security. Therefore, the use of symmetric encryption algorithms and asymmetric encryption algorithms combined to ensure the timeliness and security of the information transmission process of the intelligent supply chain platform.

P is the plaintext to be encrypted, and the DES encryption algorithm E_D and the DES algorithm key K encrypt the plaintext to obtain the ciphertext C_p, and then the DES algorithm key K is encrypted by a public key K_{Eb} of the RSA encryption algorithm to obtain ciphertext information of the key C, and after that, the ciphertext information of the key of the DES algorithm and the encrypted ciphertext information C_K are transmitted through a network to the receiver. After receiving the information, the receiver first uses the private key K_{Ea} of the RSA algorithm to obtain the key information of the DES algorithm and then decrypts the transmitted ciphertext information to obtain the plaintext P, wherein D_R is the RSA decryption algorithm.

DES_RSA hybrid encryption algorithm uses use DES algorithm to encrypt the plaintext information, uses RSA to encrypt the DES key information in front of it, and finally delivers the hybrid information. The receiver receives the information, decrypts the DES key information with RSA, and then decrypts the ciphertext information with the key information obtained by RSA decryption. Eventually, the displayable plaintext information can be obtained. With the realization of a hybrid encryption algorithm, the security processing speed of the system is significantly improved. The combination of RSA and DES encryption methods is used to realize data encryption, which not only improves the security transmission speed of the system but also solves the problem of distributing separate keys. Sender A represents company B, and receiver B represents enterprise customers or suppliers, and the detailed process is as follows.

1) Sender A encrypts the plaintext message using the DES algorithm.

2) Receiver B uses RSA to encrypt the DES key information in front of it, and then the ciphertext generated by the key is sent to receiver B.

3) The receiver has the private key of the RSA algorithm and uses the private key to decrypt the ciphertext generated by the key of the DES algorithm sent to him to get the key of the DES algorithm.

4) When the receiver gets the correct DES algorithm key, it uses the DES algorithm to encrypt the plaintext to be sent and then sends the ciphertext to the receiver B.

5) The receiver decrypts the ciphertext sent by the sender according to the DES key obtained by decryption and gets the plaintext sent by the sender.

6) After getting the plaintext sent by the sender, both the receiver and the sender have to delete the key of this trial to prevent illegal elements from stealing it.

In summary, the combination of RSA and DES encryption methods is used to realize the encryption of data, which can provide a guarantee for the safe transmission of information.

3 Results and discussion

3.1 Intelligent Supply Chain Management System Performance Testing

In this paper, we conduct performance testing of an intelligent supply chain innovation management system based on the non-functional requirements identified in the requirement analysis. In procurement management, the purchase order paging request interface can be simulated by using Jmeter to enable 200 threads to loop 200 times, i.e., 20000 paging requests. The aggregated results of the purchase order paging request interface test are shown in Table 1. In the purchase order paging request interface test, the error rate of the supply chain management system is 0.00%, the average time taken to process 20000 paging requests is only 305.36ms, and the system throughput can reach 623.54/sec.

Table 1. Purchase order paging request interface test aggregation results

Label	HTTP Request
Samples	10000
Average time	305.36ms
Median time	285.63ms
The fastest 90% request response takes time	564.28ms
The fastest 95% request response takes time	639.48ms
The fastest 99% request response takes time	812.63ms
Minimum time	2.36ms
Maximum time	1358.34ms
Error rate	0.00%
System throughput	623.54/sec

For each module of the system to choose the focus of the paging request and new features for performance testing, where each paging request interface in accordance with the above method to simulate 200 users concurrently test 2000 requests, each new feature interface simulation 55 users concurrently test 5500 times, each module of the focus of the paging request test results are shown in Table 2. The average time consumed by the paging request of business logic is between 150ms-200ms, and the response time of 95% of the requests does not exceed 400ms. The average time consumed by the request of a new function is between 95ms and 120ms, and the response time of 95% of the requests does not exceed 250ms, which meets the non-functional requirements of the response time requirements. Analyzing the data, it can be seen that since each item of the paged data form unit represents a new button to fill in and confirm the data, the amount of paged requests is much larger than the amount of data added at a single time, and the time consumption of the former is inevitably larger than that of the latter. During the system operation test, which lasted no more than one minute for each interface, the interface error rate was 0%, and there were no request exceptions in the Jmeter result tree column, so the interface has good usability under the simulation of 200 users using the system concurrently. In summary, the above operation simulates the performance test of several core interfaces of the intelligent supply chain management system, and the results show that the system meets the non-functional requirements of the demand analysis and also shows that the system has good stability and response speed.

