

# Research on the Development and Application of Green Packaging in China

Shuai Li

College of Transport & Communications, Shanghai Maritime University, Shanghai 201306, China.

736182364@qq.com

---

## