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Green Manufacturing Strategy of E-Commerce Express Packaging in China

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ABSTRACT

With the development of electronic business, the increase in express packages has caused innumerable express packaging wastes that lead to many problems, such as resource waste and environmental pollution. To achieve sustainable development, China should urgently develop green manufacturing of green express packaging. A questionnaire is designed to investigate consumers, e-commerce sellers, and express delivery practitioners from three research dimensions, namely, overpackaging, green packaging materials, and express packaging recycling. The six key factors uncovered with gray relational analysis are the lax supervision of express packaging; the shortage of green packaging materials and professional Research and Development (R&D) personnel; the recycling of express packaging; the lack of industry standards, laws, and regulations; materials for express packaging; and diversified difficulties of recovery. Then, green manufacturing countermeasures for developing green express packaging are proposed using Teoriya Resheniya Izobretatelskikh Zadatch (TRIZ). Strengthening the supervision of packaging and formulating plans for green talent training are necessary in the short term. In the medium term, focus should be on the monitoring of programs and R&D support for enterprises. For the long-term strategy, concerned establishments and/or authorities must retain professionals, raise public awareness of environmental protection, and establish a standardized recycling system. TRIZ improvement strategy can be introduced into the green manufacturing of green express packaging to increase the possibility of successful and sustainable development of the use of green express packaging.

1. INTRODUCTION

With the rapid growth of e-commerce companies, online shopping has become a way of life, and the successful development of e-commerce has driven the expeditious growth of China's express delivery industry [1,2]. Moreover, express delivery packaging has led to many problems. For example, overpackaged express delivery [3], low packaging recycling efficiency [4], poor packaging materials [5], and non-environmental protection [6] are common occurrences, causing resource waste and environmental pollution. The "2017 China Express Delivery Green Packaging Development Status and Trend Report" issued by the State Post Bureau showed that China's express delivery industry consumed roughly 3.2 billion woven bags, 14.7 billion plastic bags, 3.7 billion packaging boxes, and 330 million rolls of adhesive tape in 2016. The packaging waste generated by express parcels reaches millions of tons. Most express packaging materials are cartons, Polystyrene (PS), and Polyethylene (PE), which are nondegradable, and the recovery rate is <10% [7]. The accelerated growth of express packaging waste has resulted in resource waste and environmental protection problems that cause irreversible pollution to the ecological environment; this condition is unconducive to the sustainable development of human beings [8]. Thus, the pursuit of green express packaging is the top priority in the express delivery industry.

Green packaging is known as pollution-free and environment-friendly packaging [9]. Its concept is embodied in two main aspects. The core idea is to protect the environment, and the other is to save resources to effectively reduce waste [10]. Green packaging must meet the 4R1D principle, namely, reduce, reuse, recycle, regrow, and degradable [11]. The implementation of green manufacturing engineering causes the entire product life cycle of packaging products from design, manufacture, packaging, transportation, and use to end-of-life treatment to have a minimal impact on the environment, thus protecting the ecological environment and reducing the production of express packaging waste and resource waste [12]. Green packaging has become an inevitable trend in the

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development of modern logistics. The research on the problem of express packaging and the development of green express packaging can help reduce environmental pollution and maintain ecological balance. These courses of action can also help modern enterprises save packaging costs and improve environmental protection, which, in turn, can enable the synergistic effect of economy, society, and environment.

For sustainable economic development, green express packaging is bound to become the trend in future express packaging development, and disposable express packaging should be reduced or abandoned [13]. The evaluation of the impact of green express packaging on the environment is traditionally based on the environmental impact of discarded packaging materials. However, on the basis of sustainable development, the entire life cycle of green courier packaging should be considered to evaluate the impact of green express packaging on the environment—from the collection of raw materials for packaging, the manufacturing of packaging, the distribution and storage of packaging, the consumption of packaging, the recycling of packaging, and the final disposal [14]. For example, in the processes of raw material collection and manufacturing, materials used for green express packaging are environmentally unfriendly [15]. The amount of green packaging materials in the market is low, yet their prices are high. Thus, express packaging producers and e-commerce companies often choose to use low-cost and non-environmental packaging materials. In the processes of distribution, storage, and consumption, packaging of goods is excessive [16]. Several transportation links exist in the process of providing goods to customers from e-commerce companies. In these transportation links, couriers wrap goods in multiple packages to avoid damage caused by bumps during transportation; doing so requires several types and a large quantity of express packaging materials. In the processes of recycling and final disposal, express packaging is difficult to recycle [17]. China's waste-recycling industry is centered on the market. Express packaging recycling requires mobilizing a large number of personnel, substantial funds, and large quantities of materials. New express delivery companies emerge continually, and the industry competition is fierce. This condition leads to the difficulty in attracting enterprises to take the initiative to implement express packaging recycling. Most types of express packaging materials are for one-time packaging. These materials are difficult to recycle or are nonrecyclable, resulting in a low recycling rate. Therefore, the entire life cycle of green express packaging is considered in this study to establish the green manufacturing of express packaging. Green manufacturing achieves a minimum negative impact of the entire life cycle of green express packaging on the environment and maximum resource utilization.

In the entire life cycle of green express packaging, logistic companies, e-commerce companies, and consumers are the main users. This study uses questionnaires to understand the major difficulties encountered in the process of using green express packaging by the main users to establish green manufacturing for express packaging. The discussion revolves around the three research dimensions of overpackaging, express green packaging materials, and express packaging recycling to examine the issues of using green express packaging. In consideration of the diverse factors affecting the three facets, the identification of critical factors that warrant investment presents an important decision to ensure the successful improvement of green express packaging for reducing the negative impact of green express packaging on the environment during its life cycle. With this as motivation, this study uses the Gray Relational Analysis (GRA) [18] to determine the key factors influencing the use of green courier packaging. GRA measures the degree of association among factors by analyzing their similarities and differences. Unlike traditional statistical analysis methods, GRA requires less sample size and is applicable when data are irregular, and calculation is efficient and convenient [19]. However, apart from understanding the key factors affecting the use of green express packaging, favorable strategies must be devised to improve these key factors. These strategies are developed to address issues concerning the use of green express packaging through Teoriya Resheniya Izobretatelskikh Zadatch (TRIZ) [20]. TRIZ improvement strategy is introduced into the green manufacturing of express packaging to realize the scientific optimization of green express packaging products and to increase the possibility of the successful use and sustainable development of green express packaging.

The remainder of this study is organized as follows. Section 2 presents a review of related literature to identify the problems in the green manufacturing of green express packaging. Section 3 develops the questionnaire design and describes the analysis steps of GRA. Section 4 uses GRA to extract the key factors affecting the green manufacturing of green packaging in accordance with the data collected from the questionnaire. Section 5 uses TRIZ to establish an improvement strategy for the key factors of green express packaging, and the final section provides the conclusions and suggestions.

2. LITERATURE REVIEW

In this section, the problems encountered in developing the use of green express packaging are detailed below.

2.1. Over-packaging

The function of packaging is mainly reflected in the safe and convenient transportation of goods and improved transportation efficiency. Reasonable packaging is based on these functions, but e-commerce operators often give goods extra packaging to ensure safe handling or to promote stores [16,21]. Doing so reflects their respect for consumers and the value of creating services [22]. The problem is that e-commerce operators or express delivery companies pay insufficient attention to packaging technology by meeting only the requirements of sales packaging. The safety requirements for express delivery packaging during transportation and distribution are overlooked [23].

The overpackaging of goods by e-commerce sellers is inextricably linked to the low awareness of express delivery practitioners in implementing national express delivery industry standards [24]. The "Guidelines for the Operation of Express Delivery Business" promulgated in China list the standard operation specifications for receiving, sorting, and delivering express products during transportation. This regulation indicates that the sorting operation of express delivery products should be conducted under video surveillance, and destructive actions related to tug, tossing, and throwing of express parcels are prohibited [25]. However, some unprofessional employees in express delivery enterprises often mishandle and unintentionally damage goods during sorting, thereby forcing e-commerce merchants and express delivery companies to use multiple packaging to avoid the loss caused by damage to

goods [12]. The "Guidelines for the Operation of Express Delivery Business" do not regulate the environment-friendly nature and appropriateness of packaging materials. In consideration of the lack of specific industry standards and unified supervision departments, couriers may be concerned on the insufficient quality of packaging materials provided by packaging suppliers [22]. Another possibility is that couriers lack environmental awareness [26], and this condition causes excessive packaging and waste.

2.2. Green Packaging Material

Green packaging materials can be nontoxic to human health throughout their life cycle, degradable and self-degradable without polluting the environment, or recycled after being put into use; these characteristics can effectively reduce the waste of nonrenewable resources [15]. Although China has formulated a series of standards for packaging and packaging waste [27], no specific policy for green express packaging has been implemented [28]; this problem limits the development of green packaging materials.

Most commonly used types of express packaging materials are paper and plastic materials. Paper-based packaging mainly uses corrugated paper and honeycomb paperboard. These materials are easily degraded and have a recycling value; thus, they always account for a large proportion of packaging materials. However, the production of paper packaging has led to a sharp decline in global forest coverage. Plastic materials are mainly made of PS and PE. Most of these materials are nondegradable and nonrecyclable and are discarded by consumers. They cause great harm to people and the ecological environment [14,15]. The low variety and high cost of green packaging materials [12] force express delivery companies, e-commerce sellers, and packaging material suppliers to choose low-cost disposable packaging materials, making the implementation of environmental protection concepts difficult [27]. The lack of professional Research and Development (R&D) talents for green packaging materials has also adversely affected the development of green packaging materials [26].

