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Research on MHS Company's Reverse Logistics Model for Waste Electrical Appliances Based on AHP Model

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Abstract **Case Studies**

With the improvement of environmental awareness, green logistics has become a hot topic in today's logistics industry. Reverse logistics, as an important form of green logistics, is of great significance to environmental protection and resource recovery. Research has found that MHS Company has some problems in reverse logistics of waste electrical appliances, such as low processing efficiency and high costs. This article is based on the AHP model and conducts in-depth research on the reverse logistics model of MHS company's waste electrical appliances. Through the treatment and recycling of waste electrical appliances, the importance of green logistics in reverse logistics was explored, and a feasible reverse logistics model was proposed. The research results indicate that this model can effectively improve the recycling rate of waste electrical appliances and reduce environmental pollution. This article explores the reverse logistics model of MHS company's waste electrical appliances by applying the AHP model. Therefore, an improved reverse logistics model has been proposed. Through empirical analysis, some important conclusions have been drawn and suggestions have been put forward for future research directions. This study is of great significance for improving the efficiency and environmental protection level of MHS company's reverse logistics of waste electrical appliances, and also provides certain reference value for the research and practice of green logistics theory.

Keywords: Green Logistics, Reverse Logistics, Waste Electrical Appliances, MHS Company, Environmental Protection, Resource Recovery, AHP Model, Recycling Efficiency, Pollution Reduction, Logistics Model, Sustainability.

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1. INTRODUCTION

1.1 Research Background

Recently, The State Council of China issued the Action Plan to Promote Large-scale Equipment Renewal and Consumer Goods Trade-in, proposing four measures to support home appliance sales enterprises to cooperate with manufacturers and recycling enterprises to carry out trade-in promotion activities. Statistics show that by the end of 2023, the number of refrigerators, washing machines, air conditioners and other home appliances in China has exceeded 3 billion units. China's home appliance and furniture market has transitioned from a simple "incremental era" to an "era of equal emphasis on both incremental and stock". The overall ownership and scrap volume of renewal are very large, and the renewal demand is in a highly concentrated release period. According to the National Bureau of Statistics, the output of color TV reached 193.396 million units, the output of refrigerators climbed to 96.323 million units, the output of washing machines reached 104.583 million units, the output of air conditioners reached 244.87 million units, the output of microcomputers reached 430 million units, and the output of range hoods reached nearly 40 million units. At present, China is in the peak period of household appliances scrap, every year there are 100 million to 120 million waste household appliances are eliminated, and every year is still in a small range of continuous growth. With the continuous updating and iteration of automobiles, home appliances and other products, it is expected to release the market space of one trillion yuan. However, behind this trend, the recycling of waste electrical appliances has become increasingly prominent, which has a profound impact on China's resource utilization, environmental protection and economic development.

The research of waste electrical appliances reverse logistics mode is of great significance to improve the recycling efficiency of waste electrical appliances reverse logistics and

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reduce environmental pollution. With the rapid development of science and technology, people's demand for electronic products is increasing, resulting in the number of waste electrical appliances is also increasing. Waste electrical appliances contain a large number of toxic and harmful substances, which will cause great harm to the environment and human health if discarded or land filled (Xia,Z.X.,S.2023).

Research on the reverse logistics mode of waste electrical appliances based on AHP model is of great significance, which can not only improve the efficiency of reverse logistics of waste electrical appliances, promote resource recycling and reduce environmental pollution, but also inject new vitality and power into the sustainable development of enterprises and industries. It is hoped that through the in-depth discussion of this study, it can provide beneficial reference and enlightenment for the development of the reverse logistics processing industry of waste electrical appliances. By using AHP model to study and optimize the reverse logistics mode of waste electrical appliances in MHS Company, it can promote the effective recycling of waste electrical appliances and the reuse of resources. The selection of reverse logistics mode is of great significance to the sustainable development of enterprises and the realization of green logistics. As an effective decision-making method, AHP model can help enterprises evaluate and compare the importance of various factors, so as to select the optimal reverse logistics mode. In the reverse logistics of waste electrical appliances, the application of AHP model can improve the efficiency and resource utilization rate of waste electrical appliances, reduce the impact on the environment, and promote the realization of green and sustainable development. Through the research and optimization of the reverse logistics mode of waste electrical appliances in MHS company,it can not only provide scientific decision-making basis for enterprises, improve the efficiency and systematization of logistics, but also provide reference and promotion for the development of the reverse logistics processing industry of waste electrical appliances. The research and practice of waste electrical appliances reverse logistics is of great significance to promote the development of green logistics industry and the recycling of resources. It is hoped that through the in-depth discussion of this study, it can provide beneficial reference and enlightenment for the development of the reverse logistics mode of waste electrical appliances.

1.2 Research Status at Home and Abroad

In recent years, with the increasing awareness of environmental protection and the importance of resource utilization, the research on the reverse logistics mode of waste electrical appliances has attracted much attention. Scholars at home and abroad have carried out relevant research and accumulated rich experience and achievements. In China, there have been many papers discussing the design, optimization and management of waste electrical appliances reverse logistics mode, which provides important theoretical support and practical guidance for the resource utilization of waste electrical appliances in China. In foreign countries, some developed countries have established a relatively perfect reverse logistics system for waste electrical appliances, and formed a certain experience mode, which provides reference for China's research and practice.

1.2.1 Research Status of Waste Electrical Appliances Reverse Logistics

First of all, from the perspective of resource utilization, the reverse logistics processing of waste electrical appliances is an important resource reuse work. Electrical appliances contain a large number of recyclable materials such as metals and plastics.Through scientific and effective recycling and processing, resources can be recycled, the exploitation of new resources can be reduced, and energy consumption can be reduced. However, at present, the waste electrical appliances reverse logistics system in China is not perfect, the recovery rate of reverse logistics is relatively low, a large number of waste electrical appliances are randomly discarded or improperly treated, resulting in a great waste of resources.

