A DEMATEL approach to select green reverse logistics service providers

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Abstract. With the development of science and technology, the problems of environmental pollution and waste of resources are becoming more and more serious. Urban logistics is one of the regions with the highest frequency of logistics activities. In the face of the destruction of the environment and its impact on human life, urban logistics need to be transformed to be more friendly to the environment. This study aims to find the key success factors for selecting green reverse logistics service providers. Based on urban logistics and reverse logistics, on the perspective of sustainability, this study collected five aspects and twenty-four factors. DEMATEL is employed to process the data of expert assessments. Referring to the causal map, “Green operations level” and “Greenness of facilities and equipment” are crucial.

1. Introduction

With the rapid development of science and technology, the continuous advance of society, and the continuous extension of economic scope, the public has developed more requirements on both the physical and spiritual levels. However, the progress of human civilization has brought a series of irreversible problems to environmental resources, such as energy shortage, serious decrease of forest resources, and sharp decline in mineral resources, etc. The contradiction between economic benefits and environmental benefits is increasingly exposed, which has seriously threatened the survival and development of human beings. Therefore, the emergence of circular economy and low-carbon economy brings the coordinated development of environmental resources and material and spiritual life of humans. Sacrificing the limited resources is “drain the pond to get all the fish” in order to pursue the rapid development of the economy, and if only protecting the environment and not pursuing the economy development is just like that you seek fish on the tree, only the organic combination of the two aspects, and the environmental improvement in development can achieve the sustainable development of resources. In order to keep up with the trend of circular economy, China has introduced a lot of environmental resources protection policies in recent years, spent a large number of manpower, material resources and funds, proposed to build an environment-friendly and resource-saving society, and the slogan has become a household phrase of environmental protection that clear water and green mountains are like gold and silver mountains. The rise of the e-commerce industry and the logistics industry has brought a more convenient and fast and indoor lifestyle, and a series of environmental problems which brings have attracted more and more attentions. The logistics activities contrary to the traditional logistics
direction, such as returns, product recalls, waste recycling and so on, are gradually increasing. This is a new module of logistics research, this form of logistics is called reverse logistics. On the premise of protecting environmental resources, one of the most wasteful activities in the logistics process, that is, reverse logistics and green activities, should be connected to reduce the influence of reverse logistics activities on the environment, such as waste disposal, recycling and reprocessing of goods, circulating processing and recycling, etc.

Similarly, China’s urban logistics is facing the situation of environmental pollution and resource destruction caused by the expansion of economic scope, which proposed new challenges and requirements for urban logistics. In the past, when customers selected logistics service providers, they considered more factors, such as transportation safety, transportation speed, storage level, advanced information system, etc. However, with the development of big data and the instruction of sharing economy, actually, many service providers have a little difference in these important logistics characteristics. When these standards are considered by the customers as the basic standards they should reach, they will put the standards of choice on the logistics characteristics that the service providers can provide is different from other operators. Reverse logistics is in the field of emerging logistics, there are many different points from traditional logistics, now most of urban logistics service providers can not propose a more comprehensive construction form. Therefore, developing reverse logistics can be as an important means for enterprises to expand their competitive advantage, combined with green logistics, it not only creates profits and value for the enterprise itself and the city's reverse logistics suppliers, but also contributes to form a green society.

Through the basic understanding of the status of green logistics and urban logistics research, combined with the selection model of reverse logistics service providers, through the analysis of DEMATEL, this paper proposes the key factors that select green city reverse logistics service providers to explore the importance of various key factors of selecting green city reverse logistics service providers, and thus further concluded, provides the reference that the relevant companies and logistics enterprises make decision when select reverse logistics service providers.

2. Literature review

2.1. Green logistics
Green logistics refers to a behaviors, which is in a series of logistics activities about purchasing, production, transportation, warehousing, packaging, distribution, recycling and so on, from the perspective of environmental protection, its purpose is to minimize environmental pollution and the waste of resources. Through advanced logistics means, building system logistics planning and carrying out green management and control, to make the links of logistics activities more environmental and green. Green logistics covers not only green transportation, green warehousing, green packaging, green circulation and processing, etc, but also green reverse logistics.

In “Logistics Terms” (GB/T 18354-2001) published by China in year 2001, the definition of green logistics is: to prevent the logistics from harming the environment during the logistics process, meanwhile, to achieve the purification of the logistics environment, and to make the most use of logistics resource.

2.2. Urban logistics
Urban logistics is a new industry in the 21st century, domestic and international scholars defined urban logistics according to their own understanding from different perspectives, but there is still no unified expression. Cheng pointed out that urban logistics is all logistics links within a certain scope, including all physical movements, like warehouse, packaging, transportation, circulation processing and information transmission, etc [1]. Dai believes that the development of urban logistics is affected by the expansion of economic scale, and is also affected by traffic conditions and resource abuse, so as to improve the relevant logistics activities of urban logistics enterprises [2]. Zou believes that the expansion of scale economy cannot be separated from the development of urban logistics, optimizing
the management of urban logistics activities, so as to make urban traffic running more smoothly, and to help to achieve a balance between urban logistics activities and urban planning operations [3]. Cao pointed out that urban logistics refers to the physical movement and distribution of goods within a certain scope [4].

Based on the research of above scholars, this paper thinks urban logistics refers to the logistics that services for the city, it promotes the economic development of the city, takes into account the systematic management of environment and transportation, and consists of this kind of activities like the spatial flow of goods in the urban area, the transportation of goods with external areas, and urban reverse logistics.

2.3. The selection model of reverse logistics operator

Lu combined with the methods of Analytic Hierarchy Process (AHP) and Data Envelopment Analysis to research the performance dynamics of service providers [5]. Xang established a neural network through modular neural network method and established an evaluation model to select third-party reverse logistics service providers [6]. Guo constructed an evaluation index system from four aspects: service quality, resource capacity, management level and cooperation index, and selected third-party reverse logistics service providers by using the comprehensive evaluation method of improved fuzzy analytic hierarchy process and grey correlation degree analysis [7]. Chen adopted a weighted fuzzy clustering method when evaluating third-party reverse logistics service providers [8]. Chen established a comprehensive evaluation index system for reverse logistics service providers through fuzzy comprehensive evaluation method, and combined the analytic hierarchy process to determine the weights of evaluation indicators, and carried out data analysis to draw conclusions [9].

3. Research method

The method used in this research is Decision Making Trial and Evaluation Laboratory (DEMATEL). DEMATEL was proposed by the Bastille National Laboratory in the United States in 1971, it is a method proposed by screening the central factors of complex systems and simplifying the analysis process of system structure. Professor Zeng Guoxiong promoted DEMATEL in the 2002 Taiwan’s election, which made many scholars gradually realize the effectiveness of this method, and thus apply this method to more various studies. For example, Professor Wang established a risk analysis model for mobile e-commerce supply chain by using DEMATEL analysis method, and took Taobao as an example for empirical research [6]. Yang integrated the factors that affect the quality of logistics service by studying relevant literature, sorted the factors by DEMATEL method, found out the main factors that affect the quality of logistics service, and helped to build the index system that influences the factors of logistics service quality [10].

The calculation process of DEMATEL as shown in Figure 1.

Figure 1. The calculation process of DEMATEL
4. Discussion on key success factors in selection of green city reverse logistics suppliers

4.1. Problem description
China's urban logistics started late, but it developed rapidly. Due to the influence of geographical environment and urban planning, the characteristics of urban logistics are more characterized by small batch size, high frequency, many nodes, etc. In response to the goal of building a green society, urban logistics should also develop new businesses and appropriately transform. With the continuous popularization of e-commerce and the continuous occurrence of positive logistics generated by shopping, the reverse logistics are generated when customers are not satisfied with the goods, or when recycle certain items that customer discard, both of them will cause a certain burden on the environment. In order to solve such problems, green logistics and reverse logistics should be combined, which not only helps enterprises increase economic efficiency, expand economic scale, but also contributes to building a resource-saving society.

4.2. The experiment
Through the analysis and research of green city reverse logistics service providers, the following five aspects is discussed, which are operation level, service quality, information level, cooperation attribute and green activity.