2.3. Express Packaging Recycling

The recycling of express packages involves two approaches. On the one hand, parcels for packaged goods are recycled after the order is delivered, and the parcels are used for a second time to package goods that are transported and delivered. On the other hand, waste from packaging materials is independently recycled by packaging suppliers for reproduction activities [17]. Present express packaging is mostly made of plastic materials, most of which cannot be recycled. The cost effectiveness of express packaging recycling is excessively low. Most of the choices for packaging materials are discarded, and only a small part will be reused [16,17,24]. Moreover, consumers have insufficient understanding of express packaging recycling, resulting in the idea that express packaging recycling is difficult to implement. To enhance consumers' willingness to recycle express packaging materials, an e-commerce platform has launched activities that earn reward points. However, these activities are time consuming and laborious with low economic benefits; thus, a service mechanism for recycling express packaging materials has yet to be established [27].

The "Resource Conservation and Recycling Act" was enacted in the United States, resulting in high packaging recycling rates, and Germany promulgated "Packaging Waste Management Regulations" [29]. China lacks a corresponding department for express packaging recycling management. The main rules and regulations are the "Guidelines for the Operation of Express Delivery Businesses." Therefore, recycling of packaging materials in China and recycling regulations are imperfect, and recycling channels are limited [16,17]. Without a unified industry standard of packaging, the packaging of many different specifications and properties can be designed by the express delivery industry in accordance with the needs of e-commerce operators, resulting in diverse packaging materials [30]. Consequently, the screening and classification of express packaging are necessary in recycling [24]. The cost of recycling is high, which increases the difficulty of packaging recycling; financial support from the policy is thus needed [12,17,29].

Several express delivery companies use inferior packaging materials to save costs. These packaging materials may contain toxic and hazardous substances [24]. A packaging recycling system technology must be established to ensure the feasibility of recycling inferior packaging materials for reducing the harm to humans and the environment [14].

The relevant problems are compiled in accordance with the three research dimensions of express packaging, express packaging materials, and express packaging recycling (see Table 1). These problems serve as the basis for designing the questionnaire to investigate the key factors affecting the development of the use of green express packaging.

3. QUESTIONNAIRE DESIGN AND GRAY RELATIONAL ANALYSIS

3.1. Questionnaire Design

The questionnaire items in Table 1 are based on the development status of China's green express packaging and are according to relevant literature, from overpackaging and express packaging materials to express packaging recycling. Each dimension has 8–10 related impact items to be filled out. The Likert scale is used to measure the importance of each item in the questionnaire. The score is given in accordance with the degree of importance, in which the highest score is 5 (see Appendix).

After the questionnaire is designed, research data are collected through on-site and online questionnaires. Given that most express packaging waste is generated by online shopping, converting express packaging from packaging to garbage involves three major subjects, namely, consumers, express delivery practitioners, and e-commerce sellers. The questionnaire survey thus targets these subjects.

- Consumers, as the mainstay of online shopping, are frequently exposed to express delivery in daily life. They are the sufferers of overpackaging and participants in express packaging recycling. Consumers have their own opinions on green packaging materials.
- Express packaging is one of the main tasks of express delivery practitioners. Overpackaging inevitably occurs during the packaging process to ensure product safety. In the current setting of environmental protection advocacy, most logistic companies have made attempts in green express packaging.

Table 1 | Measurement indicators of questionnaire on green express packaging

Dimension	No.	Indicator	References
Over-packaging	P1	Ensure that the courier goods are not damaged	[12,16,21]
	P2	To provide better service	[11]
	P3	Quality of packaging materials	[11]
	P4	Cater to psychology of consumer	[11]
	P5	To get good reviews and improve the rating of the store for e-commerce operator	[16,21]
	P6	Perfect packaging technology	[23]
	P7	Quality of express delivery practitioners	[24]
	P8	Environmental awareness	[26]
	P9	Uniform standard for express packaging	[11]
	P10	Supervision system for express packaging	[11]
Express packaging materials	W1	Scope of use of new packaging materials	[14,15]
	W2	Suitable green material	[14,15]
	W3	Professional R&D talent for green packaging materials	[26]
	W4	Express delivery companies, e-commerce sellers, and packaging suppliers pursue interests	[12,26]
	W5	Price of green materials	[12,26]
	W6	National policy	[28]
	W7	Relevant industry standards	[26]
	W8	Implementation of the idea of green environmental protection	[27]
Express packaging recycling	R1	Consumers' understanding of express packaging waste	[16,17,24]
	R2	Whether e-commerce and courier companies have considered setting up packaging recycling services	[27]
	R3	Recycling system technology	[14]
	R4	Relevant industry standards	[16,24]
	R5	Recycling cost of express package	[17,24]
	R6	Variety of express packaging materials	[30]
	R7	Express packaging is not recyclable	[16,24]
	R8	Soundness and perfection of relevant laws and regulations	[17,24]
	R9	Support for appropriate policies and funding	[12,17,29]
	R10	Implementation of the ideas of green environmental protection	[27]

Express delivery practitioners naturally have the opportunity to access green express packaging materials. From the viewpoint of corporate social responsibility, logistic companies should implement express packaging recycling, whereas express delivery practitioners should be the main workers.

- Express delivery is a bridge between e-commerce sellers and consumers. Most e-commerce sellers focus on the packaging of goods to obtain favorable comments, thus resulting in excessive packaging. E-commerce sellers represent the main body of overpackaging and are the users of green packaging materials. They are also participants in express packaging recycling.

A total of 112 valid questionnaires are collected, of which 18 are e-commerce sellers, 18 are express delivery practitioners, and 76 are consumers. Table 2 shows the statistical analysis results. Most e-commerce sellers (88.89%) and express delivery practitioners (77.78%) are aware of overpackaging, whereas only approximately half of consumers (47.37%) are aware of it. Although most express delivery practitioners are aware of overpackaging, 50.00% of them believe that the impact of overpackaging on the environment is minimal. Compared with express delivery practitioners, 44.44% of e-commerce sellers and 56.58% of consumers believe that the environmental impact of overpackaging is serious. Express delivery practitioners have the highest awareness of the concept of green express packaging (83.33%), e-commerce sellers follow (55.56%), and consumers have the lowest awareness (31.58%). Half of e-commerce sellers (55.56%) choose to reuse express packaging waste, and half of consumers (52.63%) choose to discard it. Only 38.89% of express delivery practitioners are willing to recycle abandoned courier packaging.

3.2. Steps of Gray Relational Analysis

To extract the key factors affecting the development of the use of green express packaging, the GRA steps are described as follows:

- Step 1. Calculating the difference sequence

  The difference sequence $\Delta_{0i}(k) = |x_0(k)-x_i(k)|$ is the difference between the reference and comparison sequences. The comparison sequence ($x_i = \{x_i(1), x_i(2),..., x_i(k),..., x_i(n)\}$) represents the original data of the questionnaire, where $x_i(k)$ is the kth survey respondent in the questionnaire survey answered by scores of immense importance to the questionnaire asking for the ith item. The reference sequence ($x_0 = \{x_0(1), x_0(2),..., x_0(k),..., x_0(n)\}$) represents the most important evaluation criteria for each item in the questionnaire, where $x_0(1) = x_0(2) =...= x_0(k) =...= x_0(n) = 5$. If the value of $\Delta_{0i}(k)$ is low, then the reference sequence is nearest to the comparison sequence, and the corresponding item in the questionnaire is substantially important.

- Step 2. Calculating the gray correlation coefficient

  The gray correlation coefficient can be calculated using Equation (1), where ζ is the identification coefficient and is generally set to 0.5; $\Delta_{0i}(k)$ is the difference sequence; and Δmin and Δmax are the minimum and maximum of $\Delta_{0i}(k)$, respectively. If $\Delta_{0i}(k) = \Delta$min, then the gray correlation coefficient $r(x_0(k), x_i(k))$ has the maximum value and equals 1. This result implies that the survey respondent believes that the importance of the ith item in the questionnaire is high. Otherwise, the survey respondent believes that the importance of the ith item in the questionnaire is low.