Secondly, the problem of reverse logistics of waste electrical appliances is also directly related to environmental protection. The heavy metals and harmful chemicals contained in waste electrical appliances will pollute the environment such as soil and water source, and even pose a threat to human health if they are not properly treated. Therefore, it is of great significance to establish a sound reverse logistics system for waste electrical appliances and realize the safe and environmentally friendly treatment of waste electrical appliances for the protection of China's ecological environment (Zhang,J.J. et al.,2023).

Thirdly, the reverse logistics of waste electrical appliances is also closely related to economic development. The waste electrical appliances reverse logistics industry is an emerging market with great potential, which is of great significance to promoting China's economic transformation and upgrading and cultivating new economic growth points. However, due to the lack of unified standards and norms, the market order is chaotic, which restricts the healthy development of the waste electrical appliance reverse logistics industry.

In view of the above problems, China has issued a series of policies and measures, which are also aimed at promoting the recovery, circulation and treatment of waste electronic products. For example,the state has issued the Regulations on the Management of Recycling and Processing of Waste Electrical and Electronic Products, which defines the responsible subjects and methods of recycling and processing of waste electrical and electronic products in reverse logistics, providing legal guarantee for the reverse logistics of waste electrical appliances. At the same time, the government also encourages and supports enterprises to carry out research and innovation in reverse logistics and processing technology of waste electrical appliances, so as to improve the efficiency of reverse logistics processing and environmental protection level. However, to realize the effective management and utilization of the reverse logistics of waste electrical appliances, it still needs the joint efforts of the whole society. On the one hand, the government needs to increase publicity efforts to raise public awareness of the importance of reverse logistics of used electrical appliances and guide residents to actively participate in the action of reverse logistics of used electrical appliances. On the other hand, enterprises also need to actively fulfill their social responsibilities, establish a perfect reverse logistics

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system for waste electrical appliances, and improve the processing capacity and level of reverse logistics.
In addition, in view of the current situation and problems of the reverse logistics industry of waste electrical appliances, it is also necessary to strengthen industry supervision and norms. The government should formulate more stringent standards for reverse logistics and disposal of used electrical appliances, strengthen industry supervision and law enforcement, crack down on illegal recycling and disposal, and maintain market order and fair competition.

1.2.2. Research Status of Reverse Logistics Network

Reverse logistics refers to the process of reverse logistics from the end user to the manufacturer or supplier of the product. With the increasing awareness of environmental protection and the increasing importance of resource recycling, reverse logistics has become an important research field. At present, the research on reverse logistics network at home and abroad mainly focuses on the recycling, remanufacturing and reuse of discarded products (Xu,H.X.,S.2023).
The research of foreign scholars in the field of reverse logistics is relatively mature, and has formed a set of perfect theoretical system and methods. For example, the AHP model of the United States is widely used in the research of the reverse logistics network of waste electrical appliances, which can effectively evaluate the influencing factors of different reverse logistics channels and provide decision support (Wang,Q. et al.,2022). However, domestic research mainly focuses on manufacturing and e-waste recycling, which lacks systematization and comprehensiveness.
However, there are still some problems and deficiencies in the current research on reverse logistics networks.The research on the structure, operation mechanism and influencing factors of reverse logistics network is not deep enough, and there is a lack of specific models and frameworks. There is a lack of effective information sharing and cooperation mechanism among various links in reverse logistics network, which leads to waste of resources and low efficiency. There are also bottlenecks in technical and policy support, and innovation and standardization need to be strengthened.
Therefore, based on the AHP model and combined with the actual situation of the reverse logistics of waste electrical appliances in MHS company, this study intends to explore its reverse logistics network mode,so as to provide theoretical reference and practical guidance for the reverse logistics utilization of waste electrical appliances. At the same time, through the comparison with foreign advanced experience,the existing problems and deficiencies in the current research are explored and solved, so as to promote the healthy development of reverse logistics network in China.

1.2.3 Research Status of Waste Electrical Appliances Reverse Logistics

The reverse logistics of waste electrical appliances is one of the important issues in the field of environmental protection, which has attracted more and more attention from the government, enterprises and academia.In terms of policies and regulations, the state has promulgated a series of regulations and policies for the reverse logistics of waste electrical appliances,such as the Interim Measures for the Management of Waste electrical and Electronic Products Recycling, aiming to regulate the recycling behavior of waste electrical appliances,improve the utilization rate of resources,and reduce environmental pollution.
In terms of corporate practice, some companies have been trying to waste electrical appliance reverse logistics mode, through the establishment of perfect reverse logistics network to classify the reverse logistics of waste electrical appliance, disassembly and reuse, realize resource recycling of waste electrical appliance. China mobile, for example, through cooperation with reverse logistics enterprise, set up mobile phone of the reverse logistics channel, effectively reduce the environmental impact of waste mobile phone (Wang,X.L. et al., 2022).
In terms of academic research, scholars have also carried on the thorough research on reverse logistics of waste electrical appliance. By using AHP model, the influence of different factors on the reverse logistics of waste electrical appliances is analyzed, which provides a reference for enterprises to formulate reasonable reverse logistics strategy of waste electrical appliances. At the same time, researchers also explored the feasibility and benefits of the reverse logistics of waste electrical appliances through field investigation and data analysis, which provided theoretical support for promoting the development of the reverse logistics mode of waste electrical appliances.
The research on the reverse logistics of waste electrical appliances has made some achievements in the three aspects of policy and regulation, enterprise practice and academic research. In the future, we can further strengthen inter-departmental cooperation, perfect the laws and regulations of the reverse logistics system; Encourage innovation, and promote the application and popularization of the reverse logistics mode; Strengthen academic research, deeply explore the theory and practice of the reverse logistics of waste electrical appliances, and make contributions to the construction of a society of resource recycling.

