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Review on Performance Evaluation of Green Innovation in Enterprise Logistics

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Abstract

Facing the pressure of energy conservation and emission reduction under the global climate change and the environmental pollution and energy constraints under the rapid development of domestic economy, the road of low-carbon, green and ecological development and the realization of sustainable development have become the strategic guidance of China's economic transformation and development reform. As the "13th Five -Year" economic development mode transformation battle is about to start, enterprises have to integrate "green" elements in the process of formulating strategies to meet the increasingly fierce competition in the global market. As an important means of enterprise logistics performance management, the construction of logistics performance evaluation index system adapted to the new requirements of green development has become an urgent issue. Green innovation in logistics reflects the integration of green development and innovation-driven development, and plays an important role in economic development and environmental protection. Green development is an inevitable choice for transformation and upgrading in the new situation and enhancing international competitiveness. Establishing a correct and feasible evaluation index system of logistics green innovation plays an important role in assessing and mastering the development of enterprises, industries and regions. On the basis of sorting out the relevant concepts of green innovation, this paper reviews the research status of green innovation performance from the aspects of index system, research methods and influencing factors. Literature review found that: (1) The green innovation performance of existing literature is mostly concentrated in China's industry, manufacturing industry or enterprises whose energy consumption has a large impact on the environment, and there are few studies on logistics, service industry, emerging industries and modern agriculture. (2) There is no targeted evaluation index system in each specific industry. (3) There are more external factors influencing the development of green innovation in logistics than internal factors, and the interaction between each factor is not specified.

Keywords

Green Innovation Performance; Influencing Factors; Index System.

1. Introduction

Our country is in a critical period of climbing camp, crucial transformation, development of unbalanced, uncoordinated and unsustainable problem still prominent, the traditional extensive development is unsustainable, "innovation, coordination, green, open, sharing" is the fifth plenary session of the party 18 puts forward five development concept, explained the construction of "ecological civilization" development goals. Under this background, logistics links caused by environmental pollution has become the common challenge faced by many countries, but in today's low carbon, green theme and trend of world economic development, the enterprise logistics green innovation has become a response to an effective way to the problem of environmental pollution, green innovation research by the attention of the academia. Green innovation is the primary choice for the logistics industry to win market

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competitiveness under the operating conditions of limited resources and strict environmental regulations. It has functions such as product provision, process protection and technology promotion [1,2], and each function has distinct antagonistic dual attributes. In the current main four "green innovation" in the definition of integration of green innovation quality of duality is sustainable and ecological points of the concept of innovation, coordination "protection - pollution" positive and negative external duality is the essence of the concept of environmental innovation, specific concept of green innovation is focused on green technology in the balance between the common and private. Its effective development depends on the investment of RESEARCH and development funds and the strengthening of green management. The obvious duality of positive and negative external causes the phenomenon of "high investment, high consumption and low output". Under this premise, regions of our country enterprise green innovation performance evaluation and comparative analysis, looking for low performance of the specific link, to change the traditional energy-intensive, highly polluting mode of economic growth and development of clean, energy-saving, environmental protection of green economy, develop green industry, speed up the adjustment of industrial structure has an important significance. According to the existing literature, the research on green innovation and its performance in China is still in the exploratory stage, and there are still some limitations. The concept of green innovation has not been clearly defined, and the research perspective, evaluation index, method and research results of green innovation performance are diverse. Therefore, this paper will sort out and evaluate the current research status of green innovation performance from the aspects of evaluation indicators, research methods and influencing factors, so as to provide theoretical reference for the country and enterprises to formulate reasonable green innovation strategies and optimize the allocation of innovation resources.

