

Original Research Article

Dilemma of green packaging promotion and collaborative governance strategies in E-commerce logistics under the dual-carbon target

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Abstract: With the explosive development of China's e-commerce industry, express logistics has become a key driver of national socio-economic growth, but also a major source of packaging waste and carbon emissions. Under the "dual-carbon" target of peaking carbon emissions before 2030 and achieving carbon neutrality before 2060, the promotion of green packaging in e-commerce logistics faces prominent dilemmas: high cost pressure on enterprises, insufficient recycling and reuse infrastructure, weak consumer participation and fragmented supervision. Taking e-commerce logistics packaging as the research object, this paper analyzes the main obstacles of green packaging promotion from the perspectives of cost structure, system design and stakeholder behavior, constructs a collaborative governance framework involving government, platforms, logistics enterprises and consumers, and puts forward targeted strategies such as standard system optimization, incentive mechanism design, digital supervision and reverse logistics system improvement, so as to provide reference for promoting the green and lowcarbon transformation of e-commerce logistics.

Keywords: dual-carbon target; e-commerce logistics; green packaging; promotion dilemma; collaborative governance; system design

1. Introduction

In recent years, China's e-commerce logistics industry has maintained rapid growth, and the express delivery volume has ranked first in the world for many consecutive years. A huge number of parcels means a huge amount of packaging consumption. Plastic bags, cartons, cushioning materials and tape have become an important source of urban solid waste. Packaging waste not only occupies a large amount of land and treatment capacity, but also increases energy consumption and carbon emissions in production, transportation and disposal, which is obviously inconsistent with the national dual-carbon strategic objectives^[1].

However, in practice, the penetration rate of green packaging in e-commerce logistics is still not high. Many small and medium-sized logistics enterprises and thirdparty sellers still prefer low-cost traditional packaging, and the recycling and reuse rate of cartons and plastic bags is far lower than policy expectations. There is a clear gap between policy objectives and actual implementation outcomes. Therefore, systematically identifying the dilemmas encountered in the promotion process and establishing a collaborative governance framework with the participation of multiple stakeholders have become urgent issues in the green development of e-commerce logistics.

Taking the dual-carbon target as the background and Chinese e-commerce logistics packaging as the application scenario, this paper analyzes the current situation and main problems of green packaging promotion, puts forward a system architecture and functional design of a green packaging collaborative governance system, and discusses the implementation steps and safeguard measures of coordinated promotion, in order to effectively improve the green level of e-commerce logistics packaging^[2].

2. Overview of green packaging for E-commerce logistics

E-commerce logistics green packaging refers to the packaging activities and technical means that meet the basic requirements of product circulation and customer experience, while minimizing resource consumption and environmental impact in the whole life cycle of design, production, use, recycling and disposal. Compared with traditional packaging, green packaging emphasizes reduction, recyclability, reuse and harmlessness.

In terms of industrial development, some large platforms and logistics enterprises have carried out green

packaging pilot projects, and initially formed demonstration projects such as standardized cartons, recyclable express boxes and recycling kiosks. However, due to factors such as cost, management and consumer habits, these pilots are still difficult to scale up in the entire industry, showing a significant differentiation between leading enterprises and a large number of small and medium-sized participants.

3. Promotion dilemmas of E-commerce logistics green packaging

3.1. Cost pressure and benefit mismatch

The biggest direct obstacle to promoting green packaging lies in cost. Green materials such as high-strength lightweight cartons, degradable plastics and reusable turnover boxes are generally more expensive than traditional materials. For example, the cost of a recyclable or degradable express bag is often 2-3 times that of an ordinary plastic bag^[3]. For small and medium-sized logistics enterprises and platform merchants with low profit margins, this cost increase is difficult to absorb.

At the same time, the environmental benefits of green packaging are public goods, and it is difficult for individual enterprises to convert them into direct economic returns in the short term. When competitors still use low-cost packaging, early adopters may fall into an unfavorable competitive position. The benefit mismatch between social environmental benefits and individual enterprise interests leads to insufficient endogenous motivation for enterprises to adopt green packaging.