2. LITERATURE REVIEW

2.1 Circular Economy Theory

The theory of circular economy takes "reduction, reuse and resource recovery" as the core connotation, and emphasizes the efficient recycling of resources and the minimization of environmental load (Wang,X.L. et al.,2022). In this theoretical framework, was no longer perceived as a waste of waste electrical appliance, but a renewable resources, the value of the reverse logistics process become a key link to realize resources circulation. Existing research shows that reverse logistics can effectively promote the transformation of circular economy from concept to practice through the recycling, dismantling, remanufacturing and other links of waste materials (Hao,J.,S.2021). Some scholars have discussed the synergistic mechanism between circular economy and reverse logistics. Hao,J., for example, in the leather industry wastes, points out that in the study of reverse logistics network construction is the important carrier of circular economy be born, through the resources recycling chain extension, realized the unity of economic benefits and environmental benefits(Hao,J.,S.2021).

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Li,H. et al., through AHP-FCE model analysis, found that scientific reverse logistics mode design can significantly improve the operation efficiency of circular economy, especially in the field of waste electrical appliances, which can maximize the value of resource recycling through the coordination of recycling collection, disassembly and treatment, material reuse and product remanufacturing (Li,H. et al.,2022). Yu,H. et al., taking pharmaceutical distribution center as an example, further verified that the reverse logistics process optimization based on system thinking can effectively reduce the cost loss in the practice of circular economy, and provide a reference operation paradigm for the resource recycling of waste electrical appliances and other categories (Yu,H. et al.,2023).

2.2 Basic Theory of Reverse Logistics Network

As the physical carrier of resource circulation, the theoretical research of reverse logistics network focuses on the design of network structure, optimization of operation mechanism and identification of influencing factors. Ding,Y. by Flexsim simulation study found that the efficient operation of the reverse logistics network aspires to recovery, processing costs and environmental risk multidimensional index, and the network node (such as recovery site, dismantling center) of reasonable layout is the key to enhance the overall efficiency (Ding,Y.et al.,2022). Driven by the concept of green logistics, the ecological properties of reverse logistics network have attracted increasing attention. Zhong,M. et al. 's research on regional logistics based on AHP method shows that the construction of reverse logistics network needs to integrate environmental protection goals, and achieve the dual goals of resource recycling and pollution reduction through technological innovation (such as automatic dismantling equipment) and process optimization (such as collaborative transportation) (Zhong,M. et al.,2022). Yang,C. et al. 's SWOT analysis is pointed out that the current reverse logistics network problems such as insufficient standardization, information island, restricting the play its role in the circulation economy, by cross subject collaboration and technology can assign to breakthrough (Yang, C. et al., 2021).

2.3 AHP Model

As an effective tool of multi-objective decision making, analytic Hierarchy process (AHP) has been widely used in reverse logistics mode selection and network optimization. The core value of AHP is to decompose complex decision-making problems into hierarchical structures and realize the combination of qualitative and quantitative analysis through weight assignment (Li,H. et al.,2022). The application of AHP model in the field of reverse logistics of waste electrical appliances is mainly reflected in mode evaluation and factor ranking. Wang, x.l. et al. through AHP method for evaluation of regional logistics capability research shows that this model can effectively identify the key factors affecting the efficiency of reverse logistics, such as cost, professional level, provide scientific basis for mode selection (Wang, x. l. et al., 2022). Party light rain to research further validation of Jingdong mall as an example, the AHP model to quantify the advantages and disadvantages of each scheme through pairwise comparison matrix, especially in the self-management,joint venture, the third party outsourcing pattern choice, can significantly reduce the subjectivity of decision (Dang, X. Y., s. 2022).

In addition, the research on the integration of AHP and other methods has become a trend. Li,H. et al. combined AHP with fuzzy comprehensive evaluation (FCE) to construct a service quality evaluation system for terminal logistics, which provides a new perspective for the service optimization of reverse logistics of waste electrical appliances (Li, H. et al.,2022).

3. REVERSE LOGISTICS MODE OF WASTE ELECTRICAL APPLIANCES REVERSE LOGISTICS NETWORK

3.1 Enterprise Self-Management Reverse Logistics Mode

The enterprise self-supporting reverse logistics mode means that the enterprise establishes its own reverse logistics network and reverse logistics system in order to realize the recycling and reuse of waste electrical appliances. Through the establishment of reverse logistics network and reverse logistics mode, enterprises can effectively reverse logistics waste electrical appliances to the internal processing and reuse, reduce the degree of resource consumption and environmental pollution, and achieve the goal of green logistics (Kong,L.F.,S.2022). Enterprise self-management reverse logistics model has certain advantages, can better control of recycled link, improve the efficiency of reverse logistics, and reduce the cost, so as to realize the goal of sustainable development. Companies can use AHP model to scientifically evaluate and optimize the reverse logistics mode of waste electrical appliances reverse logistics network, so as to improve the efficiency and benefit of waste electrical appliances reverse logistics (Lai,J.N. et al.2022). By continuously optimizing the reverse logistics mode of the reverse logistics network,enterprises can realize the effective management and reuse of waste electrical appliances, and make positive contributions to the sustainable development and environmental protection of enterprises.The enterprise self-operated reverse logistics mode is an important measure for enterprises to continuously explore and innovate in the field of reverse logistics, which helps to improve the competitiveness and sustainable development ability of enterprises.

3.2 Enterprise Joint Operation of Reverse Logistics Mode

The construction of reverse logistics mode of waste electrical appliances is one of the trends in the development of green logistics. Enterprises can realize the recycling and utilization of waste electrical appliances by establishing reverse logistics mode of joint operation.By using AHP model to study the reverse logistics mode of waste electrical appliances in MHS company, it can realize the effective recycling of waste electrical appliances, reduce the waste of resources and environmental pollution, and promote the healthy development of green logistics industry.The joint operation of reverse logistics mode can integrate the resources of all parties, form a complete network of reverse logistics of waste electrical appliances, improve the efficiency of resource utilization, reduce the cost of reverse logistics, increase the

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profits of enterprises, and provide more possibilities for sustainable development. Reverse logistics is not only an economic behavior, but also a manifestation of corporate responsibility consciousness. By establishing a reverse logistics network for waste electrical appliances, enterprises can fulfill their social responsibilities, promote the development of circular economy, and achieve a win-win situation of economic benefits and environmental benefits (Yang,L.Z. et al.2023). Through the in-depth research and model construction of the reverse logistics of waste electrical appliances, it can provide more development ideas and strategic options for enterprises, accelerate the development of green logistics industry, and promote the sustainable development of enterprises.

