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Research on Evaluation of Green Supply Chain Management System Based on Grey System Theory

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Abstract: The green supply chain management system established is a system that integrates environmental protection and resource conservation concepts throughout the entire process of product design, raw material procurement, production, logistics, sales, and recycling. Establishing a green supply chain management system can play a leading role for core enterprises, reduce environmental pollution, drive upstream and downstream enterprises such as suppliers and distributors to improve resource and energy utilization efficiency, and improve the environmental performance of the entire supply chain. This article studies the six dimensions of the enterprise's green supply chain management system and evaluates the enterprise's green supply chain management system using grey system theory. This article has good reference value for enterprises to establish and improve green supply chain management systems, and also has certain reference significance for certification agencies to better implement green supply chain certification.

1. Introduction

With the rapid development of economy, enterprises are facing resource constraints, environmental pollution, and other challenges in their development[1][2].With the gradual improvement of relevant environmental laws in China, traditional environmental cost management methods are no longer meet the growing demand of enterprises for environmental protection today. Using traditional management methods that ignore environmental costs can lead to uncontrolled environmental costs for enterprises, which is not conducive to their green development[3][4].In recent years, green supply chain has provided a new environmental cost management model for enterprises. The green supply chain system established is a system that integrates environmental protection and resource conservation concepts throughout the entire process of product design, raw material procurement, production, logistics, sales, and recycling[5][6]. Establishing a green supply chain management system can play a leading role for core enterprises, reduce environmental pollution, drive upstream and downstream enterprises such as suppliers and distributors to improve resource and energy utilization efficiency, and improve the environmental performance of the entire supply chain[7][8]. In addition, establishing a green supply chain system is also an important sub item recognized by the government, such as applying for green factories, green parks, and specialized, refined, special, and new products. It is recognized by the government and receives special green funding subsidies, while improving the influence and reputation of enterprises[9][10].

2. Materials and Methods

2.1 Selection and determination of risk factors of green supply chain management system in enterprises

2.1.1 Green design

Green design focuses on environmental attributes such as product disassembly, recyclability, maintainability, and reusability throughout the entire product lifecycle, and takes them as design goals. While meeting environmental requirements, it ensures that the product meets its functional, lifespan, quality, and other requirements. In the research and development design phase, based on a series of standards such as ISO14025, ISO14040, ISO14044, ISO14067, and the concept of full lifecycle assessment, basic processes and product databases can be integrated and established. A full lifecycle assessment (LCA) model can be constructed, and design can be carried out based on the evaluation model.

2.1.2 Implement green procurement

Green procurement means the behavior of enterprises in their procurement activities, promoting the concept of green and low-carbon, fully considering environmental protection, resource conservation, safety and health, circular low-carbon, and recycling promotion, prioritizing the procurement and use of energy-saving, water-saving, and material saving raw materials, products, and services that are conducive to environmental protection. Enterprises should establish rules and regulations for implementing green procurement, and pay attention to environmental protection factors during the procurement process, such as selecting environmentally friendly materials and reducing packaging waste. At the same time, enterprises should also establish an evaluation and selection system for green suppliers, scoring their green performance as a reference for further selection. In addition, suppliers should actively participate in the design and development work related to energy conservation and emission reduction, guide them to use more environmentally friendly materials to replace existing materials, and reduce the use of packaging materials and raw materials. Enterprises should also regularly provide technical guidance and training to suppliers, convey the environmental requirements of the enterprise and other stakeholders, and assist suppliers in incorporating these requirements into their own business.

2.1.3 Implement green production

Green production means a comprehensive measure aimed at energy conservation, consumption reduction, and pollution reduction, using management and technology as means to implement pollution control throughout the entire industrial production process and minimize the generation of pollutants. Enterprises need to comply with environmental laws and regulations during the production process, not use prohibited equipment, and take a series of environmental protection measures such as reducing energy consumption and pollutant emissions. Enterprises should continuously enhance their green technology innovation capabilities, pay attention to and timely sample new technologies, models, and methods for environmental protection, such as high-temperature raw gas purification and resource utilization technologies based on special metal film dry smelting furnaces, purification and resource utilization technologies for ammonia liquid nitrogen washing tail gas, and so on; Reduce or avoid the generation and discharge of pollutants such as wastewater, exhaust gas, and dust during the production process, promote the improvement of green production level, and improve environmental performance level. In the production process, a sound energy consumption measurement system should be established, environmental indicators should be monitored and inspected, and statistical analysis should be done well. In addition, for green products produced, green labels can be affixed according to relevant requirements to enhance the brand value of the enterprise.

