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RESEARCH ARTICLE

# Development and Application of Smart Logistics Warehousing

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## Abstract

**With the rapid development of the economy, the gradual formation of the logistics Internet and the advent of the era of science and technology have promoted the rapid rise of the logistics industry in the development of enterprises across the country. This paper studies the development and application of warehousing under the smart logistics system by taking Guangzhou Porcelain Cosmetics Co., Ltd. as an example through the AHP method The results show that the company chooses warehouse B as the best. Finally, this paper aims at the problems existing in the warehousing system and improves them Targeted advice on warehouse storage capacity, rent reduction, and proximity to important points of sale.**

**Keywords**: Smart logistics, Warehouse location, Analytic Hierarchy Process, Optimization.

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## 1 Introduction

With the rapid development of information technology, smart logistics is an important force to promote the transformation and upgrading of the modern logistics industry [1]. Smart warehousing, as the core link of smart logistics, is related to the efficiency and cost of the entire logistics system. This article aims to explore the current situation, development trend and provide theoretical support and practical guidance for the sustainable development of the logistics industry.

In recent years, many scholars have focused on the in-depth research of smart logistics and smart warehousing. Zhou [2] discussed the application of Internet of Things technology in intelligent warehouse management. Anoop et al. [3] used Arena to develop a discrete-event simulation model for analyzing warehouse operations, with a particular focus on unloading. Oner et al. [4] analyzed the use of RFID technology in the wool yarn industry, conducted a cost-benefit analysis and a risk analysis of RFID investment. The results showed that the new system economy is improving. Zhou and Lu [5] first studied the processing process of image processing technology for image preprocessing, and used the polygon approximation method to recognize the shape and locate the moving target. Then, the mobile platform of the warehousing and logistics robot was designed, and the vision system of the robot was designed by using image recognition technology to realize obstacle collision prediction and path planning. Finally, comparative experiments were used to analyze the positioning and grasping ability, trajectory following performance and semantic segmentation ability of the robot.

This paper studies the development status of smart logistics, and discusses the definition and theoretical basis of smart logistics, especially the application of unmanned system technology in the logistics industry. On this basis, the article also discusses the basis of AHP

Method the problem of warehouse location selection analyzes the impact of the digital environment on the supply chain, especially the connotation and transformation significance of the digital supply chain platform. In summary, this study makes a discussion on the theoretical and practical significance of smart logistics, which provides a useful reference for the development of the logistics industry.

## 2 The development status of smart logistics

Smart logistics is a modern logistics pattern [6]. Its core is to use cutting-edge technological methods such as intelligent software and hardware, the Internet of Things and big data to realize delicacy, dynamic and visual management of all links of logistics. At present, the development environment of smart logistics in China is quite optimistic, and the market scale shows a rapid growthtrend.

Specifically, the development of smart logistics has the following characteristics.

**The market scale continues to expand**: According to the report of the China Research Institute of Puhua Research, the market scale of China's smart logistics industry has climbed to about 790.3 billion yuan in 2023, with a growth rate of 12.98% compared with the previous year. This data fully shows the strong development momentum of the smart logistics industry.

**The application of technology continues to deepen**: Smart logistics uses cutting-edge technological methods such as intelligent software and hardware, the Internet of Things and big data to realize the delicacy, dynamic and visual management of all links of logistics, which greatly improves the intelligent analysis and decision making and automated operation execution ability of the logistics system. With the development of information technology, Smart logistics has been widely used in logistics management, transportation control, warehousing management and other aspects. Using Internet of Things technology and big data analysis technology, real time monitoring and scheduling of logistics and transportation vehicles can be realized, transportation efficiency can be improved and transportation costs can be reduced. At the same time, the application of intelligent warehousing equipment and warehousing management system can achieve accurate positioning and rapid sorting of goods, improve warehousing efficiency and reduce wrong operation.

**Optimization of industry development environment**: More and more logistics enterprises realize the importance of smart logistics, and have increased their investment in information technology and intelligent equipment to promote the intelligent transformation of enterprises [8]. Some large logistics enterprises have established a perfect smart logistics platform to realize the visual management and intelligent operation of logistics throughout the whole process. Some small and medium-sized logistics enterprises are also actively exploring the development path of smart logistics, gradually introducing information technology and intelligent equipment, and improving the level and competitiveness of logistics services. And in order to promote the development of smart logistics, relevant departments and industry organizations actively promote the establishment of smart logistics standard system. This helps to standardize the development of the smart logistics industry, improve the compatibility and interoperability of smart logistics systems, and promote the innovation and application of smart logistics technology. Governments and enterprises are actively promoting the development of smart logistics, providing a good environment for the development of smart logistics through policy support and capital investment.