3.3 Enterprises Outsource Third-Party Reverse Logistics Mode

The development of reverse logistics mode of waste electrical appliances is one of the hot topics in the field of green logistics. As an important way to recycle waste electrical appliances, it is of great significance to promote the development of circular economy. In the reverse logistics network of old electrical appliances, the establishment and operation of the outsourcing mode of reverse logistics is a very key link. Through the outsourcing mode, enterprises can make use of the power of external professional organizations to effectively integrate resources and improve the efficiency and benefit of the reverse logistics of waste electrical appliances.

The implementation of the third-party mode of reverse logistics outsourcing can effectively reduce the operating costs of enterprises in the process of reverse logistics of waste electrical appliances, reduce the risk, and further improve the service quality and customer satisfaction. Under the outsourcing mode, enterprises can entrust professional third-party organizations to take charge of the recycling and disposal of waste electrical appliances, which avoids the dilemma of insufficient resources and technology of enterprises themselves. At the same time, the outsourcing mode can also save enterprises' investment in equipment and manpower, and improve the efficiency and scale of reverse logistics of waste electrical appliances (Zeng,T.H.L. et al.2022). In practice, the outsourcing mode of reverse logistics needs to establish a scientific and reasonable cooperation mechanism,clarify the responsibilities and rights of all parties, and ensure the information fluency and coordination in the process of reverse logistics of waste electrical appliances. Enterprises should choose service providers with rich experience and technical capabilities to ensure the safe recycling and reasonable disposal of waste electrical appliances. Enterprises should also strengthen the supervision and evaluation of outsourcing services, find and solve problems in a timely manner, and ensure that the whole reverse logistics process complies with relevant regulations and standards.

4. ANALYSIS OF THE CURRENT SITUATION OF REVERSE LOGISTICS OF WASTE ELECTRICAL APPLIANCES IN THE BUSINESS AREA OF MHS COMPANY

4.1 Current Situation of Reverse Logistics in Business Area of MHS Company

MHS company focused on waste electrical and electronic products and the reverse logistics of waste household appliances,disassemble and sales,but also to carry out the scrap metal and waste materials recycling business.Major customers include auto parts enterprises,pharmaceutical enterprises,leather enterprises,e-commerce enterprises,furniture enterprises,lighting manufacturers as well as individual users. The company provides a variety of services such as delivery, mailing, vehicle, storage and supply chain to customers within its business coverage. The company has an annual disassembly capacity of 200,000 units, with two processing workshops, respectively corresponding to the disassembly assembly line of waste TV sets and computers and the disassembly assembly line of waste washing machines, refrigerators and air conditioners, and several warehouses for disassembly storage and processing parts,so as to classify and heap the disassembly and recycling parts of waste electrical appliances and their disassembly parts. Processing waste electric and electronic products category for waste televisions, washing machine, refrigerator, air conditioner, waste scrap computer.

Table 1 Summary of the annual dismantling and disposal of MHS in 2023

Categories	Amount recycled/unit	Actual amount of disassembled processing/unit	Self-check reduction/set	Declared subsidy standard dismantling capacity/unit
Waste TV set -1	59057	57601	177	57424
Waste TV set 2 (CRT)	46749	45732	146	45586
Waste refrigerator	142069	142500	24	142476
Waste washing machine -1	1284	1233	0	1316
Waste washing-2	189134	188784	63	188721
Waste air conditioner	36036	36667	455	36212
Waste desktop computer mainframe	12278	13088	45	13043
Waste CRT computer monitors	12006	13088	45	13043

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4.2 Analysis of Existing Problems

(1) No effective reverse logistics model has been established
According to the investigation, MHS company operates a large business area distribution area, business concentrated areas will be targeted to build warehouses, the surrounding areas with less business volume to join. As a result, for its central business area, it can achieve rapid logistics reverse logistics transportation and high-quality services. However, for some customers in the periphery of the business area, it has not been able to establish an effective reverse logistics mode suitable for covering all business areas for a longtime, and will miss part of the market.
(2) The disassembly and recovery rate of old electrical appliances is low
Restricted by objective conditions, it is impossible to deeply extend the processing industry chain of waste electrical and electronic products, resulting in a low recycling rate and recycling rate of some old electronic products. Some waste electrical appliances cannot be disassembled and directly thrown into the waste parts accumulation area, which consumes human and material resources and occupies most of the operating area of the company's disassembly and treatment plant.
(3) The government subsidy distribution cycle is too long
Most of MHS company's waste electronic products are declared subsidies for standardized dismantling processing, but in reality, the subsidy fund has a long distribution cycle, part of the time too dependent on subsidies for dismantling, will make the enterprise bear a high cost of capital, and to a certain extent, will delay the operation time, long-term will restrict the development of enterprises.