2.1.4 Implement green logistics

Green logistics refers to the series of environmental protection measures that enterprises should take in transportation, storage, packaging, and other logistics processes. For example, for transportation, priority should be given to using new energy transportation vehicles, and transportation routes should be reasonably planned to avoid empty vehicles or ships returning as much as possible, improve the loading rate of transportation vehicles, and consider joint distribution and review of consistent transportation methods for transportation. For the storage process, various factors should be comprehensively considered to choose the warehouse location and supporting facilities, especially the impact on the environment. For example, the storage of flammable and explosive materials should be kept away from residential areas, and the storage of harmful substances should be kept away from important water sources. Choose storage technologies such as plastic film sealing, controlled atmosphere storage, and air curtain moisture isolation according to actual needs, while minimizing storage costs and even achieving zero inventory. Avoid rough handling during the loading and unloading process, and ensure that special equipment and operators have complete certificates and licenses. Implementing packaging reduction, packaging should be easy to recycle and reuse. For example, enterprises should try to use paper bag packaging instead of plastic packaging in food production packaging to reduce the difficulty of degrading and decomposing plastic packaging after recycling. Huang Chenghan, Hu Shuya, Li Hexi. Strategies for the development of China's home appliance industry under green trade barriers. Northern Economic and Trade Journal, 2023 (11): 136-139.

2.1.5 Green Marketing

Enterprises should establish and implement green sales, and take a series of environmental protection measures such as using environmentally friendly packaging materials and providing recycling services when selling products. In the marketing process, enterprises should shape a green image, design authentic, scientific, and cultural green advertisements, and stimulate customer purchasing desire through green advertisements. At the same time, a series of green marketing public welfare activities can be carried out to cultivate the green awareness of consumers and pay attention to the green products of the enterprise.

2.1.6 Implement green recycling

Green recycling refers to the treatment and recycling of products after they are scrapped. They can be reused or recycled to improve resource utilization and reduce environmental pollution. If its waste is not recycled and treated after the end of the product lifecycle, it will result in environmental pollution and resource waste. Green product recycling is the process of considering that the cost of product recycling is lower than the recycling price. Various solutions are analyzed and evaluated to determine the best recycling solution. Enterprises should establish a green recycling system through information technologies such as the Internet of Things, electronic tags and cloud computing to achieve traceability throughout the entire process in order to get the highest recycling value at the lowest cost,

2.2 Method

The grey system theory was proposed by Deng Julong in 1982. After more than 40 years of development, this theory has been widely applied in various areas of sciences. This theory uses "black" and "white" to represent information unknown and known, respectively, and "gray" to represent partial information known and partial information unknown. The indicators for the comprehensive evaluation of enterprise green supply chain management system in this article are known, and the evaluation scores of each enterprise's green supply chain management system indicator are known. However, the quality of the comprehensive evaluation of each enterprise's green supply chain management system is unknown, which meets the definition and scope of application of "gray". The application of grey system theory includes modules such as grey correlation, grey prediction, grey decision-making, and grey control, as well as methods and tools such as grey correlation analysis, grey clustering evaluation, grey decision-making, and grey combination.

Selecting appropriate comprehensive evaluation methods based on indicators is of great significance for multi-dimensional objective evaluation of research objects. Common evaluation methods include Analytic Hierarchy Process, Fuzzy Comprehensive Evaluation, Entropy Weight Method, TOPSIS Method, Grey Relational Analysis, etc. Analytic Hierarchy Process (AHP) has many legal components, and the fuzzy comprehensive evaluation method is difficult to directly give the weights of each evaluation indicator when there are many evaluation indicators that affect each other. The shortcomings of the entropy weight method and TOPSIS method are that it is difficult to make judgments when the sample dependency is large and the distance from different evaluation objects to the ideal point is equal. Relevance refers to a measure of the degree of correlation between factors in two systems over time or different objects. If the trends of the changes in two factors are consistent, it indicates a high degree of correlation between the two factors; On the contrary, it is lower. The grey correlation method is a method of measuring the degree of correlation between factors based on the degree of similarity or dissimilarity in their development trends (also known as "grey correlation degree"). The core idea of grey correlation method is to express the degree of influence of factors on behavior through correlation coefficients and correlation degree values, and to rank the correlation degree. The main steps include establishing a systematic and scientific indicator system, data preprocessing, calculating absolute value sequences, calculating correlation coefficients, calculating correlation degrees, and ranking correlation degrees. The grey correlation method does not require high sample size or typical distribution patterns, is simple to calculate, easy to understand, and the results can strongly reflect the objective relationship between samples, which can to some extent overcome the limitations of other methods.