Table 2. Key paging request test results for each module

Request address	Number of requests	Meantime (ms)	The fastest 95% request response takes time (ms)	Error rate
Log-in	4000	27.58	158.96	0.00%
Register	4000	69.53	122.57	0.00%
Purchase order	20000	186.34	386.42	0.00%
Logistics order	20000	188.72	399.26	0.00%
Workshop management	20000	164.29	364.78	0.00%
Sales order	20000	188.42	399.64	0.00%
Stock material	20000	159.42	352.42	0.00%
New logistics entry interface	5500	100.42	213.52	0.00%
New sales order interface	5500	95.63	228.72	0.00%
New procurement plan interface	5500	111.24	248.93	0.00%
New equipment maintenance interface	5500	102.35	211.48	0.00%
New material entry interface	5500	104.52	215.63	0.00%
New product outbound interface	5500	119.63	224.67	0.00%

3.2 Analysis of the effect of supply chain cost management

3.2.1 Basic Analysis of Company H

Company H, a commercial and industrial enterprise that was founded in 2017, has already gone through two years of development and is currently establishing a development system. In recent years, the scale of Company H has constantly expanded, and the company has established a relatively excellent reputation in the entire operator industry. At present, Company H has entered a period of rapid development. The company's agent's goods are in the market to further improve the competitiveness of the goods in the market, and many customers have favored the quality of goods in the market. However, the company has a major problem with supply chain management, which seriously increases the cost of the enterprise and negatively affects customer satisfaction.

Among the company's overall supply chain management costs, Company H's delivery costs account for a relatively large portion, so this paper analyzes this part of the costs specifically. The industry usually thinks that the main content of the delivery cost is the company involved in the manufacture and delivery of goods. Repeated logistics distribution makes the proportion of delivery costs in the overall logistics costs the largest, which generally includes the company's operating costs and external expenses. The specific composition of the company's delivery costs is shown in Table 3. Company H's delivery costs increased by a total of 27.58% from 2017 to 2018, of which the cost of delivery equipment maintenance increased by 43.55%. It can be seen that the company, currently in the process of product delivery, did not formulate a scientific delivery plan in advance, not in accordance with their own needs, customer needs, and market needs to design a scientific delivery plan, which ultimately led to an increase in transportation costs, trucks and other means of transportation idle and wasteful. In the end, the transportation cost increased and the trucks and other means of transportation were idled and wasted.

Moreover, the bridge tolls paid during transportation were not recorded in the cost. At present, the cost of Company H lacks scientific calculation. There is no way to accurately reflect the total amount of costs incurred in the delivery process. The inadequacy of this supply chain management system has finally led to the company's high delivery costs. The intelligent supply chain management system in Company H is utilized in this paper to examine its effect on the enterprise's supply chain cost management and user satisfaction.

Table 3. H Company shipping cost composition situation

Project	2017 (Yuan)	2018 (Yuan)	Year-on-year growth
Fuel	69515.62	95263.52	37.04%
Maintenance of transport equipment	85964.24	102564.4	19.31%
Express delivery	5964.82	8562.36	43.55%
Outsourcing	192563.2	245263.4	27.37%
Total	354007.9	451653.6	27.58%

3.2.2 Supply Chain Cost Management Analysis

After constructing a perfect collaboration platform for the supply chain by combining the intelligent supply chain innovation management system proposed in this paper, Company H combines the actual situation in the supply chain management, integrates the production equipment, production management facilities, information collection module, and network communication equipment into a single unit and carries out networking control. After continuous tracking and improvement of the system, the system was ready for trial operation in early 2020, and the access management of the supply chain management system and data collection system was completed during the trial operation. As of the end of February 2021, a total of 12 months of operation, during the operation, the system is running normally, with no accidents, and the system data indicators and related functions can meet the daily business application needs. The impact of the intelligent supply chain innovation management system on Company H is discussed through an analysis of cost growth and cost-effectiveness.