5. SELECTION OF REVERSE LOGISTICS MODE FOR WASTE ELECTRICAL PRODUCTS BASED ON AHP MODEL

5.1 Influencing Factors of Reverse Logistics Mode of MHS Company

When studying the reverse logistics mode of MHS companies based on AHP model, how to choose the reverse logistics mode suitable for the long-term operation of MHS companies is the main goal of this research. At the same time, there will be many influencing factors in the research process, and the logistics cost, logistics efficiency, service quality and information transmission have the most significant influence on the selection of logistics mode, and these factors are critically related to the selection of factors in our criteria layer (Chao, M. H. et al.,2023).
(1) Logistics cost, including transportation cost, storage cost, packaging cost, handling cost, these costs reflect the economy of logistics activities. Logistics cost is a key factor for enterprises to choose logistics mode, which directly affects the operation efficiency and competitiveness of enterprises. Enterprises will calculate the cost of different logistics modes and choose the mode with the best cost effectiveness (Krstić, M. et al.,2022).
(2) the logistics efficiency, efficient logistics mode can reduce operating costs, improve customer satisfaction, and accelerate the goods turnover in,s.N.,s.(2021). Therefore, the enterprise in the choice of logistics mode, will tend to choose those who can provide fast, accurate, and reliable service mode, such as advanced logistics information system and the optimization of distribution network, to ensure the logistics efficiency maximization, and strengthen the competitive power of the enterprise.
(3) Service quality, including customer satisfaction, service timeliness and reliability. The high quality service to enhance customer satisfaction, thus influence enterprise logistics mode choice can continue to provide satisfactory services, such as the third party logistics or logistics alliance.
And high quality logistics services can quickly response to customer needs, and to rely on its stability to ensure that the logistics efficiency, prompting companies tend to choose have the characteristics of logistics mode (He,C.C., S. 2021).
(4) information transmission, the effective transmission of information also must be accurately reflected that the customer's demand information, enterprise can real-time grasp the needs of users, to improve the management level of enterprises, integration of resources, realize the scale effect has very important significance, between enterprise and enterprise between supply and demand of information transmission efficiency is very high, Can reduce resource depletion due to asymmetric, improve the efficiency of the whole supply chain, and the most important is, can protect the enterprise's secret key (Tang, Y. et al., 2022).

5.2 Factor Selection at Target Layer, Criterion Layer and Solution Layer

(1) Target layer selection
The model study of MHS company reverse logistics mode, how to choose suitable for MHS company long-term operation of reverse logistics mode is the main target of the study, in the reverse logistics of waste electrical appliance recycling mode as the research object, namely target layer for the model.
(2) the selection criterion layer
Based on the AHP model to simulate the MHS company research in the process of reverse logistics mode, criterion layer factors selected is a key link. Through to the related literature, found that the previous factors have influence on how to select the reverse logistics mode has a detailed discussion, but most of these indicators related to logistics cost, service quality, this is clearly not enough (Chang,H.P.,S.2023). To select the reverse logistics mode of an enterprise, needs to multidimensional, considering such as cost, quality of service, specialization of enterprises, and so on. The following form for after the related logistics mode selection of after the sorting of literature and learning, specific shown in the table below:

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Table 2 arrangement the influence factors of the literature

The author	time	indicators
(Lu, X., T.Ss.2023).	2023	Logistics cost and economic benefit, social benefit and external influence
(Qiao, Z. B.,Yang et al.,2023)	2023	Economic factors, technological factors, social factors, environmental factors
(Li, D. Q. et al.,2020)	2020	Economic factors and managerial factors, social factors
(Ding, Q. M. et al.,2020)	2020	Strategic factors, management factors, economic factors, technological factors and environmental factors
(Wen, S. S. et al.,2019)	2019	Financial factors, management factors, technical factors, social factors
(Lin, W. B. et al.,2019)	2019	Economic factors, technical factors, social factors

As shown in the above table, after literature sorting and induction, it can be found that economic, technical, management, social and other factors are the key factors affecting the selection of reverse logistics mode by enterprises. However, in order to ensure that the selected factors are more objective and reasonable, it is necessary to consult and interview relevant people in the industry.

Again, with the approval of MHS company relevant personage and MHS company financial personnel, storage and transportation department, logistics network and other units of staff communication, and got the idea of the personage inside course of study and the suggestion. Finally, after finishing the preliminary MHS Company which affect reverse logistics mode selection of four specific factors, it is respectively: cost, professional, service quality and information management.

1) Cost factors: the cost is the key factor for enterprises choose logistics mode, directly affect the operation efficiency and competitiveness of the enterprise. Complete a project cost as a metric enterprises, income generated by one of the main indicators, the cost level directly determine whether or not the reverse logistics circulation pattern of MHS company able to healthy, sustainable operation.

2) Specialized factors: professional has a significant influence on logistics mode selection. Professional and technical innovation is not only improve the efficiency of the logistics, reduce the cost and also makes the logistics process more transparent and controlled. With advanced technology of logistics mode tends to provide more quality services, to meet changing market needs.

3) Service quality factors: service quality has a direct and important influence on logistics mode selection. The high quality service to ensure safe and on time delivery of goods, to provide quality customer experience at the same time. When choosing logistics mode, the enterprise will tend to choose those models can provide a stable, reliable service, in order to ensure the stability of the supply chain and customer satisfaction.

4) Information management factors: efficient information transmission management can ensure the logistics information updated in real time and accurate delivery, so as to improve the efficiency of the logistics operation. By optimizing the information transmission process, reduce the information redundancy and errors, helps to reduce logistics cost. Different types of information transmission management mode is suitable for the different logistics mode.

(3) Scheme layer selection

Scheme layer selection, in this paper, the model mainly for the research of the former mentioned in this paper, three kinds of commonly used mode of reverse logistics, respectively: proprietary reverse logistics mode, enterprise joint venture mode of reverse logistics, enterprise outsourcing third party reverse logistics mode, so the solution of the model layer of selected from these three reverse logistics mode.

To sum up, the hierarchical structure model of reverse logistics mode for waste electrical appliances is shown in Figure 2.