## 3 The roles of smart logistics

The roles of smart logistics are as follows:

**Improve efficiency and reduce costs:** Smart logistics can monitor the location and status of goods in real time, and achieve accurate distribution and intelligent scheduling, so as to improve logistics efficiency and reduce operating costs. At the same time, by optimizing logistics paths and reducing unnecessary transportation links, smart logistics can also effectively reduce energy consumption and emissions, and achieve green logistics.

**Improve service quality:** Smart logistics can provide more accurate and timely logistics information, help enterprises optimize logistics operations, and improve customer service experience.

**Promote industrial upgrading and innovation:** The development of smart logistics needs to rely on the support of emerging technologies, which will promote the technological upgrading and innovation of related industries, and promote the optimization and transform- ation and upgrading of industrial structure.

**Enhance competitiveness:** Having an efficient smart logistics system can help enterprises better grasp

market opportunities, improve competitiveness, and achieve sustainable development advantages [9].

Smart logistics not only has huge market potential and development prospects, but also is of great significance for improving logistics efficiency, reducing costs, improving service quality, promoting industrial upgrading and innovation, and enhancing the competitiveness of enterprises. Therefore, the study of smart logistics has important theoretical and practical value.

## 4 Warehousing site selection application under smart logistics

From the investigation, it can be seen that the company is located at No.246 Guangming North Road, Shiqiao Street, Panyu District, Guangzhou. There are three warehouses in Panyu District. However, in the process of continuous development, the three warehouses are gradually unable to meet the needs of daily business activities affecting the development of the company. The company has initially screened out warehouse sites in three different places. How to choose the three best warehouse addresses has become a problem in the company's development. We choose the analytic hierarchy process to systematically deal with complex decision making problems, and through hierarchical structure and quantitative analysis, we combine subjective judgment with objective data to provide a scientific and comprehensive basis for decision making. Therefore, we will analyze and decide the location of the warehouse. Through the company's understanding of the location of the warehouse, the company's criteria for choosing the warehouse address are: large storage capacity, low rent, and close to important points of sale. In order to facilitate our next analysis, we set the large storage capacity to $Y_1$, low rent to $Y_2$, and $Y_3$ close to the point of sale [10]. After understanding the company's internal personnel, there are three warehouses (for the following analysis, we set up three warehouses as A, B and C), of which A warehouse: average storage capacity, average rent, not far from important points of sale, B warehouse B: large storage capacity, high rent, not far from important points of sale, C warehouse: small storage, low rent, close to important points of sale. After asking professionals in the company's warehouse location to score, judge the importance of each standard and the importance of the three warehouses under each standard [11]. We get the following judgment matrix, as shown below.

**Table 1.** Judgment Matrix

| G | $Y_1$ | $Y_2$ | $Y_3$ |
|---|---|---|---|
| $Y_1$ | 1 | 4 | 3 |
| $Y_2$ | 1/4 | 1 | 1/3 |
| $Y_3$ | 1/3 | 3 | 1 |

| $Y_1$ | A | B | C |
|---|---|---|---|
| A | 1 | 1/4 | 2 |
| B | 4 | 1 | 8 |
| C | 1/2 | 1/8 | 1 |

| $Y_2$ | A | B | C |
|---|---|---|---|
| A | 1 | 4 | 1/2 |
| B | 1/4 | 1 | 1/8 |
| C | 2 | 8 | 1 |

| $Y_3$ | A | B | C |
|---|---|---|---|
| A | 1 | 1 | 1/2 |
| B | 1 | 1 | 1/4 |
| C | 2 | 4 | 1 |

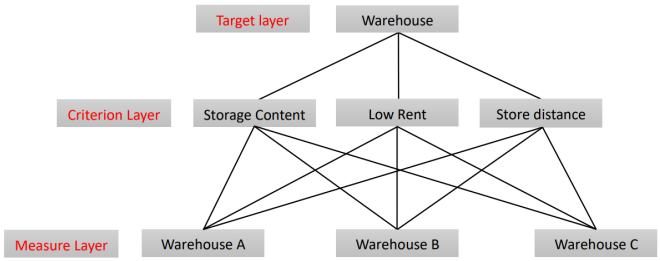


**Figure 1.** Hierarchy diagram of warehouse location problems

### 4.1 Calculate Weight

Put the data of the G judgment matrix into the formula:

$$\overline{W}_i = \sqrt[n]{\prod_{j=1}^{n} C_{ij}} \ (I = 1, 2, \ldots, n) \tag{1}$$