3. Comprehensive evaluation of enterprise green supply chain management system based on grey correlation method

3.1 Establish a systematic and scientific indicator system

When selecting evaluation indicators, they should be as independent as possible to avoid information duplication, and should also follow principles such as comprehensiveness, operability, development, and a combination of quantitative and qualitative methods. After designing using the Delphi method, a green supply chain management system is a set of interrelated or interacting elements necessary for completing measurement confirmation and continuously controlling the measurement process. This study used the Delphi method and expert input evaluation to establish an evaluation system based on 7 relatively representative primary indicators. There are six indicators: green design, green procurement, green production, green logistics, green sales, and green recycling. In the design process of indicators, both comprehensiveness and practicality are considered to avoid resource waste caused by excessive and redundant indicators, as well as to avoid insufficient quantity and dimensions of indicators that cannot objectively and comprehensively achieve evaluation results.

This article uses the grey correlation method to analyze the green supply chain management systems of 10 enterprises in Shandong Province, starting from 7 secondary indicators. A-G represents the evaluation indicators, and the last column H represents the sum of scores for each row. 1-10 respectively represent enterprises 1-10, and the evaluation scores of the enterprise's green supply chain management system are as follows.

$$\left(X_A^{'}, X_B^{'}\cdots, X_F^{'}\right) = \begin{pmatrix} x_A^{'}(1) & \cdots & x_F^{'}(1) \\ \vdots & \ddots & \vdots \\ x_A^{'}(10) & \cdots & x_F^{'}(10) \end{pmatrix} = \begin{pmatrix} 5 & 6 & 7 & 7 & 5 & 7 \\ 6 & 4 & 5 & 7 & 6 & 6 \\ 5 & 6 & 7 & 5 & 6 & 6 \\ 6 & 5 & 6 & 4 & 4 & 5 \\ 5 & 5 & 4 & 6 & 6 & 7 \\ 6 & 5 & 7 & 6 & 5 & 6 \\ 6 & 5 & 7 & 6 & 7 & 7 \\ 5 & 6 & 5 & 6 & 5 & 5 \\ 5 & 4 & 6 & 5 & 6 & 5 \\ 6 & 5 & 6 & 5 & 6 & 5 \end{pmatrix}$$

$$X_i^{'} = \left(x_i^{'}(1), x_i^{'}(2), \cdots, x_i^{'}(10)\right)^T$$

3.2 Data preprocessing

Through data preprocessing, the dimensionalization of indicators can be removed, making the data more objective and effective. Before dimensionality reduction, calculate the average value of each column of data. Divide each data by the average value of that column to obtain a relative value.

$$x_i(k) = \frac{x_i^{'}(k)}{\frac{1}{m}\sum_{k=1}^{m} x_i^{'}(k)}$$

$$x_A(1) = \frac{x_i^{'}(k)}{\frac{1}{m}\sum_{k=1}^{m} x_i^{'}(k)} = \frac{x_A^{'}(1)}{\frac{1}{10}\sum_{k=1}^{10} x_A^{'}(k)} = 0.91$$

$$x_A(2) = \frac{x_i^{'}(k)}{\frac{1}{m}\sum_{k=1}^{m} x_i^{'}(k)} = \frac{x_A^{'}(2)}{\frac{1}{10}\sum_{k=1}^{10} x_A^{'}(k)} = 1.09$$

$$x_A(3)=\frac{x_i^{'}(k)}{\frac{1}{m}\sum_{k=1}^{m}x_i^{'}(k)}=\frac{x_A^{'}(3)}{\frac{1}{10}\sum_{k=1}^{10}x_A^{'}(k)}=0.91$$