Table 2 | Statistical analysis results of the questionnaire

Questionnaire items	Identity			Total
	Consumers	Express delivery practitioners	E-commerce sellers	
	Count (%)	Count (%)	Count (%)	Count (%)
Do you know about over-packing?				
Yes	36 (47.37)	16 (88.89)	14 (77.78)	66 (58.93)
No	40 (52.63)	2 (11.11)	4 (22.22)	46 (41.07)
Do you think that the impact of China's express packaging on the environment is?				
No	0 (0.00)	3 (16.67)	0	3 (2.68)
Slight	27 (35.53)	9 (50.00)	8 (44.44)	44 (39.29)
More serious	43 (56.58)	4 (22.22)	8 (44.44)	55 (49.11)
Very serious	6 (7.89)	2 (11.11)	2 (11.11)	10 (8.93)
Do you know the concept of green express packaging?				
Yes	24 (31.58)	15 (83.33)	10 (55.56)	49 (43.75)
No	52 (68.42)	3 (16.67)	8 (44.44)	63 (56.25)
How do you deal with express packaging waste in most cases?				
Discard	40 (52.63)	–	2 (11.11)	42 (44.68)
Recycle after using	23 (30.26)	–	5 (27.78)	28 (29.79)
Reuse for next time	9 (11.84)	–	10 (55.56)	19 (20.21)
Other	4 (5.26)	–	1 (5.56)	5 (5.32)
Would you like to recycle the abandoned express packaging?				
Yes	–	7 (38.89)	–	7 (38.89)
No	–	11 (61.11)	–	11 (61.11)

$$r(x_0(k), x_i(k)) = \frac{\Delta\min + \zeta\Delta\max}{\Delta_{0i}(k) + \zeta\Delta\max} \quad (1)$$

- Step 3. Calculating the gray relational degree and sequence

  For the ith item in the questionnaire, the average value of the gray correlation coefficient of all survey respondents is the gray relational degree $r(x_0, x_i)$, which is given as Equation (2), where the value of $r(x_0, x_i)$ is between 0 and 1. The closer the value of $r(x_0, x_i)$ is to 1, the higher the importance of the ith item in the questionnaire will be. The gray relational degrees are arranged from large to small, then the gray relational sequence can be formed. The gray relational sequence indicates that the importance ranking of the factors affecting the development of the use of green express packaging can be obtained and used for analysis and decision making.

$$r(x_0, x_i) = \frac{1}{n}\sum_{k=1}^{n} r(x_0(k), x_i(k)) \quad (2)$$

The calculated results of the gray relational degree indicate that a horizontal line graph can be drawn on the basis of the gray relational sequence. On the horizontal line, the point on the right side indicates that the gray relational degree is larger than that on the left side (i.e., the corresponding item is important). Subsequently, k-means clustering is used to group the items on the basis of the proximity of the gray relational degree between the points. Finally, three to six key factors are selected on the basis of Daniel's principle [31].

4. RESULTS OF GRAY RELATIONAL ANALYSIS

The GRA results of e-commerce sellers, express delivery practitioners, and consumers for the three major problems of green express packaging are detailed in this section.

4.1. Over-packaging

The gray relational degree and sequence of the three main subjects for "overpackaging" items can be obtained in accordance with the calculation steps of GRA (Table 3).

The values of gray relational degree in Table 3 are then drawn as a line graph (see Figure 1). Each point on the line represents a question item; the nearer they are to the right side, the higher their importance will be. These values are grouped by k-means clustering. When consumers are the survey target, the gray relational degrees of the "overpackaging" items can be divided into four groups. When express delivery practitioners and e-commerce sellers are the targets, the gray relational degrees of the "overpackaging" items are divided into five groups. From the grouping results, the key factors are extracted in Table 3 by applying Daniel's principle [31] (background part).

Table 3 indicates that consumers, express delivery practitioners, and e-commerce sellers think that "P10" is the key factor in "overpackaging." From consumers' point of view, "overpackaging" is caused

Table 3 | Gray relational degree and gray relational sequence of express over-packaging

No.	Consumers		Express delivery practitioners		E-commerce sellers	
	Gray relational degree	Gray relational sequence	Gray relational degree	Gray relational sequence	Gray relational degree	Gray relational sequence
P1	0.3827	10	0.6639	3	0.4100	7
P2	0.5883	2	0.7444	1	0.4000	10
P3	0.4277	6	0.4889	8	0.4383	2
P4	0.4576	5	0.4926	7	0.4283	3
P5	0.4645	4	0.5222	5	0.4250	5
P6	0.4199	7	0.6917	2	0.4150	6
P7	0.5883	1	0.4685	9	0.4083	8
P8	0.4165	8	0.4593	10	0.4033	9
P9	0.4143	9	0.5222	6	0.4267	4
P10	0.5766	3	0.5593	4	0.5950	1

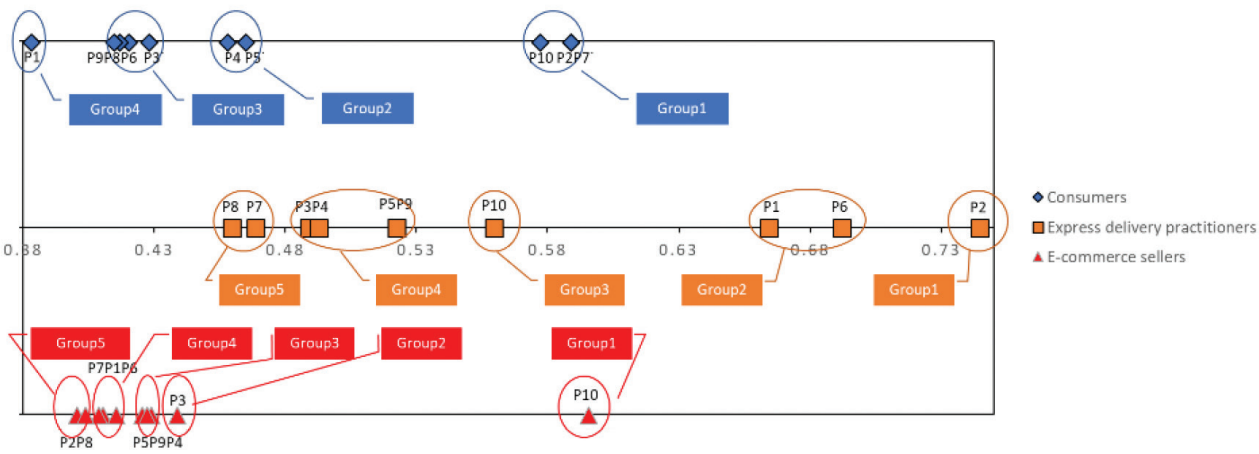

Figure 1 | Line graph of gray relational degree of express over-packaging.

Table 4 | Gray relational degree and gray relational sequence of green packaging material

No.	Consumers		Express delivery practitioners		E-commerce sellers	
	Gray relational degree	Gray relational sequence	Gray relational degree	Gray relational degree	Gray relational sequence	Gray relational degree
W1	0.3996	8	0.5593	5	0.6425	6
W2	0.5727	5	0.7889	2	0.7567	4
W3	0.5818	2	0.6444	4	0.7800	2
W4	0.4320	6	0.8000	1	0.6700	5
W5	0.4022	7	0.7519	3	0.9000	1
W6	0.5786	3	0.5537	6	0.6375	7
W7	0.5838	1	0.5259	7	0.6300	8
W8	0.5779	4	0.4537	8	0.7667	3

by express delivery practitioners and e-commerce sellers. The main purpose is to provide improved services to cater to consumers' psychology. From the point of view of express delivery practitioners, "overpackaging" requires a perfect packaging technology to ensure that courier goods are not damaged, thereby providing consumers with enhanced services. From the perspective of e-commerce sellers, "overpackaging" requires uniform standards for express packaging, which then establish quality for express materials, thus catering to the psychology of consumers, improving store ratings, and obtaining favorable store comments.

4.2. Green Packaging Material

Table 4 shows the gray relational degree and sequence of the three main subjects for the "green packaging material" items. The values of gray relational degree can be drawn as a line graph (see Figure 2). The corresponding values of consumers, express delivery practitioners, and e-commerce sellers can be divided respectively into three, four, and three groups by using *k*-means clustering. From the grouping results, the key factors are extracted in Table 4 by applying Daniel's principle [31] (background part).

Table 4 implies that consumers, express delivery practitioners, and e-commerce sellers think that "W2" and "W3" are the key factors in "green packaging material." Consumers think that "green packaging materials" require the government to formulate specific policy support to establish industry packaging material standards and to prohibit express delivery companies, e-commerce sellers, and packaging suppliers from choosing low-cost disposable packaging materials. From the perspective of express delivery practitioners and e-commerce sellers, the important factor of "green packaging materials" is the price of green materials because it affects the profitability of express delivery companies and e-commerce sellers, thus reducing their willingness to use green packaging and making the concept of green environmental protection difficult to implement.

4.3. Express Packaging Recycling

Table 5 shows the gray relational degree and sequence of the three main subjects for the "express packaging recycling" items. The values of gray relational degree can be drawn as a line graph (see Figure 3). Subsequently, the corresponding values of consumers, express delivery practitioners, and e-commerce sellers can be

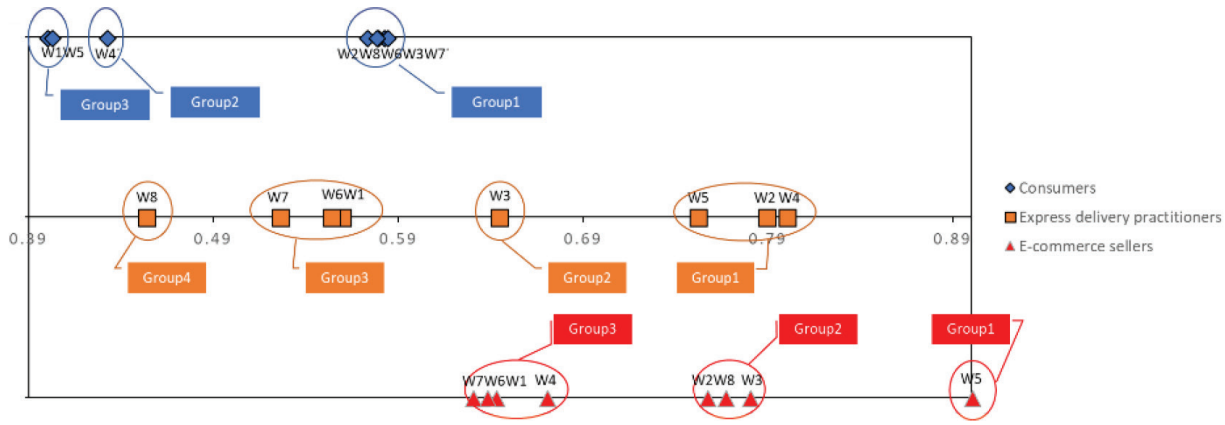

Figure 2 | Line graph of gray relational degree of green packaging material.