Get:

$$\overline{W}_1 = \sqrt[3]{1 \times 4 \times 3} = \sqrt[3]{12} \approx 2.2894$$

$$\overline{W}_2 = \sqrt[3]{\frac{1}{4} \times 1 \times \frac{1}{3}} = \sqrt[3]{\frac{1}{12}} \approx 0.4368$$

$$\overline{W}_3 = \sqrt[3]{\frac{1}{3} \times 3 \times 1} = 1$$

Then normalize all the above data and replace it with the formula:

$$W_i = \frac{\overline{W}_i}{\sum_{j=1}^{n} \overline{W}_j} \ (I = 1, 2, \ldots, n) \tag{2}$$

Get the weight,

$$W_1 = \frac{2.2894}{2.2894 + 0.4368 + 1} \approx 0.61$$

$$W_2 = \frac{0.4368}{2.2894 + 0.4368 + 1} \approx 0.12$$

$$W_3 = \frac{1}{2.2894 + 0.4368 + 1} \approx 0.27$$

The remaining $Y_1$, $Y_2$, $Y_3$ The data of the judgment matrix is calculated according to the above method, and the corresponding weights can be obtained:

$Y_1$:

$$W_1 = \frac{0.7937}{0.7937 + 3.1748 + 0.3968} \approx 0.18$$

$$W_2 = \frac{3.1748}{0.7937 + 3.1748 + 0.3968} \approx 0.73$$

$$W_3 = \frac{0.3968}{0.7937 + 3.1748 + 0.3968} \approx 0.09$$

$Y_2$:

$$Y_2 : W_1 = \frac{1.2599}{1.2599 + 0.3149 + 2.5198} \approx 0.31$$

$$W_2 = \frac{0.3149}{1.2599 + 0.3149 + 2.5198} \approx 0.08$$

$$W_3 = \frac{2.5198}{1.2599 + 0.3149 + 2.5198} \approx 0.61$$

$Y_3$:

$$W_1 = \frac{0.7937}{0.7937 + 0.6299 + 2} \approx 0.23$$

$$W_2 = \frac{0.6299}{0.7937 + 0.6299 + 2} \approx 0.18$$

$$W_3 = \frac{2}{0.7937 + 0.6299 + 2} \approx 0.58$$

### 4.2 Calculate the maximum eigenvalue

The characteristic vector of the G judgment matrix is $W(0.61, 0.12, 0.26)^T$. Find the formula for calculating the maximum eigenvalue:

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{(c \cdot w)_i}{n \cdot w_i} \tag{3}$$

$$CW = \begin{bmatrix} 1 & 4 & 3 \\ \frac{1}{4} & 1 & \frac{1}{3} \\ \frac{1}{3} & 3 & 1 \end{bmatrix} \begin{bmatrix} 0.61 \\ 0.12 \\ 0.26 \end{bmatrix}$$

$$CW_1 = 1 \times 0.61 + 4 \times 0.12 + 3 \times 0.26 = 1.87$$

$$CW_2 = \frac{1}{4} \times 0.61 + 1 \times 0.12 + \frac{1}{3} \times 0.26 = 0.36$$

$$CW_3 = \frac{1}{3} \times 0.61 + 1 \times 0.12 + 1 \times 0.26 = 0.82$$

$$\lambda_{\max} = \frac{1.87}{3 \times 0.61} + \frac{0.36}{3 \times 0.12} + \frac{0.82}{3 \times 0.26} = 3.073$$

The remaining $Y_1$, $Y_2$, $Y_3$.The data of thejudgment matrix is calculated accordingto the above method to obtainthemaximum eigenvalue:

$Y_1$:

$$\lambda_{\max} = \frac{0.54}{3 \times 0.18} + \frac{2.20}{3 \times 0.73} + \frac{0.27}{3 \times 0.09} = 3.004$$

$Y_2$:

$$\lambda_{\max} = \frac{0.935}{3 \times 0.31} + \frac{0.234}{3 \times 0.08} + \frac{1.87}{3 \times 0.61} = 3.002$$

$Y_3$:

$$\lambda_{\max} = \frac{0.705}{3 \times 0.23} + \frac{0.5575}{3 \times 0.18} + \frac{1.787}{3 \times 0.59} = 3.053$$