Similarly, after dimensionless transformation, the following matrix is formed, where the first row represents the dimensionless reference value:

$$(X_A,X_B,\cdots,X_G)=\begin{pmatrix} x_A(0) & \dots & x_F(0) \\ x_A(1) & \dots & x_F(1) \\ \vdots & \ddots & \vdots \\ x_A(10) & \cdots & x_F(10) \end{pmatrix}=\begin{pmatrix} 0.91 & 1.18 & 1.17 & 1.23 & 0.89 & 1.19 \\ 1.09 & 0.78 & 0.83 & 1.23 & 1.07 & 1.02 \\ 0.91 & 1.18 & 1.17 & 0.88 & 1.07 & 1.02 \\ 1.09 & 0.98 & 1.00 & 0.70 & 0.71 & 0.85 \\ 0.91 & 0.98 & 0.67 & 1.05 & 1.07 & 1.19 \\ 1.09 & 0.98 & 1.17 & 1.05 & 0.89 & 1.02 \\ 1.09 & 0.98 & 1.17 & 1.05 & 1.25 & 1.19 \\ 0.91 & 1.18 & 0.83 & 1.05 & 0.89 & 0.85 \\ 0.91 & 0.78 & 1.00 & 0.88 & 1.07 & 0.85 \\ 1.09 & 0.98 & 1.00 & 0.88 & 1.07 & 0.85 \end{pmatrix}$$

3.3 The way to calculate the absolute value sequence

Determine the maximum value of each column as the reference data column

$$X_i^{'}=\left(x_A^{'}(0),x_B^{'}(0),\cdots,x_F^{'}(0)\right)=(1.09,1.18,1.17,1.23,1.25,1.19)$$

We create a relationship between the subsequence and the parent sequence by taking absolute values for comparison.

$$Y_i(k)=\left|x_i(0)-x_i(k)\right|\ (k=1,\cdots,m,\ \ i=1,\cdots,n)$$

$$Y_B(1)=\left|x_B(0)-x_B(1)\right|=\left|1.18-1.18\right|=0$$

$$Y_B(2)=\left|x_B(0)-x_B(2)\right|=\left|1.18-0.78\right|=0.40$$

$$Y_B(3)=\left|x_B(0)-x_B(3)\right|=\left|1.18-1.18\right|=0$$

And so on, we get

$$\left(Y_A^{'},Y_B^{'}\cdots,Y_G^{'}\right)=\begin{pmatrix} y_A^{'}(1) & \dots & y_G^{'}(1) \\ \vdots & \ddots & \vdots \\ y_A^{'}(10) & \cdots & y_G^{'}(10) \end{pmatrix}=\begin{pmatrix} 0.18 & 0 & 0 & 0 & 0.01 & 0.04 \\ 0 & 0.40 & 0.34 & 0 & 0.11 & 0.16 \\ 0.18 & 0 & 0 & 0.35 & 0.01 & 0.08 \\ 0 & 0.20 & 0.17 & 0.53 & 0.14 & 0.04 \\ 0.18 & 0.20 & 0.50 & 0.18 & 0.11 & 0.08 \\ 0 & 0.20 & 0 & 0.18 & 0.01 & 0.08 \\ 0 & 0.20 & 0 & 0.18 & 0.14 & 0.08 \\ 0.18 & 0 & 0.34 & 0.18 & 0.01 & 0.04 \\ 0.18 & 0.40 & 0.17 & 0.35 & 0.11 & 0.16 \\ 0 & 0.20 & 0.17 & 0.35 & 0.01 & 0.08 \end{pmatrix}$$

The maximum and minimum values from the matrices obtained after taking absolute values:

$$\min_{i=1}^{n}\min_{k=1}^{m}\left|x_i(0)-x_i(k)\right|=0$$

$$\max_{i=1}^{n}\max_{k=1}^{m}\left|x_i(0)-x_i(k)\right|=0.54$$

3.4 The way to calculate correlation coefficient

$$\zeta_i(k)=\frac{\min_i\min_k\left|x_i(0)-x_i(k)\right|+\rho*\max_i\max_k\left|x_i(0)-x_i(k)\right|}{\left|x_i(0)-x_i(k)\right|+\rho*\max_i\max_k\left|x_i(0)-x_i(k)\right|}$$

ρ is the resolution coefficient, with a value between 0 and 1. The smaller the indicator, the greater the difference between the correlation coefficients and the stronger the discrimination ability. Generally, it is taken 0.5.