2. Related concepts of green innovation

"Green" is the catalyst for enterprises to carry out continuous innovation [3]. The rapidly changing social environment and consumer demand have brought about rapid technological innovation. Innovation is essentially the identification and use of opportunities to create new products, services and working methods [4]. Knowledge accumulation and application help organizations seize opportunities to achieve innovation goals. The process of innovation is equivalent to the continuous pursuit and application of new and unique knowledge. Green innovation refers to the improvement and improvement of enterprises' products and production processes in terms of environmental management. Compared with traditional innovation, green innovation puts more emphasis on ecology and puts forward new requirements for environmental management in the production process [5]. Porter [6] believes that pollution is a manifestation of inefficient use of resources. Enterprise logistics can innovatively reduce or eliminate pollution emissions in the production process through green design of products and production process, and improve the production resource rate. According to the innovation compensation theory, compared with the enterprises using traditional production methods and technologies, the first to use innovative environmental technology has a mover advantage. The concept of green is not only reflected in the attention to environmental protection, but also in the saving of technological innovation talents and equipment [7]. With the continuous advancement of product innovation, environmental principles are integrated into every stage of the product innovation process cognition, analysis, definition, development, selection, refinement, formulation of detailed specifications, development and implementation, production, diffusion, and marketization. The marketization of products is the goal of the whole production system activities. In order to realize the marketization of products and gain more market shares, enterprises need to achieve non-technical innovation in organizational structure, management mode, business model and marketing means. Therefore, according to the existing literature, green innovation reduces the

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impact of enterprises on the environment by carrying out activities that consume fewer resources, produce less waste and produce less environmental damage.

From the perspective of impact effect, zeng Jianghong [8] analyzed the concept and expression form of green innovation performance. Using the panel data of 712 a-share companies in Shanghai and Shenzhen stock markets from 2008 to 2017, he divided green innovation into two dimensions: green product innovation and green process innovation. The driving factors of green innovation are analyzed from three aspects: environmental regulation factor, demand-pull factor and supply-push factor. The results show that green product innovation can significantly improve enterprise economic performance, but green process innovation does not. In pursuit of profit maximization as the core target of enterprise, the reason of its green technology innovation behavior and performance, and elegant refined et al. [9] green technology innovation enterprise environmental behavior as the research object, under the perspective of resource-based view, attention to reflect the critical elements of their own resources and capabilities - internal r&d spending on its innovation performance. Chen Jin et al. [10] also emphasized the impact of innovation performance on enterprises, such as the reduction of resource search cost, rational utilization of labor force, accumulation of innovative knowledge, and improvement of differentiation and heterogeneous competitiveness of innovative products. Li Tao [11] proposed corresponding research hypotheses and empirically tested the relationship between enterprise innovation and environmental performance by constructing a fixed effect model of the relationship among enterprise innovation, environmental performance and external governance environmental factors. Anthoy et al. divided environmental innovation performance into indirect performance, direct performance and knowledge output level [12]. Indirect performance refers to the improvement of resource utilization rate and productivity. Direct performance is mainly reflected by the sales revenue of green innovative products and the number of innovative projects, while knowledge output includes the number of green patents and monographs. Xu Yuanzhao [13] constructed an evaluation index system based on the life cycle theory of green products based on the evaluation characteristics of the whole process innovation of green products. The whole process innovation performance of green products was constructed from four index systems of design and development process innovation, manufacturing process innovation, use process innovation and recycling process innovation. Cheng et al. [14] constructed an index system from the three dimensions of ecological organization, ecological process innovation and ecological product innovation. Hua Zhen and Bi Kexin believe that economic performance reflects the economic profit created by innovative activities, which can be reflected from the output value of green new products and pollution control costs [15]. Social performance and environmental performance reflect the beneficial impact of green innovation activities on social culture and ecological environment respectively, and the improvement of these two performance can promote the accumulation of green innovation knowledge, the increase of employment, and the reduction of pollution and energy consumption. In addition, Zhu Jianfeng and Yu Huimin also described economic performance and environmental performance, which is basically consistent with the introduction of Hua Zhen and Bi Kexin. From the perspective of performance decomposition, the above scholars elaborated the connotation and expression form of economic, environmental and social performance respectively, providing a feasible theoretical framework for the construction of innovation indicator system in the follow-up research.