Approach $Y_1$ Matrix $\lambda_{\max} = 3.004$

$Y_2$ Matrix $\lambda_{\max} = 3.002$

$Y_3$ Matrix $\lambda_{\max} = 3.053$

### 4.3 Consistency test Consistency indicators

$$\text{CI} = \frac{\lambda - n}{n - 1} \tag{4}$$

$G$ judgment matrix consistency test:

$$\text{CI} = \frac{3.073 - 3}{3 - 1} = 0.0365$$

Because $CI = 0.036520$, the consistency of the judgment matrix is acceptable. It's the same: $Y_1$ Judgment matrix consistency test:

$$\text{CI} = \frac{3.004 - 3}{3 - 1} = 0.002$$

$CI = 0.002 < 0.1$ Therefore, the consistency of the judgment matrix is acceptable.
$Y_2$ Judgment matrix consistency test:

$$\text{CI} = \frac{3.002 - 3}{3 - 1} = 0.001$$

$CI = 0.001 < 0.1$ Therefore, the consistency of the judgment matrix is acceptable. $Y_3$ Judgment matrix consistency test:

$$\text{CI} = \frac{3.053 - 3}{3 - 1} = 0.0265$$

CI=0.0265<0. 1Therefore, the consistency of the judgment matrix is acceptable. Consistency test corrected value index:

$$\text{CR} = \frac{CI}{RI}$$

**Table 2.** Corrected value data table

| n | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| RI | 0 | 0 | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 |

Gjudgment matrix:

$$\text{CR} = \frac{0.0365}{0.58} = 0.062$$

$CR = 0.062 < 0.1$,It is believed that the degree of inconsistency of the $G$ judgment matrix is within the allowable range, and its normalized eigenvector can be used as the weight vector.It's the same:

$$Y_1\text{Matrix CR} = \frac{0.002}{0.58} = 0.003 < 0.1$$

$$Y_2\text{Matrix CR} = \frac{0.001}{0.58} = 0.001 < 0.1$$

$$Y_3\text{Matrix CR} = \frac{0.0265}{0.58} = 0.04 < 0.1$$

Three matrices $CR$ The value is less than 0.1, Therefore, all three matrices have passed the consistency test.

Consistency test of hierarchical general sorting:

$$\text{CR} = \frac{a_1\text{CI}_1 + a_2\text{CI}_2 + \cdots + a_m\text{CI}_m}{a_1\text{RI}_1 + a_2\text{RI}_2 + \cdots + a_m\text{RI}_m} \quad (5)$$

YABC Consistency ratio of hierarchical total sorting:

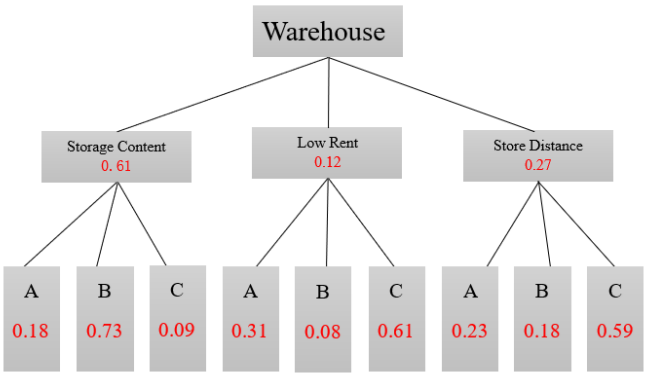


**Figure 2.** Warehouse location hierarchy diagram

**Table 3.** Corrected value data table

| ABC | $Y_1$ 0.61 | $Y_2$ 0.12 | $Y_3$ 0.27 | Final total weight | Vital ranking |
|---|---|---|---|---|---|
| A | 0.18 | 0.31 | 0.23 | 0.2091 | 3 |
| B | 0.73 | 0.08 | 0.18 | 0.5035 | 1 |
| C | 0.09 | 0.61 | 0.59 | 0.2874 | 2 |

$$\begin{aligned}\text{CR}_{\text{total}} &= \frac{0.61 * \text{CI}_1 + 0.12 * \text{CI}_2 + 0.27 * \text{CI}_3}{0.61 * 0.58 + 0.12 * 0.58 + 0.27 * 0.58} \\ &= \frac{0.61 * 0.002 + 0.12 * 0.001 + 0.27 * 0.0265}{0.61 * 0.58 + 0.12 * 0.58 + 0.27 * 0.58} \\ &= 0.015\end{aligned}$$

$CR = 0.015 < 0.1$, so the YABC hierarchy total sorting consistency test passed.

After the hierarchical analysis method [12], it is found that warehouse B ranks first in the ranking of importance. Therefore, under the three standard conditions of the company, warehouse B should be selected as the location of the warehouse, which can have a positive impact on the enterprise, increase the efficiency of logistics transportation, and increase the profit of logistics enterprises.