$$\zeta_C(1)=\frac{\min_i\min_k\left|x_i(0)-x_i(k)\right|+\rho*\max_i\max_k\left|x_i(0)-x_i(k)\right|}{\left|x_i(0)-x_C(1)\right|+\rho*\max_i\max_k\left|x_i(0)-x_i(k)\right|}=\frac{0+0.5*0.54}{0+0.5*0.54}=1.00$$

$$\zeta_C(2)=\frac{\min_i\min_k\left|x_i(0)-x_i(k)\right|+\rho*\max_i\max_k\left|x_i(0)-x_i(k)\right|}{\left|x_i(0)-x_C(2)\right|+\rho*\max_i\max_k\left|x_i(0)-x_i(k)\right|}=\frac{0+0.5*0.54}{0.34+0.5*0.54}=0.44$$

$$\zeta_C(3)=\frac{\min_i\min_k\left|x_i(0)-x_i(k)\right|+\rho*\max_i\max_k\left|x_i(0)-x_i(k)\right|}{\left|x_i(0)-x_C(3)\right|+\rho*\max_i\max_k\left|x_i(0)-x_i(k)\right|}=\frac{0+0.5*0.54}{0+0.5*0.54}=1.00$$

By analogy, the matrix obtained is as follows

$$(\zeta_A,\zeta_B,\cdots,\zeta_G)=\begin{pmatrix}\zeta_A(1) & \cdots & \zeta_G(1)\\ \vdots & \ddots & \vdots\\ \zeta_A(10) & \cdots & \zeta_G(10)\end{pmatrix}=\begin{pmatrix}0.60 & 1.00 & 1.00 & 1.00 & 0.43 & 1.00\\ 1.00 & 0.40 & 0.44 & 1.00 & 0.60 & 0.61\\ 0.60 & 1.00 & 1.00 & 0.43 & 0.60 & 0.61\\ 1.00 & 0.57 & 0.61 & 0.34 & 0.33 & 0.44\\ 0.60 & 0.57 & 0.35 & 0.60 & 0.60 & 1.00\\ 1.00 & 0.57 & 1.00 & 0.60 & 0.43 & 0.61\\ 1.00 & 0.57 & 1.00 & 0.60 & 1.00 & 1.00\\ 0.60 & 1.00 & 0.44 & 0.60 & 0.43 & 0.44\\ 0.60 & 0.40 & 0.61 & 0.43 & 0.60 & 0.44\\ 1.00 & 0.57 & 0.61 & 0.43 & 0.60 & 0.44\end{pmatrix}$$

3.5 Calculate correlation degree

Calculate the average correlation coefficient between the various indicators of each evaluation object and the corresponding elements of the reference sequence, and call it the correlation order, denoted as: $r_k=\frac{1}{m}\sum_{i=1}^{m}\zeta_i(k)$

Taking the green supply chain management system of the fourth fifth and sixth Enterprise as an example:

$$r_4 = \frac{1}{m}\sum_{i=1}^{m}\zeta_i(k) = \frac{1}{6}\sum_{i=1}^{6}\zeta_i(4) = \frac{1.00+0.57+0.61+0.34+0.33+0.44}{6} = 0.54$$

$$r_5 = \frac{1}{m}\sum_{i=1}^{m}\zeta_i(k) = \frac{1}{6}\sum_{i=1}^{6}\zeta_i(5) = \frac{0.60+0.57+0.35+0.60+0.60+0.99}{6} = 0.62$$

$$r_5 = \frac{1}{m}\sum_{i=1}^{m}\zeta_i(k) = \frac{1}{6}\sum_{i=1}^{6}\zeta_i(6) = \frac{1.00+0.57+1.00+0.60+0.43+0.70}{6} = 0.70$$

By analogy, the results are as follows:

$$R_i = \left(r(1) \quad \ldots \quad r(10)\right)^T = \left(0.83 \quad 0.67 \quad 0.70 \quad 0.55 \quad 0.62 \quad 0.70 \quad 0.86 \quad 0.58 \quad 0.51 \quad 0.61\right)^T$$

3.6 Correlation ranking

If the weights of each indicator are not considered, the higher the correlation value, the higher the correlation. From the above, it can be seen that Enterprise 7 has the best green supply chain management system, followed by Enterprise 1, and then followed by Enterprises 3, 6, 2, 5, 10, 8, 4, and 9.

4. Conclusions

4.1 Conclusions

Firstly, enterprises have insufficient understanding of green supply chain management systems. Many enterprises lack a deep and thorough understanding of the concept, practical methods, and importance of green supply chain management for sustainable development, which makes it difficult to effectively implement green supply chain management in practice. Therefore, certification bodies should strengthen the promotion of green supply chain management systems, so that enterprises can have a deeper and more comprehensive understanding of green supply chain management systems.