1) Cost growth analysis

The annual growth rate of operating revenue and the annual growth rate of operating expenses of Company H are put together for comparison, which can show whether the growth rate of operating expenses matches the annual growth rate of operating revenue. The results of the analysis of the cost growth of Company H are shown in Figure 2. The annual growth rate of operating revenue of Company H has been on a downward trend since 2018 (5.34%) compared with 2017 (11.80%), resulting in a decline in operating The reason for the decline in revenue is mainly due to the fluctuating upward trend in the cost of commodity raw materials, which in turn causes great trouble to the production and operation of Company H. The cost of raw materials of Company H has not been effective. Company H does not have an effective supply chain management method for cost sharing, which will lead to a continuous decrease in Company H’s operating income due to the external environment. From the analysis of the results, Company H’s operating costs and operating income are synchronized. However, the annual growth rate of operating costs of Company H in 2020 shows a relatively large increase from 2.78% in 2019 to 11.43%, which is due to the fact that Company H started to apply the intelligent supply chain innovation management system in 2020 to invest certain costs on it, which leads to an increase in operating costs in that year. In addition, the growth rate of operating costs of Company H has continued to decrease since 2021 and showed negative growth in operating costs (-3.36% and -4.34%). Company H’s control of operating costs is effective, and the smart supply chain management system implemented since 2020 is important for managing supply chain costs.

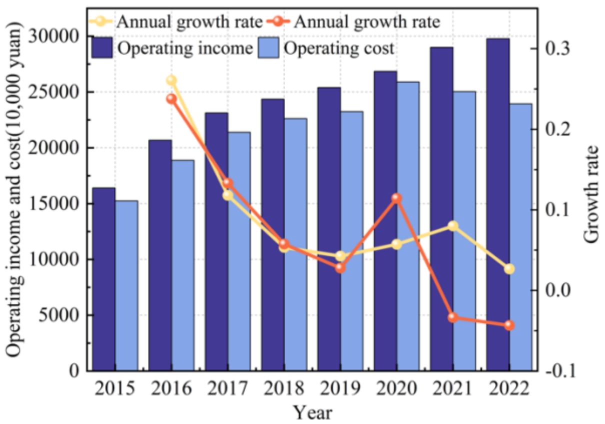

Figure 2. Cost growth analysis of H company

2) Cost-effectiveness analysis

Cost-expense margin is the ratio of total profit to total cost and expense of an enterprise in a certain period, and the higher this indicator, the better cost cost-control effect of the enterprise and the higher the profit. Calculating and analyzing this index of Company H can reflect the profitability of Company H in terms of the sum of costs and expenses paid out in the current period. The results of the analysis of the cost and expense margin of Company H from 2015 to 2022 are shown in Figure 3, which indicates that the cost and expense margin of Company H has shown an overall "U" trend in the past five years. From 2015 to 2020, the index declined and even fell to -2.28% in 2020, which means that in 2020, the cost was paid but did not make a corresponding profit, but incurred a loss. But after 2020, the cost-expense margin climbs sharply to 6.23% (2022). For Company H, the cost and expense margin has increased by 8.50% in two years, which indicates that Company H has achieved good results in cost management, and the input-output effect of the enterprise is good, which enhances the competitiveness of Company H. The cost and expense margin of Company H has increased by 6.23% (2022). This is inextricably linked to the fact that Company H always insists on applying the intelligent supply chain management system proposed in this paper to supply chain cost management, constructing an information-sharing platform, and realizing precise marketing. Therefore, by using the intelligent supply chain innovation management system to control the entire supply chain cost, Company H has achieved remarkable results.