3.2. Imperfect recycling and reuse system

The green value of many packaging materials can only be realized on the premise of effective recycling and reuse. At present, the number and coverage of recycling facilities such as express packaging recycling points, smart recycling cabinets and community green stations in most cities are limited, and the connection with the reverse logistics networks of logistics enterprises is not close enough.

In the end distribution link, couriers are under great time pressure and lack incentives to guide consumers to reasonably dispose of packaging. For consumers, the cost of returning packaging to designated recycling points in terms of time and effort is significantly higher than the perceived benefits, resulting in a low participation rate in recycling. The lack of an efficient and convenient recycling and reuse system leads to the fact that a large number of packaging that could have been recycled ultimately enter landfills or incineration systems, weakening the actual effect of green packaging.

3.3. Fragmented standards and information asymmetry

Although relevant departments have issued a series of standards and norms for express packaging, there are still problems such as inconsistent implementation standards among industries and regions, unclear classification of green packaging labels, and lacking of effective information disclosure. Different platforms and logistics enterprises adopt different packaging specifications and evaluation criteria, which is not conducive to large-scale procurement and coordinated optimization of the supply chain^[4].

Consumers and some small merchants often cannot accurately identify whether packaging materials are truly green, and some products with low environmental performance are even labeled as "degradable" or "environmentally friendly", resulting in information asymmetry and "pseudo-green" phenomena. Under the lack of transparent and unified standards, market mechanisms cannot effectively drive high-level green packaging supply.

3.4. Insufficient collaborative incentives among multiple actors

Green packaging involves government departments, e-commerce platforms, logistics enterprises, packaging material manufacturers, recycling enterprises and consumers. The goals and constraints of these actors are different, and effective incentive compatibility mechanisms have not yet been formed^[5].

Government departments are limited by regulatory resources and information acquisition capabilities, making it difficult to carry out fine-grained supervision of packaging selection and use in numerous market entities. Platforms have strong coordination capabilities, but their green requirements for merchants may increase short-term transaction costs, leading to conflicts between ecological governance and commercial interests. Logistics enterprises pay more attention to cost and delivery timeliness, while packaging material enterprises need stable demand expectations to carry out technological innovation. Consumers' environmental awareness and participation level also vary. The lack of collaborative governance tools and mechanisms makes it difficult to form joint efforts.

4. System design of collaborative governance for green packaging

In order to solve the above dilemmas, it is necessary to construct an integrated collaborative governance system for green packaging in ecommerce logistics, and clarify the system architecture and functional modules.

4.1. Overall architecture

The collaborative governance system for e-commerce logistics green packaging can be divided into four levels: policy regulation layer, platform coordination layer, enterprise implementation layer and consumer participation layer, supported by a digital information platform.

Enterprise implementation layer: Logistics enterprises and packaging material enterprises optimize packaging design and material selection, configure green packaging in accordance with standards, and connect with recycling and reuse systems through information systems.

Consumer participation layer: Consumers obtain packaging environmental information through mobile applications or page display, selectively choose green logistics services, and participate in recycling through incentive mechanisms such as points, discounts and deposits.

4.2. Main functional modules

Drawing on the logic of "data acquisition–transmission–analysis–feedback" in vehicle safety control systems, the green packaging collaborative governance system can be refined into the following functional modules:

Information display and interaction module: Provide visual dashboards for managers and regulators, display indicators such as green packaging rate, recycling rate and carbon reduction effect; at the same time, provide consumers with packaging environmental labels and recycling guidance interfaces on mobile terminals.

5. Collaborative governance strategies under the dual-carbon target

On the basis of system design, in order to better adapt to the requirements of the dual-carbon target, this paper puts forward the following collaborative governance strategies.

5.1. Improving the standard system and classification evaluation

First, accelerate the integration and revision of existing express packaging standards, clarify the classification of green packaging levels in terms of material, strength, reduction and recyclability, and form easy-to-implement technical specifications. Second, establish a unified green packaging identification system, requiring producers and platforms to truthfully label environmental attributes and strictly regulate misleading labels. Third, incorporate carbon emission indicators into the evaluation system of packaging, encourage third-party institutions to carry out life cycle assessment and provide data support for policy formulation.