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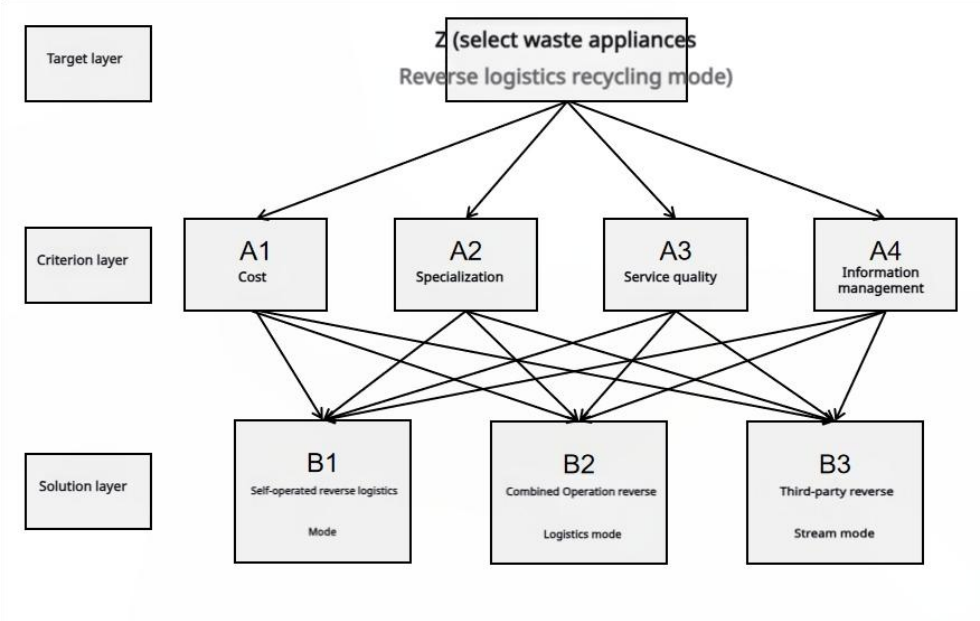

FIG. 2 Hierarchical model of reverse logistics mode for waste electrical appliances

5.3 Construction of Reverse Logistics Mode Selection Model of MHS Company

5.3.1 Parameter Description

w_i --The weight of the i-th element, i=n
n --The matrix order
λ_{max} --Maximum eigenvalue
CI --Consistency index (depicting how similar consistency)
RI -random consistency index
CR -- Consistency ratio
Now, the vector of the judgment matrix needs to be normalized. Next, the sum of each row is calculated. Then, the column vectors obtained are normalized. Finally, $W=(W_1,W_2\ldots W_N)^T$ is the required eigenvector. After that, the maximum eigenvalue λ of each matrix is calculated.Specific steps are as follows:
Step 1: Formalize the matrix through the formula

$$\overline{a_{ij}}=\frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}\ (i,j=1,2,\ldots n)$$

Here, a represents the data in the i-th row and j-th column of the judgment matrix A, and $\overline{a_{ij}}$ represents the data in the i-th row and j-th column of the normalized matrix.
Step 2: to sum the elements in the matrix

$$\overline{w_i}=\sum_{j=1}^{n}\overline{a_{ij}}\ (i,j=1,2,\ldots n)$$

Step 3: Formalize the $\overline{w_i}$ in the above text

$$w_i=\frac{\overline{w_i}}{\sum_{i=1}^{n}\overline{w_i}}\ (i=1,2,\ldots n)$$

Where $\overline{w_i}$ is the weight of the i-th indicator.
Step 4: Calculate the maximum eigenvalue of the judgment matrix A

$$\lambda_{max}=\frac{1}{n}\sum_{i=1}^{n}\frac{(Aw_i)}{w_i}$$

Where is the order of the matrix, A is the judgment matrix, and w_i is the weight of the i-th indicator, and λ_{max} is the maximum eigenvalue of the judgment matrix A.
By calculating the weight vectors of various logistics modes, the optimal reverse logistics mode of waste electrical appliances can be determined, which provides decision support for the sustainable development of MHS company.

5.3.2 Reverse Logistics of Waste Electrical Appliance Paired Comparison Matrix and the Level of Single Order

Table 3 Construction of pairwise comparison matrix and hierarchical single ranking

Scaling	Meaning
1	It means that two factors are of equal importance compared to each other
3	Compared two factors, the former than the latter a little important
5	Compared with the two factors, the former is obviously more important than the latter

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7	Said compared to two factors, the former is more important than the latter strongly
9	When two factors are compared, the former is extremely more important than the latter
2,4,6,8	Indicates the median ofthe above adjacentjudgments
Reciprocal	If the ratio ofimportance of factor i to factorj is a_{ij}, Then the ratio of importance of factor j to factor i is $a_{ij}=1/a_{ij}$

Define consistency index, when CI = 0, a complete consistency: CI close to 0, with satisfactory consistency: CI is larger, the more serious. $CI=\frac{\lambda-n}{n-1}$ In order to measure the size of the CI, the introduction of random consistency index RI, as shown in table 4.

Table 4 random consistency index RI

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

After a detailed calculation of weights at all levels, and use the consistency index to evaluate, we refer to table 2 for RI random consistency index, then calculate the consistency ratio of CR, this ratio used to determine whether the consistency of the matrix. Only when the CR < 0.1, we think that the consistency of judgment matrix is acceptable. If this condition is not met, we will continue to adjust the judgment matrix until it passes the consistency test (Zheng, Y. H. X.,S.2022).

In order to effectively obtain the weight of each index in the performance evaluation index system of values, this study designed a "MHS company reverse logistics mode selection index weight questionnaire" questionnaire for data acquisition. In the process of questionnaire distributed, a total of 16 invited senior logistics personnel, including 4 MHS staff of 12 people, scholars, thus to score of the questionnaire, after careful review and confirm all the recycling questionnaire are valid questionnaires, also achieves 100% efficient. The efficiency and effectiveness of analytic hierarchy process (AHP) data collection for the follow-up study provides a solid foundation for data.

Build index system, evaluation index for the same level of various elements of the need to pass judgment matrix to calculate the relative weight of each element. This paper constructed the index system of reverse logistics mode to build a total of 5 in the matrix, as shown in table 5 to table 9:

Table 5 cost paired comparison matrix

A1 Cost	B1	B2	B3	wi	Awi
B1	1	1/3	1/7	0.085	0.257
B2	3	1	1/4	0.213	0.645
B3	7	4	1	0.701	2.152

By analyzing the cost factor of paired comparison matrix, we concluded that plan B of various factors on the criterion layer cost factor weights of A1 sorting for [0.257, 0.645, 2.152]. After verification, the consistency of the matrix ratio CR=0.028, far below the threshold value of 0.1, thus successfully passed the consistency check, confirm the effectiveness of the matrix. Further analysis showed that the plan B, rule of various factors on the layer of A1 relative weights order from large to small is: B3 third party reverse logistics mode, B2 joint venture reverse logistics mode, B1 proprietary reverse logistics mode.