## 5 Smart logistics countermeasures and suggestions

In response to the challenges of smart logistics warehousing, the following are some countermeasures and suggestions.

**Improve infrastructure construction and establish a logistics industry association:** Governments should actively establish a collaborative mechanism for smart logistics models to optimize terminal

transportation. It is necessary to accelerate the construction of hardware and software infrastructure [13], including investing in logistics facilities, vehicles and technical equipment, and adopting advanced information technology and logistics warehousing systems. Promote the establishment of an efficient communication mechanism and information sharing platform to promote cooperation among all links, strengthen the supervision and management of the entire supply chain, and improve transportation efficiency. At the same time, strengthen the supervision and management of the smart logistics industry, and establish an efficient communication mechanism and a logistics industry association supervision system[14].

**Strengthen government support and formulate standards for the logistics industry:** To further promote the development of the smart logistics industry, the government should increase its support and encourage enterprises to innovate and invest in the field of smart logistics, such as formulating targeted support policies, including financial subsidies, tax relief, rent preferential support, etc [15]. At the same time, the government should set up special institutions or departments to establish close cooperative relations with enterprises, keep abreast of industry needs, research and development directions and technological innovation trends, and provide policy advice and support for enterprises. In addition, the government should set up an incentive mechanism to encourage enterprises to actively participate in technology research and development, talent training and standard setting, and improve the overall level of the industry. In order to ensure that the operation of each link meets consistent standards, the government should organize relevant departments and industry associations to jointly formulate standards and norms for smart logistics, which will help improve the standardization level of smart logistics and reduce unnecessary processes and links. In addition, the government should promote the establishment of an information platform for the smart logistics industry, realize the timely processing of order data, enhance the punctuality and timeliness of product sorting and distribution [16], improve the efficiency of logistics operations, improve user experience, and promote the sustainable development of the smart logistics industry.

**Constantly improve the importance attached to the training of logistics talents:** In order to realize the transformation of the smart logistics model, strengthen school and enterprise cooperation, and constantly improve the importance of talent training, smart logistics enterprises and universities jointly cultivate complex technical skills talents that meet the needs of the industry, for example, formulate common courses, internship plans and enterprise mentoring systems to ensure that students can obtain knowledge and skills consistent with the needs of the actual industry; focus on cultivating high level logistics talents, encourage enterprises to provide practical cases and resource support, help colleges and universities cultivate talents suitable for their own needs to achieve a win-win situation: establish a talent training mechanism that conform to the smart logistics model, promote technological innovation and knowledge renewal, cultivate talents who adapt to new technologies and new business needs, cooperate with colleges and universities, adopt targeted training methods, jointly formulate training plans according to the needs of developing smart logistics enterprises, pay attention to the cultivation of practical ability, improve the adaptability and professional quality of talents [17].

In a word, through technological innovation, industry standards, talent training and policy support, smart logistics warehousing can be promoted to a new stage of development.

## 6 Conclusion

The development of smart logistics warehousing is an important direction for the transformation and upgrading of the logistics industry, and its application prospects are broad. However, in the face of challenges in technology, management and security, the development of smart logistics is of great significance to improving the overall efficiency and competitiveness of the logistics industry [18].

With the development of the global economy and the continuous change of industrial structure, logistics has become the core area of modern economic activities[9]. At the same time, with the continuous development and upgrading of the logistics industry, the development of the smart logistics model of the supply chain has become an inevitable trend of industry development. From the perspective of supply chain, the value of the smart logistics model is mainly reflected in the four aspects of innovation, synergy, flexibility and transparency. It can effectively improve the innovation ability of logistics services, models, technologies, etc., the ability to adapt to internal and external sources, the degree of cooperation between various subjects and the degree of sharing between

various subjects [19].

Using advanced information technology means, smart logistics maximizes the reduction of resource idleness through the reconstruction and integration of socialized resources, realizes the fine management and optimized allocation of logistics resources, and gives the supply chain a stronger operational function and vitality. At the same time, as an important development direction of the logistics industry, smart logistics will also show a trend of more diversification and innovation in the future [20]. It is necessary to constantly pursue innovation and progress, establish a more efficient, green and intelligent supply chain system, meet the needs of enterprises and consumers, and promote sustainable economic development [21]. Therefore, enterprises should actively adopt advanced logistics technologies and methods to strengthen digital transformation to adapt to the changing market and meet the needs of customers.

At the same time, the government, enterprises and research institutions need to work together to strengthen cooperation and innovation, and promote the healthy development of smart logistics warehousing and distribution.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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