5.2. Optimizing economic incentives and cost-sharing mechanisms

On the one hand, the government can provide phased financial subsidies or tax incentives for green packaging application of small and medium-sized enterprises, and tilt funds to key regions and key links to reduce the initial cost pressure of enterprises. On the other hand, explore the establishment of extended producer responsibility mechanisms in the e-commerce field, reasonably sharing the environmental governance costs among packaging producers, platforms and logistics enterprises through fund collection and differentiated charging, and guiding all parties to jointly invest in green packaging.

At the same time, platforms can give merchants that actively use green packaging preferential policies such as traffic support, ranking optimization and fee reductions, so that green behavior can obtain commercial returns. Logistics enterprises can design pricing schemes that distinguish green packaging services, and explore the possibility of jointly bearing additional costs with merchants and consumers.

5.3. Strengthening construction of recycling and reuse systems

Relying on existing express outlets, community service points and public facilities, build a wide coverage packaging recycling network, and promote the standard configuration of packaging recycling devices in large communities and office buildings. Encourage logistics enterprises and environmental protection enterprises to jointly invest in sorting, cleaning and regeneration facilities, and improve the commercial value of recycled packaging through standardized design and quality control.

At the end distribution link, reasonably arrange recovery paths based on big data of orders and consumers' willingness to recycle, and combine with door-to-door pick up services to reduce consumers' participation costs. Explore the promotion of standardized recyclable express boxes and turnover boxes in scenarios such as intra-

city distribution and warehouse to store delivery, and improve reuse frequency through deposit systems and information tracing.

5.4. Giving full play to platform governance and digital supervision

E-commerce platforms have natural advantages in data aggregation and rule design. Platforms should integrate green packaging indicators into merchant credit evaluation and category operation strategies, and gradually increase the weight of environmental performance in traffic allocation and marketing activities. By docking with government regulatory platforms, platforms can provide real-time data support such as packaging use structure and regional distribution, which is convenient for precise supervision.

At the same time, make use of technologies such as QR codes, RFID and blockchain to record key information in the life cycle of packaging, including production, use, recycling and regeneration, forming a transparent traceability chain. Consumers can voluntarily query packaging environmental information, and regulators can trace responsibility based on data in cases of violations, improving the deterrent effect of supervision.

5.5. Cultivating consumers' green awareness and participation mechanisms

Consumers are both users and disposers of express packaging, and their behavioral choices directly affect the promotion effect of green packaging. On the one hand, it is necessary to strengthen popular science education of green consumption through media, platforms and schools, and increase consumers' awareness of the environmental impact of packaging. On the other hand, design diversified incentive mechanisms, such as points, coupons, virtual green energy and honorary titles, encouraging consumers to preferentially choose green packaging options and actively participate in the recycling of cartons and bags.

In addition, guide consumers to form simple unpacking habits, reduce secondary damage to packaging, and improve the reuse rate of cartons and express boxes. In the long run, the formation of a social atmosphere of "green shopping and low carbon logistics" will help transform green packaging from passive compliance to active selection.

6. Conclusion

Under the constraints of the dual carbon target, promoting green packaging in e-commerce logistics is not only an important starting point for reducing carbon emissions in the logistics industry, but also a key link for promoting green transformation of consumption patterns. At present, the promotion of green packaging still faces prominent problems such as high cost, imperfect recycling systems, fragmented standards and low multi-stakeholder collaboration. It is urgent to build an integrated collaborative governance system.

This paper, drawing on the idea of system design from the safety control system of logistics vehicles, constructs an overall architecture of collaborative governance for e-commerce logistics green packaging, clarifies the functional modules such as packaging data acquisition, transmission, evaluation, incentive settlement and information interaction, and puts forward governance strategies from aspects of standard optimization, economic incentive, recycling system construction, platform governance and consumer participation.

In the future, it is necessary to further strengthen empirical research on different types of e-commerce enterprises and regions, explore cost-effective green packaging technologies and operation models, and form replicable and scalable typical experiences, so as to provide stronger technical and institutional support for achieving the dual carbon target and realizing the high quality development of e-commerce logistics.

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