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Table 6 professional paired comparison matrix

A2 Specialization	B1	B2	B3	wi	Awi
B1	1	1/4	1/6	0.087	0.262
B2	4	1	1/3	0.274	0.835
B3	6	3	1	0.639	1.982

Through the specialized factors in-depth analysis of the paired comparison matrix, we concluded that plan B of various factors on the criterion layer specialized factor A2 weight sorting for [0.262, 0.835, 1.982]. After verification, the consistency of the matrix ratio CR=0.047, far below the threshold value of 0.1, thus successfully passed the consistency check, confirm the effectiveness of the matrix. Further analysis showed that the plan B, each factor of rule layer A2 relative weights order from large to small is:B3 third party reverse logistics modejoint business reverse logistics mode > > B2 B1 proprietary reverse logistics mode.

Table 7 service quality paired comparison matrix

A3 service quality	B1	B2	B3	wi	Awi
B1	1	1/2	5	0.343	1.040
B2	2	1	6	0.575	1.753
B3	1/5	1/6	1	0.082	0.246

Through analyzing the service quality factors of paired comparison matrix, we concluded that solution layer B various factors on the standards of service quality factors weights of A3 sorting for [1.040, 1.753, 0.246]. After verification, the consistency of the matrix ratio CR=0.025, far below the threshold value of 0.1, thus successfully passed the consistency check, confirm the effectiveness of the matrix. Further analysis showed that the plan B, each factor of rule layer relative weights ofA3 order from large to small is:joint business reverse logistics mode > B2 B1 proprietary reverse logistics mode > B3 third party reverse logistics mode.

Table 8 information management paired comparison matrix

A4 Information Management	B1	B2	B3	wi	Awi
B1	1	2	6	0.587	1.770
B2	1/2	1	4	0.324	0.974
B3	1/6	1/4	1	0.089	0.268

Through in-depth analysis of the pairwise comparison matrix of information management factors, it is concluded that the weight ranking of each factor in scheme layer B to information management factor A4 in criterion layer is [1.770, 0.974, 0.268]. After verification, the consistency of the matrix ratio CR = 0.008, far below the threshold value of 0.1, thus successfully passed the consistency check, confirm the effectiveness of the matrix. Further analysis shows that in scheme layer B, the relative weights of each factor to criterion layer A4 are from large to small: B1 proprietary reverse logistics mode >B2joint operation reverse logistics mode >B3 third-party reverse logistics mode.

Table 9 goals paired comparison matrix

Z	A1 cost	A2 specialization	A3 Service quality	A4 Information Management	wi
A1 Costs	1	2	1/3	5	0.248
A2 Specialization	1/2	1	1/4	3	0.144
A3 Quality of Service	3	4	1	7	0.550
A4 Information Management	1/5	1/3	1/7	1	0.058

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Via a paired comparison matrix, criteria of target layer effects of single order: [0.248, 0.144, 0.550, 0.058], validated, and the consistency of the matrix ratio CR=0.008, well below the threshold value of 0.1, so the success through the consistency check, confirm the effectiveness of the matrix. Through AHF analysis, the most influential mode of scheme layer on A1 cost is B3 third-party reverse logistics mode; B3 third-party reverse logistics mode has the greatest influence on A2 specialization; The service quality of A3 is most affected by the joint operation reverse logistics mode of B2; The information flow of A4 is most affected by the self-operated reverse logistics mode of B1. Choose the overall goal of the reverse logistics of waste electrical appliance reverse logistics mode of Z factors influence from big to small ranked as follows: > > > professional cost information circulation service quality, service quality are the most important, can affect the established long-term cooperation relationship with customers.

5.4 Compute the Reverse Logistics of Waste Electrical Appliance Total Sorting Weight and Consistency Check

In the calculation process, we used the eigenvalue method to determine the total ranking weight to ensure its accuracy and rationality. At the same time, we also conduct consistency test to determine whether the weights obtained are reasonable by calculating the ratio of consistency index and random consistency index. Through the application of AHP model, we get the final ranking of the reverse logistics mode selection of waste electrical appliances, and its consistency test results.

This provides an important reference for MHS Company to make decisions on the reverse logistics of waste electrical appliances, and helps to achieve the development goal of green logistics. It can be seen from Table 10 that the calculation results and consistency test of the total ranking of scheme B to target layer Z can be obtained: the weight distribution of each scheme in target layer Z is [0.256, 0.427, 0.316], and the consistency ratio CR=0.018, far below the critical value of0.1, indicating that the overall ranking of AHP has good consistency. To sum up, according to the weight ranking, the weight of each scheme is ranked B2>B3>B1. AHP analysis further confirms that the joint operation reverse logistics mode is closer to the actual operation needs of the region than other modes. Therefore, we finally choose the joint operation reverse logistics mode, and design the corresponding reverse logistics process accordingly.

Table 10. The weight of scheme layer influences criterion layer

	A_1	A_2	A_3	A_4
	WA_1	WA_2	WA_3	WA_4
	0.248	0.144	0.550	0.058
WB_1	0.085	0.087	0.343	0.587
WB_2	0.213	0.274	0.575	0.324
WB_3	0.701	0.639	0.082	0.089
λ	3.033	3.054	3.029	3.009
CI	0.016	0.027	0.015	0.005
CR	0.028	0.047	0.025	0.008