Table 5 | Gray relational degree and gray relational sequence of express packaging recycling

No.	Consumers		Express delivery practitioners		E-commerce sellers	
	Gray relational degree	Gray relational sequence	Gray relational degree	Gray relational degree	Gray relational sequence	Gray relational degree
R1	0.5838	4	0.4148	10	0.7533	1
R2	0.5903	2	0.4315	9	0.4117	9
R3	0.5812	6	0.4796	7	0.4317	6
R4	0.5825	5	0.8389	1	0.4467	5
R5	0.3996	9	0.6667	2	0.4150	8
R6	0.6247	1	0.5852	4	0.4767	3
R7	0.4147	8	0.5889	3	0.5000	2
R8	0.5890	3	0.5815	6	0.4517	4
R9	0.3952	10	0.5852	5	0.4250	7
R10	0.5701	7	0.4333	8	0.4117	10

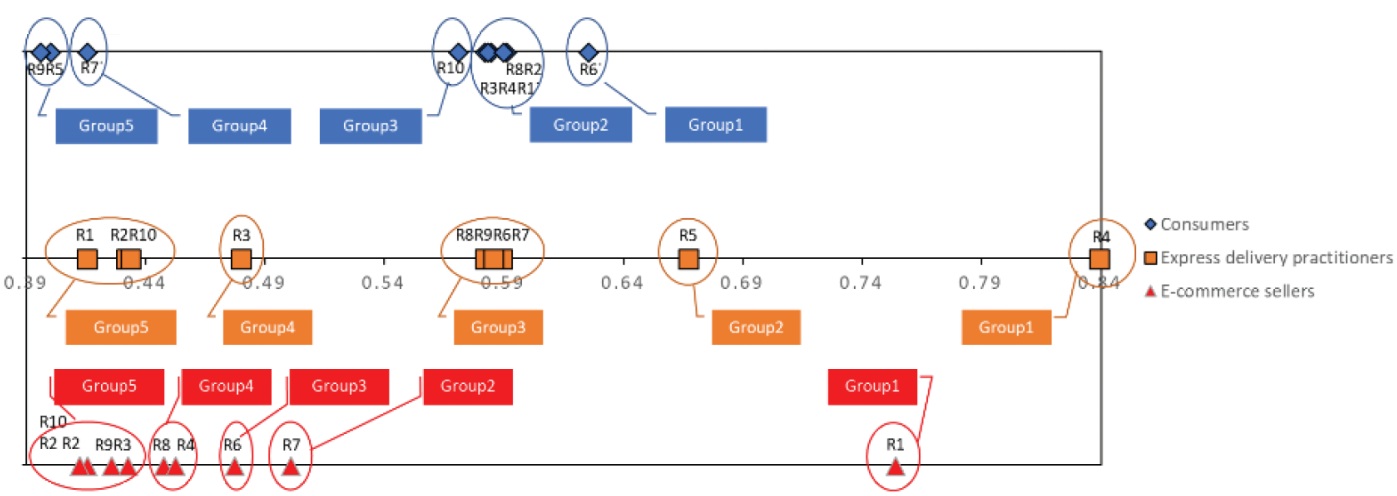

Figure 3 | Line graph of gray relational degree of express packaging recycling.

divided into five groups using k-means clustering. From the grouping results, the key factors are extracted in Table 5 by applying Daniel's principle [31] (background part).

Table 5 reveals that consumers, express delivery practitioners, and e-commerce sellers think that "R4," "R6," and "R8" are the key factors in "express packaging recycling." From consumers' point of view, "express packaging recycling" requires them to improve their understanding of recycling garbage from express packaging. Consumers think that improving their understanding establishes the technology and services of express packaging recycling systems for improving the feasibility of express packaging recycling. From the point of view of express delivery practitioners and e-commerce sellers, express packaging does not have a recycling property because it is mainly made of plastic materials, and consumers have insufficient understanding of express packaging recycling. As a result, a large amount of packaging materials are discarded by consumers. Consequently, the recycling cost of packaging materials is high. Policy support and financial subsidies are needed to address the concerns of e-commerce sellers and express delivery practitioners in recycling packaging waste, which is conducive to improving the environment.

5. TRIZ ANALYSIS

Gray relational analysis results imply that the six key factors that consumers, express delivery practitioners, and e-commerce sellers consider are "P10," "W2," "W3," "R4," "R6," and "R8." This study then develops favorable strategies to address the six key factors in accordance with TRIZ analysis steps proposed by Savransky [32].

5.1. Establishment of Key Factor Strategies

(i) P10. Supervision system for express packaging

- Step 1. Identifying the problem

  The supervising body of e-commerce in China is the Ministry of Commerce, and express delivery and packaging suppliers are supervised by the State Postal Bureau and the China Packaging Federation. These three departments differ, and unified supervision is consequently difficult. In the events of express goods damage and seeking compensation from responsible parties, the three departments are unable to coordinate in a unified manner.

  E-commerce sellers think that damages are caused by poor sorting of express delivery practitioners. Express delivery companies blame e-commerce sellers for not being effective in packaging goods at the time of delivery. Damages may also be caused by low-priced and low-quality packaging products provided by packaging suppliers. These situations make the various aspects of express delivery from packaging to delivery poorly regulated, leading to the unsolvable problem of overpackaging.

- Step 2. Determining the improving and worsening parameters

  From the definition of P10, e-commerce sellers, express delivery companies, and packaging suppliers are managed by three supervisory departments. These supervisory departments must communicate and cooperate to improve supervision; thus, the improving parameter is "13. Stability of object" on the basis of searching within 39 engineering parameters. Although the three supervisory units manage different objects, the links among them are inseparable. These supervisory units must communicate and coordinate to tighten supervision. Different supervisory units mean that the processes and steps for handling goods vary. The units face time and efficiency problems through communication and coordination. Therefore, the worsening parameter is "9. Speed" in accordance with searching within 39 engineering parameters.

- Step 3. Searching for the intentions of the innovative principles

  With the improving parameter "13. Stability of object" and the worsening parameter "9. Speed," the intersection of "13. Stability of object" on the improving axis and "9. Speed" on the worsening axis is selected in the contradiction matrix, then innovation principles can be determined. Four innovation principles are obtained; they are "Principle 28: Mechanic Substitution," "Principle 33: Homogeneity," "Principle 1: Segmentation," and "Principle 18: Mechanical Vibration." In accordance with the intention of the innovation principles, "Principle 33: Homogeneity" and "Principle 18: Mechanical Shock" are selected.

- Step 4. Constructing strategies based on innovative principles

  "Principle 33: Homogeneity" means that materials of the same properties are used. When they are used together, they will not have obvious negative effects and can bring benefits to the system. The strategy is to establish a monitoring team to improve the effectiveness of operations. The definition of "Principle 18: Mechanical Shock" is to increase frequency. The proposed strategy adopts multiple modes to strengthen communication among the three supervisory departments.

  A supervision team can be jointly established by the Ministry of Commerce, the State Postal Bureau, and the China Packaging Federation. The joint team can effectively supervise e-commerce sellers, thus alleviating the problem of overpackaging. Each of the three supervisory departments needs to appoint relevant full-time personnel in supervising the working group. Face-to-face communication is required for coordination. The three supervisory departments must be unified in time and place; otherwise, time consumption will increase. An online office should be established to communicate via the Internet.

  Establishing a supervision standard and dividing responsibilities are also necessary to improve efficiency. The China Packaging Federation and the State Postal Bureau can require packaging suppliers and express delivery companies to obtain ISO14000 environmental certification. They can then supervise packaging suppliers' production and express packaging companies' use of environment-friendly and protective packaging materials. The Ministry of Commerce needs to monitor e-commerce sellers' selection of packaging materials. Quick response (QR) codes can be used for accountability. A QR code should be placed on a product's outermost layer, and scanning the QR code can identify the type of packaging material used. The supervision team can conduct random inspections on a regular basis. If excessive packaging layers and gaps are found, e-commerce sellers must be held accountable. If packaging materials are not environmentally friendly, then express delivery companies and packaging suppliers must be in charge.

(ii) W2. Suitable green material

- Step 1. Identifying the problem

  The types of green packaging materials are few, and their price is four to five times that of ordinary packaging materials. No fixed standards for packaging exist. Material specifications are different, and the consumption of express packaging is large. If e-commerce sellers and express delivery companies cannot find suitable green packaging materials to replace ordinary packaging materials, then they can only choose low-cost non-environmental packaging.