Secondly, the cost of implementing green supply chain management system is relatively high. The implementation of green supply chain management system requires enterprises to improve and optimize their material procurement, product production, and commodity circulation, which requires a significant investment of funds and labor costs. At the same time, green supply chain management also requires enterprises to have corresponding professional technology and management capabilities, and the acquisition of these capabilities also requires a significant investment of material and human resources. If these high cost and high investment do not achieve corresponding economic and social benefits, it is difficult for enterprises to voluntarily persist for a long time. Therefore, it is necessary for relevant government departments to provide preferential treatment and assistance to enterprises that adhere to the implementation of green supply chain system management in areas such as taxation, financing, corporate social status, and social honor. As a result, enterprises will actively explore and practice, innovate in technology, management, and other aspects, reduce implementation costs, and form a virtuous cycle.

Once again, the standards and systems for green supply chain management are not yet perfect. Although a series of green supply chain management standards and systems have been introduced both domestically and internationally, there are still some problems in their implementation, such as inconsistent standards, incomplete understanding of standards, and lax implementation. Therefore, it is necessary to further improve the relevant standards and systems for the management of green supply chain systems, and enhance their operability and enforceability. In addition, it is necessary to strengthen the improvement of regulatory and incentive mechanisms. The government needs to strengthen supervision and incentives for enterprises to implement green supply chain management systems, and incentivize enterprises to implement green supply chain management system certification through tax incentives, financial subsidies, social honors, and other means. At the same time, it is also necessary to strengthen the improvement of relevant laws and regulations, strengthen the implementation of relevant laws and regulations, and encourage enterprises to have sufficient motivation and pressure to actively implement green supply chain management system certification.

In addition to the above issues, green supply chain system management also faces the following challenges. The implementation of green supply chain management system requires advanced technical support, such as green procurement, green production, green logistics, and other technologies. However, currently many enterprises lack such technology or their technical level is not high enough, which has become one of the difficulties in implementing green supply chain management. The implementation of green supply chain management requires close cooperation between upstream and downstream enterprises, including suppliers, producers, sellers, etc. However, due to differences and conflicts in business philosophy, corporate culture, and interest distribution among different enterprises, cooperation between upstream and downstream enterprises often becomes more difficult. Then, although consumers are increasingly concerned about environmental and health issues, there is still a portion of consumers who lack awareness of green products and do not understand their advantages and value. This makes the market competitiveness of green products relatively weak.

4.2 limitations

There are also disadvantages of grey relational analysis method. When determining the optimal value, individuals have strong subjectivity and lack a certain foundation of objectivity, which is not suitable for widespread application and has certain limitations. It mainly analyzes whether the changing trends of two factors are consistent. Its data is usually taken as the average in order to find the optimal value, and some of its properties are biased and not suitable for general applications.

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References

[1] Albrecht W, Albrecht W. Continuous-Time Scheduling in Green Supply Chain Management[J]. Scheduling in Green Supply Chain Management: A Mixed-Integer Approach, 2021: 93-161.

[2] Le T T, Vo X V, Venkatesh V G. Role of green innovation and supply chain management in driving sustainable corporate performance[J]. Journal of Cleaner Production, 2022, 374: 133875.

[3] Wang L, Zeng T, Li C. Behavior decision of top management team and enterprise green technology innovation[J]. Journal of Cleaner Production, 2022, 367: 133120.

[4] Qu K, Liu Z. Green innovations, supply chain integration and green information system: A model of moderation[J]. Journal of Cleaner Production, 2022, 339:130557

[5] Searcy P., Searcy, C. A comparative literature analysis of definitions for green and sustainable supply chain managemen, Journal of Cleaner Production 2013, 52, 329-341.

[6] Golicic, S.L. & Smith, C.D., A meta-analysis of environmentally sustainable supply chain management practices

and firm performance, Journal of Supply Chain Management. 2013, 49, 78-95.
[7] He J , Lei Y , Fu X .Do Consumer's Green Preference and the Reference Price Effect Improve Green Innovation? A Theoretical Model Using the Food Supply Chain as a Case[J].International Journal of Environmental Research and Public Health, 2019, 16(24):1-15
[8] Ziari M, Sajadieh M S. A Behavior-based Pricing Model in Retail Systems Considering Vertical and Horizontal Competition[J].Computers & Industrial Engineering, 2020, 152(3):107054
[9] Schiederig T, Tietze F, Herstatt C .Green innovation in technology and innovation management –an exploratory literature review [J].R & D Management, 2012, 42(2):180-192.
[10] Madani S R, Rasti-Barzoki M. Sustainable supply chain management with pricing, greening and governmental tariffs determining strategies: A game-theoretic approach[J].Computers & Industrial Engineering, 2017, 105 (Complete): 287-298.