1. Operation Level
   As the enterprise providing logistics services, its most basic attribute is to have the corresponding logistics characteristics, which can provide basic logistics activities. This is also the factor that the enterprise should have when customers choose a company, including these factors: transportation capacity, certain circulation processing capability, the level of network coverage, warehousing levels and the quality of employees, etc.

2. Service Quality
   With the expansion of the economic scale, the needs of customers have changed from the initial simple transportation of goods and receipt of goods to hope that enterprises can provide personalized and customized services to meet the non-traditional requirements of customers and enhance customer satisfaction. Today, the third industry becomes the leading industry, and the influence of customer satisfaction on an enterprise is self-evident.

3. Information Level
   The development of big data proposed by the sharing economy has put forward new requirements for the information level of logistics suppliers. Whether it has advanced information level not only affects the progress of its own logistics activities, but also affects the evaluation choices of customers.

4. Cooperation Attribute
   Among the different cooperative relationships between enterprises, it must be a strategic alliance to maximize to achieve information sharing and create economic benefits, when customers want to establish strategic partnerships with suppliers, they need to have a more comprehensive and deep understanding of suppliers. In addition to the company's ability indicators, it also includes the company's popularity, corporate reputation, corporate culture, development potential, corporate strategic decision-making ability and cost control ability. Only when both sides become good strategic partners can they progress and grow together and achieve a win-win situation.

5. Green Activity
   In order to build an environmental-friendly society, green logistics and reverse logistics can be combined, which requires enterprises to have a more mature level of green process operation, facilities and equipment should also be environmentally friendly, and goods processing and goods recycling should also have a high degree of green.

   On the basis of reference to the literature review, according to the content of this paper, the key factors of green city reverse logistics supplier selection are divided into five aspects and twenty-four
criteria to determine the research framework of this paper. This study will describe the five aspects and twenty-four criteria and connotation of these criteria of the key factors in the green city reverse logistics suppliers selection, the detailed description in the following Table 1.

| Table 1. Aspects and Criteria |
|-------------------------------|
| Aspects | Criteria | Connotation | References |
|---------|----------|-------------|------------|
| A Operation level | A1 Transportation capacity | The short-distance transportation capacity of the city reverse logistics, quickly receiving the goods returned by the customer, and can also be sent out quickly | |
| | A2 Circulating processing level | Mainly for the goods that need to be recycled and reprocessed, which should have a certain level of circulation processing | [2-4, 10] |
| | A3 The level of network coverage | The area covered by the company's reverse logistics business | |
| | A4 Warehouse level | Including storage capacity, classification ability, special cargo storage capacity | |
| | A5 The quality of employees | Including professional skill level, service awareness, environmental awareness, and the experience in handling reverse logistics items | |
| B Service quality | B1 Response timeliness | Respond to customer needs quickly and timely, improve customer satisfaction | [2, 5, 11] |
| | B2 Solving ability of emergency | As for the solving ability of emergency, whether or not can react quickly and appropriately | |
| | B3 Service price | The reasonable price that can be accepted by customers | |
| | B4 After-sales service | Deal with customer complaints in time to provide certain guarantee for reprocessing goods | |
| | B5 Ability to provide personalized value-added needs | Provide customers with unconventional personalized needs | |
| C Information level | C1 Advanced level of information system | The advanced degree of enterprise information system affects the progress of reverse logistics activities | [2, 4, 7] |
| | C2 Logistics tracking capability | Real-time logistics tracking capabilities, query logistics information | |
| | C3 Information integration and sharing ability | The ability to integrate information and share information with partners | |
| | C4 Information security | Ensure the security of information | |
| D Cooperative attribute | D1 Corporate popularity | Status and prestige in the industry | [7, 9, 11] |
| | D2 Corporate reputation | Reputation with past partners and current partners, affects partner selection | |
| | D3 Corporate culture | Corporate culture affects the future development of the company and is reflected in its business activities. | |
| | D4 Development potential | The future development potential of the company affects the choice of partners | |
| | D5 Corporate strategic decision-making ability | Whether the strategic decision of the enterprise is long-term and grand | |
| | D6 Control cost capability of enterprise | Reasonably control costs and maximize revenue with the lowest possible cost | |
| E Green activities | E1 Green process operation level | Green level of logistics activities | [3-4, 6, 11] |
| | E2 Greenness of facilities and equipment | Environmental protection level of facilities and equipment | |
Whether the handling process of non-recyclable items is environmentally friendly, whether it is to minimize or even eliminate waste of resources and environmental pollution, and how to operate.