- Step 2. Determining the improving and worsening parameters

  Increasing capital investment in R&D is expected to solve the problem of W2. Suitable green materials can be made available in the market. The improving parameter is "26. Amount of substance" on the basis of searching within 39 engineering parameters. However, enterprises also face problems with the rates of return on investment, repayment, and interest growth when they invest considerable money in R&D. If their earnings are low and R&D progress is slow or fails, then repaying within the repayment time limit is impossible. If earnings are lesser than the rate of interest growth, then their liabilities may increase. Therefore, the worsening parameter is "9. Speed" in accordance with searching within 39 engineering parameters.

- Step 3. Searching for the intentions of the innovative principles

  With the improving parameter "26. Amount of substance" and the worsening parameter "9. Speed," the intersection of "26. Amount of substance" on the improving axis and "9. Speed" on the worsening axis is selected in the contradiction matrix. Thereafter, the following four innovation principles are obtained: "Principle 10: Preliminary Action," "Principle 19: Periodic Action," "Principle 29: Pneumatics and Hydraulics," and "Principle 38: Boosted Interactions." In accordance with the intention of the innovation principles, "Principle 10: Preliminary Action" and "Principle 19: Periodic Action" are selected.

- Step 4. Constructing strategies based on innovative principles

  "Principle 10: Preliminary Action" means pre-importing useful effects into objects or systems. The proposed strategies are to evaluate the development status of green express packaging materials through pre-actions, understand the market demand, establish R&D goals, and formulate R&D planning. "Principle 19: Periodic Action" is defined as changing the periodicity if the effect is already periodic. After investing in R&D funds, R&D progress must be constantly checked to avoid investment increase, which will incur additional corporate liabilities.

  The most environmentally damaging packaging materials are plastic bags, internal buffers, and other plastic products. Most are made of PE, PP, and other materials that are nonrecyclable or nondegradable. In e-commerce platforms, a common large express bag is priced at 0.2 yuan/piece. By contrast, the cost of a biodegradable express bag with the same size is 0.9 yuan/piece, which is 4.5 times more than a common express bag's. Current e-commerce sellers and express delivery companies rarely use green packaging materials due to the high price of these materials. "Guiding Opinions on Collaborative Promotion of Green Packaging in the Express Industry" mention that the proportion of degradable green packaging materials will increase to 50% by 2020 [33], which means that green express packaging is needed in the future. The cost of green express packaging must be given attention to improve the marketization and development of green packaging materials. R&D must also be carried out on existing green materials, such as polylactic acid, which is an excellent biodegradable packaging material [14], which should be applied to express packaging. Regularly checking the use of funds and R&D results, such as establishing a management monitoring and follow-up mechanism and ensuring that R&D results and progress are closely related to the needs of market development, is also necessary. This fixed cycle avoids an increase in investment that consequently increases a company's liabilities.

(iii) W3. Professional R&D talent for green packaging materials

- Step 1. Identifying the problem

  Most developed countries have achievements in the research of packaging plastics. For example, the United States Department of Agriculture no longer uses traditional PE plastic film as the main material in the food-packaging industry. They use corn resin instead. The degradable plastic packaging materials developed by Zeneca in the United Kingdom have been produced in large quantities, and Japanese R&D institutions have developed straw as raw materials for wine packaging [26]. In China, stone paper was officially produced in 2015. Degradable plastics, such as oxidized biodegradable plastics, still require improved technology. However, reaching a standard takes time [12]. Professional R&D talents for green packaging materials must be cultivated in China.

- Step 2. Determining the improving and worsening parameters

  Increasing capital investment to train professionals is expected to solve the problem of the lack of W3. Therefore, the improving parameter is "21. Power" in accordance with searching within 39 engineering parameters. However, professional talents need to be selected, educated, and trained. A long process is required from the cultivation of talents to the development of green packaging materials. Thus, the worsening parameter is "15. Durability of moving object" on the basis of searching within 39 engineering parameters.

- Step 3. Searching for the intentions of the innovative principles

  With the improving parameter "21. Power" and the worsening parameter "15. Durability of moving object," the intersection of "21. Power" on the improving axis and "15. Durability of moving object" on the worsening axis is selected in the contradiction matrix. The following four innovation principles are then obtained: "Principle 19: Periodic Action," "Principle 10: Preliminary Action," "Principle 35: Parameter Change," and "Principle 38: Boosted Interactions."

- Step 4. Constructing strategies based on innovative principles

  "Principle 10: Preliminary Action" is the pre-introduction of useful effects into an object or system. Therefore, the proposed strategy is to evaluate the current status of R&D talents for green express packaging. This evaluation is through pre-action to understand the structural requirements of the talent market, accurately position talent training, and formulate talent-training programs. "Principle 19: Periodic Action" is defined as changing the periodicity if the effect is already periodic. Therefore, setting a monitoring frequency remains necessary to check the progress of personnel training. This monitoring frequency reduces the time wasted in the talent-training cycle after the development of talent development planning.

  China's logistic industry through the establishment of logistic majors in colleges and universities is relatively late. Logistic

education needs to be improved. Talents in professional packaging, especially professional R&D for green packaging materials, are scarce. The demand for green express packaging has increased only with the successful development of the express delivery industry. This industry needs highly professional talents. When formulating a talent-training plan, enterprises must select talents, evaluate their professional qualities, and master the professional skills of selected talents. Enterprises should pay attention to the application and practicality of cultivating talents to professional knowledge. Moreover, enterprises can establish a management monitoring and follow-up mechanism to conduct a fixed-cycle inspection to ensure that the training progress is closely linked to the development needs of green express packaging. This mechanism is intended for reducing the time wasted in talent training.

"Principle 38: Boosted Interactions" is replacing normal air with concentrated air. Therefore, the proposed strategies are meant to adjust the original talent structure and introduce strong professional capabilities. "Principle 35: Parameter Change" is the changing of temperature. The proposed strategies are intended to stimulate the interest of R&D talents and retain outstanding talents.

On the basis of market demand, talents need to be cultivated for a long time because enterprises cannot immediately invest human resources in the development of green packaging materials. Enterprises need to adjust the original talent structure and introduce highly skilled personnel, such as those with achievements in R&D of packaging materials. They must hire professors with in-depth knowledge on green packaging materials to serve as R&D instructors, thus revitalizing the R&D team. Enterprises can also motivate and retain R&D talents through incentives. For example, providing higher salary than that of ordinary R&D personnel, developing new materials to give bonus incentives, considering a long-term career plan for talent development, and respecting R&D talents will allow them to fully participate in R&D planning.

(iv) R4. Relevant industry standards

- Step 1. Identifying the problem

  The present standardization policy of the express delivery industry is backward. For example, although the "Express Service" is the national standard, it is incomplete. Most operations related to express delivery packaging are only from experiences passed down in the industry. These experiences have not formed the standard of the express delivery industry. Current standards usually only restrict the production and lack the corresponding standards to regulate the application and recycling of express packaging [34]). With the rapid growth of China's express delivery industry, additional professional and detailed industry standards must be urgently developed to promote the recycling of express packaging.

- Step 2. Determining the improving and worsening parameters

  From the definition of R4, the existing express packaging standards are imperfect. Additional professional and detailed industry standards are needed to promote courier recycling. Therefore, the improving parameter is "34. Repairability" on the basis of searching within 39 engineering parameters. Once the relevant standards are perfected, express delivery companies and e-commerce sellers must rapidly adjust to ensure that companies' coordinated operation can adapt to the standard changes. Thus, the worsening parameter is "35. Adaptability" via searching within 39 engineering parameters.

- Step 3. Searching for the intentions of the innovative principles

  With the improving parameter "34. Repairability" and the worsening parameter "35. Adaptability," the intersection of "34. Repairability" on the improving axis and "35. Adaptability" on the worsening axis is selected in the contradiction matrix. Four innovation principles are then obtained; they are "Principle 7: Nesting," "Principle 1: Segmentation," "Principle 4: Asymmetry," and "Principle 16: Partial or Excessive Action." On the basis of the intention of the innovation principles, "Principle 1: Segmentation" and "Principle 16: Partial or Excessive Action" are selected.

- Step 4. Constructing strategies based on innovative principles

  "Principle 1: Segmentation" is the separation of an object or system into parts. Therefore, the proposed strategies are intended to distinguish the recyclability of materials, develop recyclable standards, and standardize the construction of recycling systems.

  The establishment of recycling systems requires joint efforts from production to circulation and packaging recycling. Packaging suppliers are responsible for the production process. Suppliers distinguish the recyclability of materials or boxes from packaging design, such as SF's glue-less carton, Shentong's express woven bag with RFID chip, Xiaomi's water-soluble tape, and Suning's shared express box. E-commerce sellers should use express packaging materials with high environmental performance. Express delivery companies need to supervise packaging activities and train practitioners to avoid damaging express packaging in circulation. Consumers and e-commerce sellers are required to participate in recycling during the process of package recycling. The establishment of a recycling-processing center is the primary condition for the construction of an express packaging recycling system [30]. Packaging suppliers and express delivery enterprises must jointly establish a recycling-processing center to ensure operation. Moreover, the government should provide financial support.

  "Principle 16: Partial or Excessive Action" is the use of little or less of something to simplify a problem when it is impossible to solve it 100%. Therefore, the proposed strategy is meant to promote environmental protection ideas through various media for raising public awareness. This promotion should be implemented before the introduction of sound industry standards.