6. IMPLEMENTATION STRATEGIES FOR REVERSE LOGISTICS OF WASTE ELECTRICAL APPLIANCES

6.1 Scientific Cost Reduction

Due to the distribution of customers and product characteristics, the reverse logistics of waste electronic products in the business area has problems such as large and scattered demand, multiple types and miscellaneous, which makes it difficult for ordinary recycling or logistics companies to form scale advantages, making the reverse logistics cost generally high. Large and small logistics companies in various regions are reluctant to participate in the reverse logistics process, so the primary consideration is to scientifically control the cost. Firstly, the joint operation of reverse logistics mode is used to build a cooperative supply chain, and the high transportation cost is shared with each other, so as to reduce the cost of reverse logistics. MHS companies can establish contact with logistics companies and recycling departments distributed in various business areas to realize the division of tasks and share the cost of reverse logistics. Cooperative logistics companies can give full play to the organization's transport capacity, reduce the overall cost of reverse logistics, achieve efficient and high-quality reverse logistics services for customers in various regions within the business coverage, and improve the recovery rate and resource utilization rate. To promote the development of circular economy. Secondly, in the process of reverse logistics of waste electronic products, we should give full play to the advantages of joint logistics mode, and rationally allocate and utilize the transport capacity of MHS companies and cooperative companies. The idle transport capacity in each business area is first centralized and redistributed through effective centralized collection, transfer and route planning. Reduce the high transportation costs of various companies, such as vehicle maintenance, fuel consumption and renewal (Yuan, X. H.,S.2024). When making full use of each company's own transport capacity to carry out efficient reverse logistics of waste electrical appliances, the remaining resources can also be used for in-depth processing of electronic product disassembly products to extend the industrial chain.

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6.2 Improve Policy Support

In strict accordance with the requirements of the Ministry of Environmental Protection, conscientiously implement the spirit of various documents and notices, regularly organize municipal first-level environmental protection departments to participate in training, timely update the tasks and requirements of the dismantling work of domestic waste electrical and electronic products, and further improve the level of environmental management of waste electrical and electronic products. Strive for financial support, introduce a third-party audit mechanism, and strengthen the audit of the disassembly and disposal of waste electrical and electronic products in enterprises. The relevant government departments should set the standard of fund subsidies based on the treatment cost of toxic and harmful substances in waste electronic products. At the same time, the competition among enterprises of comprehensive recycling, dismantling and reuse should be taken into consideration to clarify the price transmission mechanism and interest balance under the market economy, control the adjustment and change of policies with appropriate pace and intensity, and set up an appropriate buffer period, so as to systematically reduce the negative impact.Urge enterprises in the province to actively participate in business training,formulate enterprise management system,standardize management requirements and reporting procedures,invest funds to improve the construction of enterprise facilities and equipment,improve the recycling capacity and dismantling efficiency,and strive to effectively recycle and standardize the disposal of waste electrical and electronic products in the surrounding areas within the scope of qualification.

6.3 Improve Information Management

Information management and information circulation are also the key points in the reverse logistics mode of joint operation. How to communicate efficiently with participating logistics companies or recycling departments to obtain clear and real-time information feedback, and whether the supply and demand information transmission is timely in this mode, etc. Are all factors that affect the timeliness of work connection between various cooperation links in the joint operation mode (Deng, J. et al.,2021). In view of these problems existing in the reverse logistics of waste electrical appliances, MHS companies and cooperative companies can establish a perfect information system, build a large platform for information sharing, and establish contact with participating logistics companies or recycling departments in each link of reverse logistics and recycling, so as to carry out efficient information circulation. In addition, MHS and its cooperative companies also need to sort out and summarize customer data in different business areas, constantly update the information system of the platform, according to the needs of customers, the information should be able to feed back to the relevant responsible personnel through the built information platform, and plan and sort out the optimal path through the information system, so as to slowly improve the information management under this mode. The optimal route can be planned through the information system and fed back to the decision maker, so as to gradually improve the recovery mode.

7 RESEARCH SUMMARY AND PROSPECT

The reverse logistics of waste electrical appliances refers to a green logistics method of reusing waste electrical products through reverse logistics. Through the application of AHP model, the reverse logistics of waste electrical appliances in MHS Company can be evaluated and optimized, which provides an important reference for the company to save costs and reduce resource waste. Through the analysis and research, the appropriate reverse logistics strategy can be determined to improve the recycling rate of waste electrical appliances and the utilization rate of resources, and realize the development mode of circular economy. The implementation of the implementation strategy of the reverse logistics of waste electrical appliances requires the company to carry out cost analysis, technical improvement and other aspects, in order to improve the operation efficiency of the reverse logistics system, speedup the processing of waste electrical appliances, so as to achieve the maximum utilization of resources and reduce environmental pollution. The effective implementation of reverse logistics strategy is very important for MHS Company, which can improve the company image, increase competitiveness and achieve the goal of sustainable development. When formulating the implementation strategy of reverse logistics, it is necessary to fully consider the suppliers, logistics channels, recycling process and other factors to ensure the smooth progress of the reverse logistics of waste electrical appliances. Through the application of AHP model, the in-depth research and optimization of the reverse logistics mode of waste electrical appliances in MHS Company will provide a more scientific basis for the company to make decisions, promote the smooth development of the company's reverse logistics work, and make positive contributions to the cause of environmental protection.

The research on the reverse logistics mode aims to realize the efficient treatment of waste electrical appliances and the recycling of resources. As an important direction of today's social development, green logistics advocates to reduce the impact on the environment. The AHP model is used to evaluate the feasibility and benefits of the reverse logistics mode of waste electrical appliances in MHS Company. The reverse logistics processing of waste electrical appliances is of positive significance to the environment and sustainable development. Through reasonable reverse logistics mode, the reuse of resources and the reduction of waste to the environment can be realized. As a multi-factor decision-making method, AHP model can help enterprises to make scientific evaluation and decision-making in the process of reverse logistics improvement, and improve the efficiency and environmental friendliness of logistics system. It is found that using AHP model to evaluate the feasibility of reverse logistics mode of waste electrical appliances in MHS Company can provide an important reference for the logistics operation of enterprises, and promote the scientific and green development of waste electrical appliances processing. The research and practice of reverse logistics is helpful to promote the transformation and upgrading of enterprise logistics mode, and also promote the effective utilization of resources and the common realization of environmental protection. Through this study, it provides theoretical guidance and practical reference for MHS Company

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to improve and optimize the reverse logistics mode of waste electrical appliances, and makes contributions to the sustainable development of enterprises and social green development.

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