Whether the recycling process is environmentally friendly, whether it is to minimize or even eliminate waste of resources and environmental pollution, and how to operate.

Design the DEMATEL questionnaire based on the above five facets and the twenty-four criteria, and improve the questionnaire design through experts’ and scholars’ suggestion. Secondly, before completing the questionnaire, communicate with experts and scholars to fully explain the core and content of the questionnaire, so as to successfully fulfill the effective answer.

In the questionnaire survey of 12 industry and government and university experts and scholars in related fields, the collected data were drawn into a visual causality diagram based on the calculation results of DEMATEL (as the Figure 2).

When viewing the causal map, the first quadrant is the core factor area, which is characterized by high centrality, high cause degree, and has a great influence on other factors. It is a key element of the research subject and is the important part that enterprises should pay attention to. The second quadrant is the driving factor area with low centrality, high cause degree, independence, and influence on very few other factors. The third quadrant is the independent factor area, characterized by low centrality, low cause degree, and low impact on other elements. It is enough to manage these elements independently. The fourth quadrant is the affected factor area, with high centrality and low cause degree, which is easily affected by other factors. If the factors in the first, second and third quadrants are well managed, they can be linked to improve the factors in this quadrant.

The elements of the first quadrant are: network coverage level, advanced level of information system, information integration and sharing ability, and enterprise control cost capability. The elements of the second quadrant are: the quality of employees, information security, strategic decision-making ability of enterprises, the level of green process operation, the greenness of facilities and equipment, the greenness of item processing, and the greenness of recycling process. The elements of the third quadrant are: circulation processing level, warehouse level, solving ability of emergency, logistics tracking ability, corporate popularity, corporate reputation, and corporate culture. The elements of the fourth quadrant are: transportation capacity, response timeliness, service price, after-sales service, ability to provide personalized value-added needs, and development potential.
5. Conclusions
This paper makes some conclusions on the selection factors of green city reverse logistics service providers based on the current severe environmental and resource problems. By referring to the literature review of scholars and the questionnaire survey of experts and scholars, the influencing factors are summarized as five aspects and twenty-four criteria, the results are analyzed by DEMATEL, and conclusions are as follows:

1. With the rapid development of logistics enterprises and big data, the key elements considered when choosing enterprises have changed from the basic logistics characteristics such as the original transportation capacity, warehouse level and so on to pay more attention to overall information level of the enterprise, whether it is traditional enterprise cooperation or strategic cooperation that can create more benefits, and now, the role that information level plays in the logistics stage is receiving more and more attention.

2. The fifth major aspects can be clearly found in the causality diagram, that is, all the criteria contained in the green activity are in the second quadrant: the green process operation level, the greenness of the facility and equipment, the greenness of the item processing, and the greenness of recycling process. Combined with the characteristics of the second quadrant, the enterprise can independently develop this feature, which will not greatly affect the remaining existing characteristics of the enterprise, but will increase the business scope of the enterprise. Green logistics not only helps enterprises to expand economic benefits, but also responds to the circular economy, which is a win-win situation.

3. The three elements of corporate popularity, corporate reputation, and corporate culture in the cooperative attribute aspect are distributed in the independent aspect area, and the interaction with other elements is low, and the enterprise can manage them separately.

4. The elements of the affected factor area are: transportation capacity, response timeliness, service price, after-sales service, ability to provide personalized value-added needs, and development potential. It can be clearly found that these factors are not independent, for example, after-sales service requires enterprises with certain information level, high-quality staff, certain circulation processing level, more perfect feedback system, etc. Therefore, these factors cannot be "self-improved", but can be improved jointly when the enterprise improves the other three factors.

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