3. Comprehensive evaluation of green innovation performance

3.1. Evaluation index system

Green innovation performance comprehensive evaluation of enterprise logistics mainly embarks from the multi-level and comprehensive constructing evaluation index system, so as

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to reveal the organization's technology innovation ability and greening level, is advantageous to the organization to find out the problems existing in the innovation process, and timely innovation management policy from the macro, so as to optimize the allocation of resources, improve competitiveness.

From the existing literature, input-output, innovation process and EES (i.e. economic, environment and society) all-round development are the three perspectives for constructing the indicator system in the field of comprehensive evaluation of green innovation performance, as shown in Table 1.

Table 1. Index construction perspective and evaluation index of comprehensive evaluation

Perspective	characteristics	representative literature	evaluation index
Input and output	Reflect whether the proportion of green innovation input and output is reasonable	Wang (2019)	R&D personnel, R&D funds, new product development funds, technology introduction and transformation funds, environmental pollution control funds, energy consumption as input in green innovation; Patent, new product output and economic added value are taken as green innovation output
Innovation process	Ability to measure performance level from r&d to product marketization	Yu (2012)	Green research and development, green production, product sales, product services, waste recycling and other stages
EES comprehensive development	Values that place equal emphasis on economic, environmental and social performance	BiKesin (2013)	8 indicators, such as the rate of production equipment renovation, to measure economic performance; Comprehensive utilization rate of three wastes to measure environmental performance; Total labor productivity and other measures of social performance

First, Wang Caiming constructed the green innovation performance evaluation of regional provincial industrial enterprises, based on which he proposed to improve the regional green innovation performance and promote the sustainable development of regional industry [16]. Green innovation investment capacity refers to the substantial resource investment capacity of enterprises in the process of green innovation activities, mainly including R&D personnel, R&D expenditure, new product development expenditure, technology introduction and transformation expenditure, environmental pollution control expenditure, energy consumption and so on. Green innovation output capacity refers to the economic and environmental benefits obtained by innovation activities. Economic benefits are reflected in patents, new product output, economic added value and other environmental benefits, which are mainly measured by the discharge of three wastes. Secondly, the life cycle idea is used to evaluate the performance process of green innovation [17], and the green innovation process is divided into several stages of green research and development, green production, product sales, product service, waste recycling, etc., and an analysis model of enterprise environmental innovation process is established. Based on the analysis of innovation process, environmental and economic indicators are selected to construct the evaluation index system of green innovation process. Thirdly, an evaluation index system should be established based on the concept of all-round development of economic, environmental and social performance. Different from traditional scientific and technological innovation, green innovation emphasizes that the organization should ensure the improvement of environmental performance and social performance while obtaining economic performance, and the research from the perspective of EES comprehensive development reflects the above three concepts of coordinated development of performance [18].

Based on these three viewpoints build index system from the different emphasis of the index system of input-output perspective focuses on the founding of enterprise innovation,

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intermediate inputs and the final output, the innovation process perspective on life cycle thought according to the principle of the value chain to evaluate innovative activities, is conducive to the thorough analysis of innovation stage of each child, EES comprehensive development perspective points out the economic, environmental and social benefits brought by green innovation from a macro perspective. Although these three research perspectives construct evaluation index systems from different theories, there are overlapping parts in index construction, which can be summarized as follows: innovation input index mainly includes R&D personnel, R&D expenditure, new product development expenditure, technology introduction and transformation expenditure, environmental pollution control expenditure, energy consumption, etc. The innovation output index includes the expected output including the growth rate of green patent authorization, green new products, etc., and the non-expected output such as the discharge of industrial waste, energy consumption per unit GDP, etc. Innovation environmental indicators, including the number of scientific research institutions, the number of personnel in scientific research institutions, the comprehensive utilization rate of three wastes, etc. Based on the existing studies, in the field of comprehensive evaluation of green innovation performance, scholars mostly adopt the principle of multiple indicators and comprehensive indicators to avoid the defect that single indicator analysis is not comprehensive enough. Also easily lead to the three kinds of adverse situation: one is to increase operation complexity and error probability, the second is too much index number in methods lead to the performance gap between decision making units, thus deviate from the actual situation, 3 it is easy to cause the core index number is too small, the external index number is too big, so that the evaluation results. It is a problem that needs to be solved in the research to establish feasible and representative indicators for all walks of life and construct a comprehensive indicator system.