  On the basis of the survey this study, 47% of respondents think that the effect of China's express packaging on the environment is minimal, and 64% do not understand the concept of green express packaging. A few do not know what materials are used in express packaging. Thus, the government needs to guide express packaging recycling. They can publish comprehensive knowledge about green packaging through newspapers, TV commercials, radio, and online platforms to gain public support for the packaging recycling work. The media can also encourage the public to adapt to changes when improving express packaging recycling standards.

(v) R6. Variety of express packaging materials

- Step 1. Identifying the problem

  Present packaging materials used by e-commerce sellers and express delivery companies in China include express sheets,

woven bags, envelopes, plastic bags, cartons, adhesive tapes, logo stickers, and plastic fillers. E-commerce sellers offer various products with different shapes. Thus, packaging requirements and product forms also differ. Moreover, packaging materials lack uniform specifications, and express delivery companies provide different packaging materials and sizes. China's express packaging recycling system is lagging, and people's awareness of packaging classification is low. Express packaging is consequently difficult to recycle.

- Step 2. Determining the improving and worsening parameters

  From the definition of R6, express packaging materials have many types. Recyclable and nonrecyclable materials are difficult to distinguish, making reclaiming packaging also difficult. The convenience of packaging recycling is necessary to improve. Express delivery practitioners must increase their understanding of express packaging materials. Therefore, the improving parameter is "33. Convenience of use" via searching within 39 engineering parameters. If recycling work needs to be added, then services must be expanded and employees' training on the classification of packaging materials should be strengthened. This expansion will lead to an increase in the workload of each department. Thus, the worsening parameter is "7. Volume of moving object" on the basis of searching within 39 engineering parameters.

- Step 3. Searching for the intentions of the innovative principles

  With the improving parameter "33. Convenience of use" and the worsening parameter "7. Volume of moving object," the intersection of "33. Convenience of use" on the improving axis and "7. Volume of moving object" on the worsening axis is selected in the contradiction matrix. The following four innovation principles are then obtained: "Principle 13: Inverse," "Principle 15: Dynamics," "Principle 30: Flexible Shells and Thin Films," and "Principle 12: Equipotentiality." On the basis of the intentions of the innovation principles, "Principle 13: Inverse" is selected.

- Step 4. Constructing strategies based on innovative principles

  "Principle 13: Inverse" is to reverse an action to solve a problem. Therefore, the proposed strategy is intended to allow consumers to recycle on their own.

  Consumers are the primary contacts of express packaging. A large part of the factors depends on consumers' reasonable classification and the delivery of express packaging to obtain efficient and reasonable recycling [30]. Enabling consumers to recycle independently can start from several points. First, green recycling points can be established in residential areas, business districts, and campuses to meet the last-mile requirements of express delivery and for convenience. Second, in consideration that most consumers do not know how to classify express packaging materials, packaging manufacturers can print a green mark on recyclable packages when producing materials. Consumers must be informed that packages with a green mark can be recycled, whereas packages without a green mark is nonrecyclable. Recycling convenience can be improved from the operation. Third, a point system can be used to reward consumers who recycle, such as exchanging a coupon for express fees or cash return, or to provide free mail coupons. Express delivery practitioners have numerous consumers. If consumers can recycle independently, then the recycling work of express delivery companies can be facilitated.

(vi) R8. Soundness and perfection of relevant laws and regulations

- Step 1. Identifying the problem

  Several countries, such as Germany, Japan, and the United States, have achieved high recovery rates in express packaging recycling. They have actively adopted relevant policies or constructed corresponding recycling systems for the implementation of packaging recycling. For example, Germany has enacted "Regulations on the Management of Packaging Wastes," Japan has established multiple recycling stations, and the United States has enacted the "Resource Protection and Recycling Law" [35]. In China, the policy on express packaging standards and packaging recycling has not been clearly formulated. Moreover, the subject of recycling responsibility is unknown despite China's active promotion of green logistics in recent years. As a result, efforts to increase the recycling rate of express packaging are ineffective.

- Step 2. Determining the improving and worsening parameters

  The definition of R8 implies that sound relevant laws and regulations are needed to establish clarification in the responsibility's main body for promoting the recycling of express packaging. Therefore, the improving parameter can be "10. Force" to establish a new operational mechanism from the 39 engineering parameters. The emergence of new operational mechanism indicates that express packaging recycling is mandatory. Express delivery companies will face the pressure of express packaging recycling. Thus, the worsening parameter is "11. Tension, pressure" via searching within 39 engineering parameters.

- Step 3. Searching for the intentions of the innovative principles

  With the improving parameter "10. Force" and the worsening parameter "11. Tension, pressure," the intersection of "10. Force" on the improving axis and "11. Tension, pressure" on the worsening axis is selected in the contradiction matrix. Thereafter, three innovation principles are obtained; they are the "Principle 36: Phase Transition," "Principle 35: Parameter Change," and "Principle 21: Skipping." In consideration of their intention, "Principle 36: Phase Transition" and "Principle 35: Parameter Change" are selected.

- Step 4. Constructing strategies based on innovative principles

  "Principle 36: The transition of the stage" is the phenomenon used to judge a change in a stage. Therefore, the proposed strategy is meant to adjust the structure of enterprises to cope with changes in laws. "Principle 35: Changing parameters" means changing temperature. The proposed strategy is for the government to strengthen support for enterprises to stimulate their interest in recycling.

  The requirements of laws and regulations are rigid and must be implemented. Enterprises must comply to achieve sustainable development. Hence, enterprises must adapt their internal structures and the needs of the current stage to new laws and regulations on recycling. Examples are the establishment of uniform standards for packaging, the establishment of green signs, and the development of incentive mechanisms for participation in packaging recycling. However, these works will cost considerable manpower and material resources for enterprises. Thus, the government can give financial support to express delivery companies.

For example, special funds can be provided for express packaging recycling, or tax reduction can be encouraged when recycling work reaches a certain amount. When enterprises actively comply with laws and regulations, they also need to give feedback about the difficulties encountered to the government. The government implements its responsibilities with laws and regulations. Express delivery companies cooperate with the government to conduct courier recycling work. This cooperation promotes recycling of express packaging and improves recycling rate.

Figure 4 presents the 13 strategies for the development of the use of green express packaging.

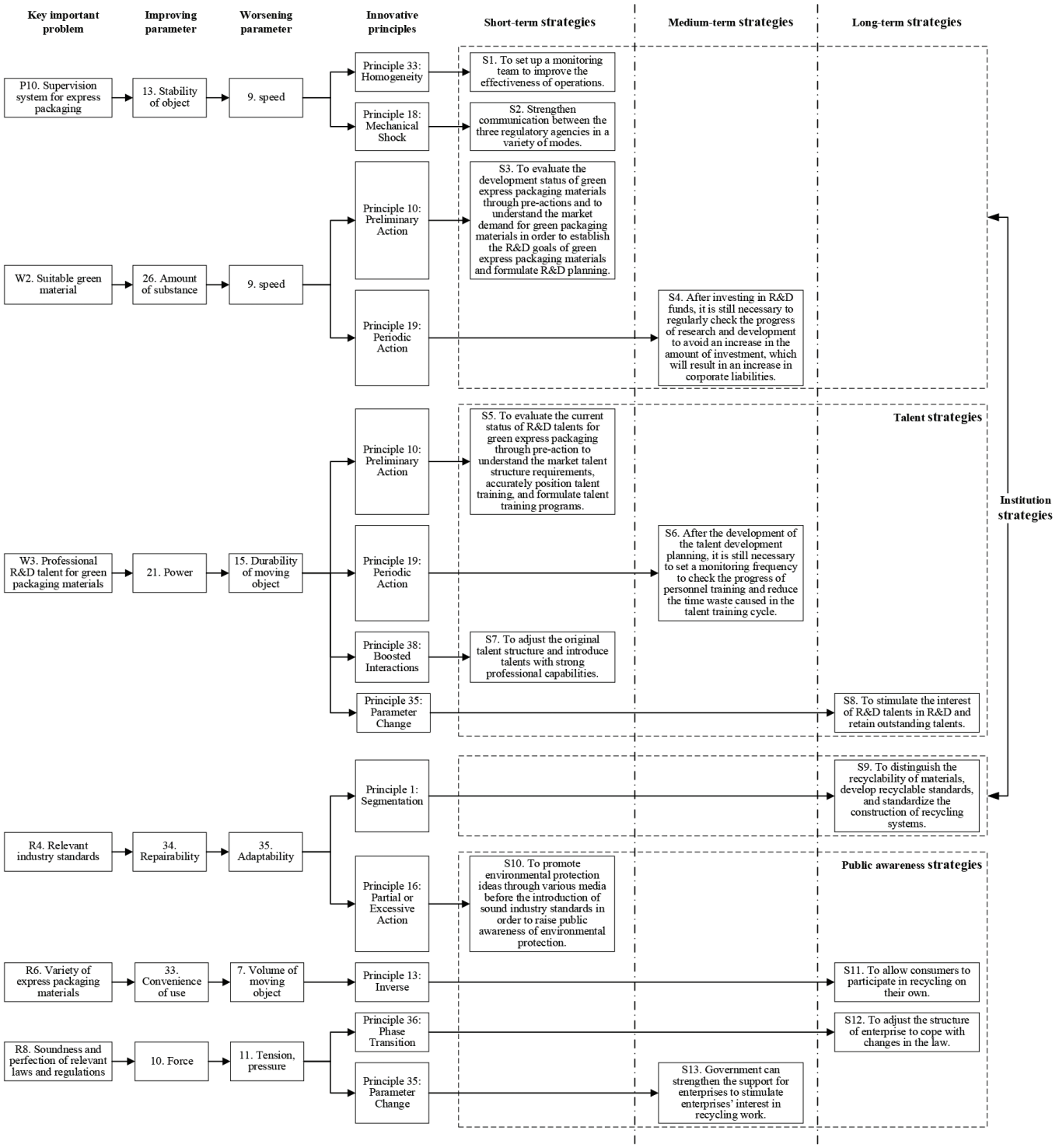

Figure 4 | Green express packaging strategies formulated by TRIZ approach.