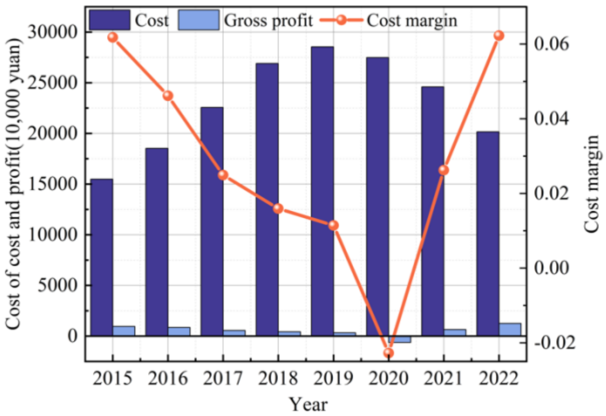

Figure 3. Cost profit margin of H company from 2015 to 2022

3.2.3 Customer Satisfaction Analysis

Company H’s cost can be effectively reduced by the application of the intelligent supply chain management system, as found in the previous analysis. This section analyzes the impact of the implementation of the system on customer satisfaction. The results of the analysis of customer satisfaction in Company H are shown in Fig. 4. The average customer satisfaction of Company H in 2019 and 2022 is 57.27% and 91.53%, respectively, which indicates that the optimized supply chain management platform of Company H that makes the relationship of customer eco-network to be fully utilized. This supply chain management system, as a source point, can realize the interconnection and interoperability of data with other business systems. With the development of the industrial Internet system and industrial service model, the industrial production information system and the Internet are moving towards deep synergy and integration, realizing efficient management of the supply chain, responding to customer needs in a timely manner, and significantly improving customer satisfaction.

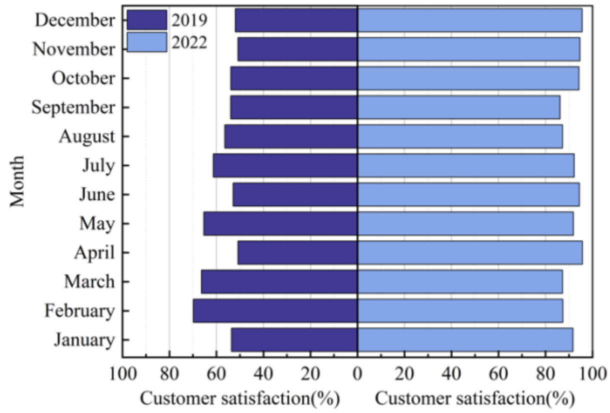

Figure 4. Customer Satisfaction Analysis

4 Conclusion

This paper builds a supply chain management innovation system for industrial and commercial enterprises within the framework of smart cities based on the optimization strategy of inventory cost and vehicle route scheduling. After conducting performance testing, the system is applied to Company H. The results demonstrate the following:

1) In the purchase order paging request interface test, the error rate of the supply chain management system is 0.00%, and the system throughput can reach 623.54/sec. The average time consumed by the paging request of the business logic is between 150ms-200ms, and 95% of the requests have a response time of no more than 400ms.

2) After applying the supply chain innovation management system in 2020, the growth rate of operating costs of Company H has been decreasing continuously since 2021 and shows a negative growth in operating costs (-3.36% and -4.34%). In addition, the cost and expense margin increased by 8.50% during 2020-2022. This reflects the effectiveness of Company H's control of operating costs and shows that the intelligent supply chain management system is meaningful in managing supply chain costs.

3) The average customer satisfaction of Company H is 57.27% and 91.53% in 2019 and 2022, respectively, which indicates that the optimized supply chain management platform of Company H is able to achieve efficient management of the supply chain, respond to customer needs in a timely manner, and significantly improve customer satisfaction. The result further demonstrates the effectiveness of the supply chain innovation management system.

4) In the future, digital transformation will become an important way to optimize the management mode of industrial and commercial enterprises, and the whole supply chain process, such as procurement, sales, logistics, and inventory, are all links that can be strengthened in the future for digital operation, and how to truly achieve comprehensive intelligent change needs to be further researched in the future.

References

[1] Dubey, R., Gunasekaran, A., Papadopoulos, T., Childe, S. J., Shibin, K. T., & Wamba, S. F. (2017). Sustainable supply chain management: framework and further research directions. Journal of cleaner production, 142, 1119-1130.

[2] Jacobs, F. R., & Chase, R. B. (2018). Operations and supply chain management. McGraw-Hill.