3.2. Evaluation methods

In terms of the comprehensive evaluation methods of green innovation performance, the commonly used evaluation methods include fuzzy comprehensive evaluation method, factor analysis, principal component analysis, projection pursuit evaluation model and particle swarm optimization algorithm. Table 2 lists the parameters.

The comprehensive evaluation of green innovation performance involves many kinds of input-output indexes and fuzzy comprehensive evaluation method can solve the multi-level complex problems. Fuzzy comprehensive evaluation method is a kind of comprehensive evaluation method based on fuzzy mathematics. The comprehensive evaluation method transforms qualitative evaluation into quantitative evaluation according to the membership degree theory of fuzzy mathematics, that is, fuzzy mathematics makes an overall evaluation of things or objects restricted by many factors. It has the characteristics of clear results and strong systematicness, and can better solve fuzzy and difficult to quantify problems, and is suitable for solving various non-deterministic problems [19]. Fuzzy comprehensive evaluation index system is the basis of comprehensive evaluation. Whether the evaluation index is suitable will directly affect the accuracy of comprehensive evaluation. For the allocation of index weight subjectivity is stronger, easily affected by experts and other human factors, because of the performance evaluation of green innovation usually involves dozens of decision making units and the evaluation index and index set resolution will reduce the difference between the indexes, which can lead to weight distribution exist errors, so the fuzzy comprehensive evaluation is more applicable to distinguish the pros and cons of several plan or program.

In many cases, there is a certain correlation between variables, when there is a certain correlation between two variables, it can be interpreted as the two variables reflect the information of the subject has a certain overlap. Principal component analysis is to delete redundant duplicate variables (closely related variables) and establish as few new variables as

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possible for all the previously proposed variables, so that these new variables are unrelated in pairs and keep the original information as far as possible in reflecting the information of the subject [20]. It is a statistical method that tries to recombine the original variables into a group of new comprehensive variables unrelated to each other, and at the same time, according to actual needs, several less comprehensive variables can be taken out from them to reflect the information of the original variables as much as possible. The main purpose of factor analysis is to describe some more basic implicit variables hidden in a group of measured variables that cannot be directly measured [15]. These two methods can classify the information in the sample data and reduce the operation complexity to reduce the impact of information duplication. Green innovation performance can only be objectively measured, but the inefficiency of input or output cannot be accurately identified.

Table 2. Comparison of comprehensive evaluation methods of green innovation performance

Method	Advantages	Disadvantages
Fuzzy comprehensive evaluation	Able to solve multi-level complexity problems	Index weight is subjective
Principal component and factor analysis	The ability to extract common factors from information overlap and correlation variables has objectivity	The innovation process cannot be decomposed
Projection pursuit model /BP neural network/genetic algorithm	It can transform complex high-dimensional data into one-dimensional data with strong objectivity and operability	There is a defect in judging whether the optimized one-dimensional result can reflect the global optimal solution
Particle swarm optimization algorithm	It has global advantage to find the global optimal solution by following the current optimal value	The iterative process is complicated

The basic core of particle swarm optimization algorithm is to make use of the information sharing of individuals in the group so that the movement of the whole group can evolve from disorder to order in the problem solving space, so as to obtain the optimal solution of the problem. Su Yueliang et al. used this algorithm to optimize the BP neural network. The optimized model searched for the optimal solution in an iterative way, which had advantages of local search and global search, making the measurement results more accurate, but the iterative process was complicated [21].

4. Summarizes

Starting from the influencing factors and indexes in three aspects, the research method on the system of green innovation performance, through summarizing can be concluded that: (1) the green innovation performance of the existing literature is mostly focused on the industrial, manufacturing, or energy consumption of large enterprises, environmental impact, services for the logistics industry, emerging industries and modern agricultural research is less. (2) There is no targeted evaluation index system in each specific industry. (3) There are more external factors influencing the development of green innovation in enterprise logistics than internal factors, and the interaction between each factor is not specified.

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