5.2. TRIZ Strategy Summary

This study has established 13 development strategies for green express packaging. On the basis of package content, the development of the use of green express packaging should be based on "talent," "institution," and "public awareness." To effectively use the 13 strategies, the following section will explain the sequence of strategic development in the short, medium, and long stages. The strategies at each stage can be planned in accordance with the duration of implementation (Figure 4). The green manufacturing of express packaging is combined to integrate the "talent," "institution," and "public awareness" strategies (Figures 5–7, respectively). This integration promotes the sustainable development of green express packaging.

First, the "talent" strategy has four substrategies, namely, S5, S6, S7, and S8. Express delivery companies should actively seek professional talents on the basis of market talent structure. In the short-term "talent" strategy, they can focus on "S5. To evaluate the current status of R&D talents for green express packaging

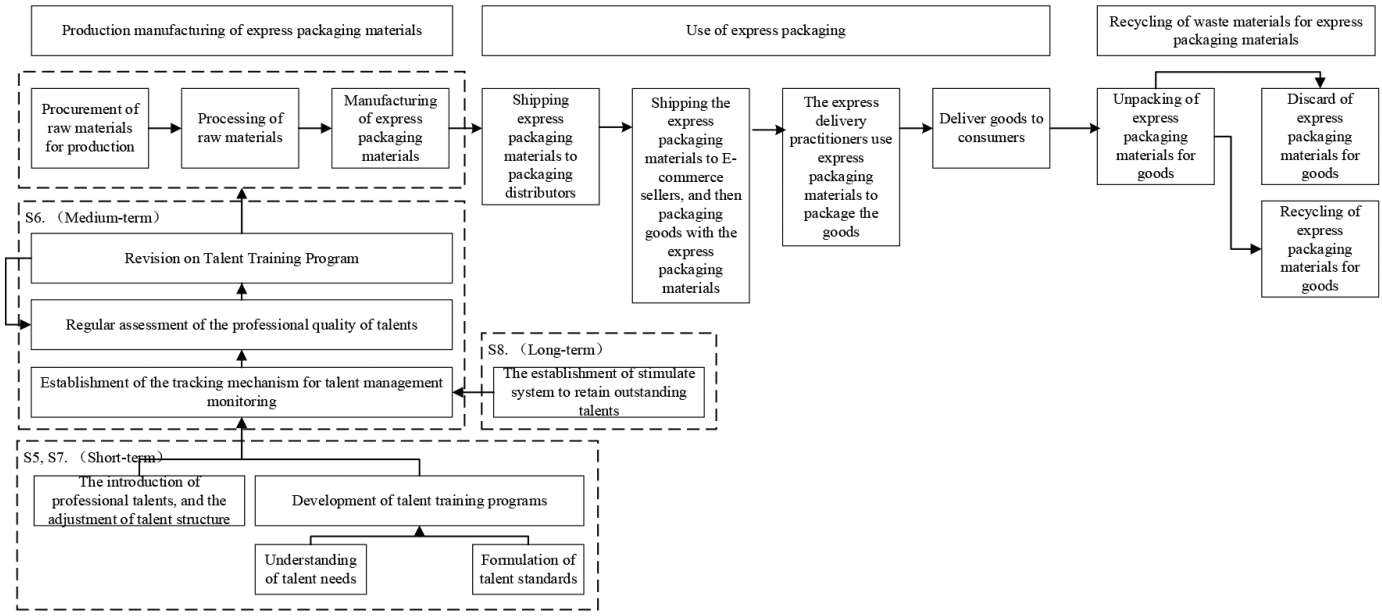

Figure 5 | Talent strategy for express packaging green manufacturing.

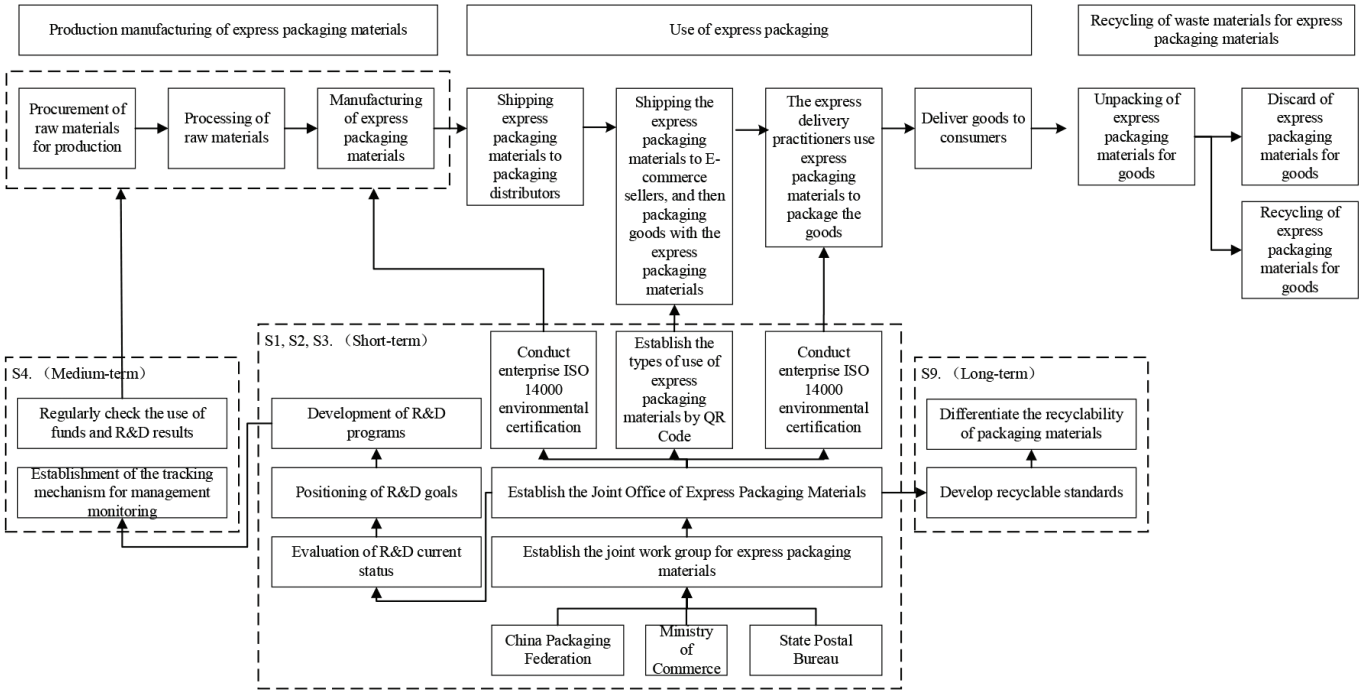

Figure 6 | Institution strategy for express packaging green manufacturing.

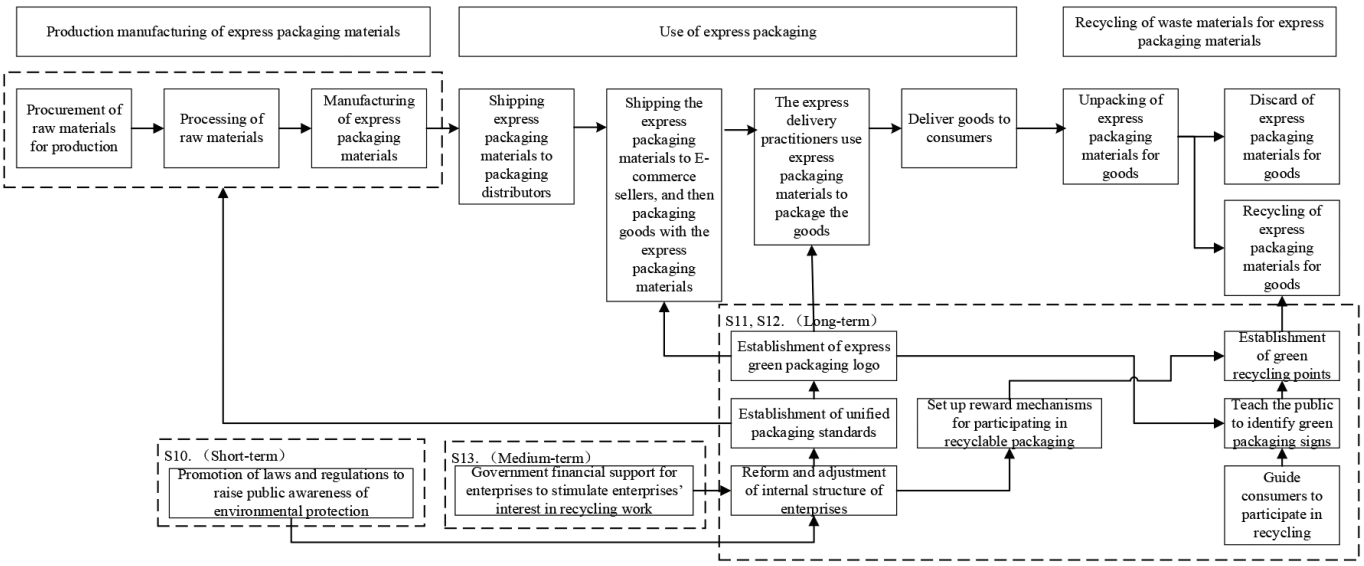

Figure 7 | Public awareness strategy for express packaging green manufacturing.