[3] Lambert, D. M., & Enz, M. G. (2017). Issues in supply chain management: Progress and potential. Industrial marketing management, 62, 1-16.

[4] Blanchard, D. (2021). Supply chain management best practices. John Wiley & Sons.

[5] Wieland, A. (2021). Dancing the supply chain: Toward transformative supply chain management. Journal of Supply Chain Management, 57(1), 58-73.

[6] Kache, F., & Seuring, S. (2017). Challenges and opportunities of digital information at the intersection of Big Data Analytics and supply chain management. International journal of operations & production management, 37(1), 10-36.

[7] Copacino, W. C. (2019). Supply chain management: The basics and beyond. Routledge.

[8] Hugos, M. H. (2024). Essentials of supply chain management. John Wiley & Sons.

[9] De Angelis, R., Howard, M., & Miemczyk, J. (2018). Supply chain management and the circular economy: towards the circular supply chain. Production Planning & Control, 29(6), 425-437.

[10] Tseng, M. L., Islam, M. S., Karia, N., Fauzi, F. A., & Afrin, S. (2019). A literature review on green supply chain management: Trends and future challenges. Resources, Conservation and Recycling, 141, 145-162.

[11] Hong, J., Zhang, Y., & Ding, M. (2018). Sustainable supply chain management practices, supply chain dynamic capabilities, and enterprise performance. Journal of cleaner production, 172, 3508-3519.

[12] Nowicka, K. (2019). Digital innovation in the supply chain management. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, 63(8), 202-214.

[13] Bastas, A., & Liyanage, K. (2018). Sustainable supply chain quality management: A systematic review. Journal of cleaner production, 181, 726-744.

[14] Soares, A., Soltani, E., & Liao, Y. Y. (2017). The influence of supply chain quality management practices on quality performance: an empirical investigation. Supply Chain Management: An International Journal, 22(2), 122-144.

[15] Rajeev, A., Pati, R. K., Padhi, S. S., & Govindan, K. (2017). Evolution of sustainability in supply chain management: A literature review. Journal of cleaner production, 162, 299-314.

[16] Attaran, M. (2020, July). Digital technology enablers and their implications for supply chain management. In Supply Chain Forum: An International Journal (Vol. 21, No. 3, pp. 158-172). Taylor & Francis.

[17] Rejeb, A., Keogh, J. G., & Treiblmaier, H. (2019). Leveraging the internet of things and blockchain technology in supply chain management. Future Internet, 11(7), 161.

[18] Toorajipour, R., Sohrabpour, V., Nazarpour, A., Oghazi, P., & Fischl, M. (2021). Artificial intelligence in supply chain management: A systematic literature review. Journal of Business Research, 122, 502-517.

[19] Dzhuguryan, T., & Deja, A. (2021). Sustainable waste management for a city multifloor manufacturing cluster: A framework for designing a smart supply chain. Sustainability, 13(3), 1540.

[20] Liu, W., Long, S., & Wei, S. (2022). Correlation mechanism between smart technology and smart supply chain innovation performance: A multi-case study from China's companies with Physical Internet. International Journal of Production Economics, 245, 108394.

[21] Peter Nielsen,Mahekha Dahanayaka,H.Niles Perera,Amila Thibbotuwawa & Deniz Kenan Kilic. (2024). A systematic review of vehicle routing problems and models in multi-echelon distribution networks. Supply Chain Analytics100072-100072.

[22] Li Cai,Junting Li,Haitao Zhu,Chenxi Yang,Juan Yan,Qingshan Xu & Xiaojiang Zou. (2024). Charging Station Site Selection Optimization for Electric Logistics Vehicles, Taking into Account Time-Window and Load Constraints. World Electric Vehicle Journal(5),181-.

[23] Haojie Du,Xinjie Peng,Guang Yang & Xia Yang. (2024). Design of RFID-based weight sorting and transportation robot. Paladyn(1).

[24] Jo Hyeon & Park DoHyung. (2023). A study of user switching intention for ERP systems based on push-pull-mooring model: Focusing on the important role of information quality for users. PloS one(11), e0289483-e0289483.