through pre-action to understand the market talent structure requirements, accurately position talent training, and formulate talent-training programs" and "S7. To adjust the original talent structure and introduce talents with strong professional capabilities." The medium-term "talent" strategy can focus on "S6. After the talent development planning, a monitoring frequency must be set to check the progress of personnel training and reduce the time waste caused by the talent-training cycle." Express delivery companies should ensure that they can retain outstanding talents in the long-term planning. This strategy can focus on "S8. To stimulate the interest of R&D talents and retain outstanding talents."

Second, the "institutional" strategy has five substrategies, namely, S1, S2, S3, S4, and S9. The first objective is to solve the problem of over-packaging in the early stage of developing green express packaging. Therefore, the short-term "institutional" strategy can focus on "S1. To establish a monitoring team for improving the effectiveness of operations" and "S2. Strengthen communication among the three regulatory agencies in various modes." Express delivery companies can also adopt "S3. To evaluate the development status of green express packaging materials through pre-actions, to understand the market demand for green packaging materials, to establish R&D goals, and to formulate R&D planning." Setting the medium-term goal of green express packaging development is next. During this period, express delivery companies often face problems, such as insufficient funds and whether R&D has progress. The medium-term "institutional" strategy can focus on "S4. After investing in R&D funds, regularly checking the progress of R&D remains necessary to avoid investment increase. This increase will result in additional corporate liabilities." The development of the use of green express packaging is basically the need to improve industry standards and legislation. Thus, the long-term "institutional" strategy can focus on "S9. To distinguish the recyclability of materials, develop recyclable standards, and standardize the construction of recycling systems."

Finally, the "popular awareness" strategy has four substrategies, namely, S10, S11, S12, and S13. In the early stage of the development of the use of green express packaging, the public needs active cooperation. The government can focus on "S10. To promote environmental protection ideas through various media before the introduction of sound industry standards for raising public awareness of environmental protection." The government should strengthen its support for enterprises. The development of the "public awareness" strategy in the medium term can focus on "S13. The government can strengthen the support for enterprises to stimulate their interest in the recycling work." In the long-term planning for green express packaging development, express delivery companies should ensure that they can adapt to policy changes, and active cooperation from the public is needed. The strategy of long-term "public awareness" should accordingly focus on "S12. To adjust the structure of enterprises to cope with changes in laws" and "S11. To allow consumers to participate in recycling on their own."

6. CONCLUSION AND FUTURE RESEARCH

6.1. Conclusion

National and local communities have given increasing attention to the greenness of express packaging due to the serious pollution caused by express packaging in recent years. Therefore, green express packaging should be developed to reduce environmental pollution, maintain ecological balance, and achieve sustainable economic development.

This study regards green express packaging as the research object and conducts a questionnaire survey on three main subjects, namely, e-commerce sellers, express delivery practitioners, and consumers. GRA is used to extract key factors. The development of the use of green express packaging in China encounters the following problems: insufficient supervision of express packaging; a lack of suitable green materials; a lack of professional R&D talents for green packaging materials; diversity of express packaging materials; and imperfect industry standards, laws, and regulations. TRIZ analysis is used to propose a corresponding improvement strategy for these problems. Short-, medium-, and long-term planning strategies are recommended.

This study suggests that the development of the use of green express packaging should be based on "talent," "institution," and "public awareness." The following three recommendations are accordingly provided.

- Strengthening the cultivation of green talents

  Green packaging materials are expensive due to the lack of suitable green packaging materials. The main reason is that green packaging products are highly developed or have no suitable low-cost raw materials. These problems require the help of professional green R&D talents. Thus, the industry should strengthen the cultivation of green packaging talents and consider the kind of talents needed to develop green express packaging.

- Construction of sound industry system

  Express overpackaging problems have not been alleviated. E-commerce sellers and express delivery companies use nondegradable packaging products because no institutional constraints exist. A sound industry system should be constructed from packaging material specifications to packaging recycling.

- Improvement of the public's awareness of environmental protection

  Consumers, as the primary contact persons of express packaging, can reasonably classify and influence weak consumers. They play a significant role in whether express packaging can be recycled efficiently and reasonably. Therefore, the development of the use of green express packaging not only requires improvements from the government and enterprises but also needs enhanced public awareness on environmental protection to actively cooperate with recycling

The development of the use of green express packaging requires the joint efforts of the government, enterprises, and consumers. The strategies proposed in this study are hoped to provide references for the development of green express packaging. Green express packaging can have remarkable development through their joint efforts.

6.2. Future Research

This study focuses on three major issues in express packaging, namely, overpackaging, express packaging materials, and express packaging recycling. However, the choice of packaging will vary for different express products. For example, the packaging of fresh produce requires foam boxes and ice packs. These packages are basically nonrecyclable. Therefore, future research can explore issues in packaging different express products.

CONFLICTS OF INTEREST

The authors declare they have no conflicts of interest.

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APPENDIX: QUESTIONNAIRE

Dear Sir/Madam,
Hello! Thank you for participating in this survey. The purpose of this questionnaire is to study the key factors affecting the development of green express packaging and their importance. The questionnaire will be filled in anonymously, thus it will not cause any inconvenience to you. Please rest assured to fill out the questionnaire. Your real thoughts are very important for this study, thank you for your support and cooperation!

Research dimensions	No.	Indicator of measurement questionnaire	Degree of important: Not important (1)	Less important (2)	Regular (3)	Important (4)	Very important (5)
Over-packaging	P1	Ensure that the courier goods are not damaged	☐	☐	☐	☐	☐
	P2	To provide better service	☐	☐	☐	☐	☐
	P3	Quality of packaging materials	☐	☐	☐	☐	☐
	P4	Cater to psychology of consumer	☐	☐	☐	☐	☐
	P5	To get good reviews and improve the rating of the store for e-commerce operator	☐	☐	☐	☐	☐
	P6	Perfect packaging technology	☐	☐	☐	☐	☐
	P7	Quality of express delivery practitioners	☐	☐	☐	☐	☐
	P8	Environmental awareness	☐	☐	☐	☐	☐
	P9	Uniform standard for express packaging	☐	☐	☐	☐	☐
	P10	Supervision system for express packaging	☐	☐	☐	☐	☐
Express packaging materials	W1	Scope of use of new packaging materials	☐	☐	☐	☐	☐
	W2	Suitable green material	☐	☐	☐	☐	☐
	W3	Professional R&D talent for green packaging materials	☐	☐	☐	☐	☐
	W4	Express delivery companies, e-commerce sellers, and packaging suppliers pursue interests	☐	☐	☐	☐	☐
	W5	Price of green materials	☐	☐	☐	☐	☐
	W6	National policy	☐	☐	☐	☐	☐
	W7	Relevant industry standards	☐	☐	☐	☐	☐
	W8	Implementation of the idea of green environmental protection	☐	☐	☐	☐	☐
Express packaging recycling	R1	Consumers' understanding of express packaging waste	☐	☐	☐	☐	☐
	R2	Whether e-commerce and courier companies have considered setting up packaging recycling services	☐	☐	☐	☐	☐
	R3	Recycling system technology	☐	☐	☐	☐	☐
	R4	Relevant industry standards	☐	☐	☐	☐	☐
	R5	Recycling cost of express package	☐	☐	☐	☐	☐
	R6	Variety of express packaging materials	☐	☐	☐	☐	☐
	R7	Express packaging is not recyclable	☐	☐	☐	☐	☐
	R8	Soundness and perfection of relevant laws and regulations	☐	☐	☐	☐	☐
	R9	Support for appropriate policies and funding	☐	☐	☐	☐	☐
	R10	Implementation of the ideas of green environmental protection	☐	☐	☐	☐	☐

1. Your identity is: ☐ Consumers ☐ E-commerce sellers ☐ Express delivery practitioners
2. Do you know about overpacking: ☐ Yes ☐ No
3. Do you think that the impact of China's express packaging on the environment is:
   ☐ No ☐ Slight ☐ More serious ☐ Very serious
4. Do you know the concept of green express packaging: ☐ Yes ☐ No
5. How do you deal with express packaging waste in most cases (filled by consumers and e-commerce sellers):
   ☐ Discard ☐ Recycle after using ☐ Reuse for next time ☐ Other
6. Do you want to recycle discarded courier packaging (filled by express delivery practitioners): ☐ Yes ☐ No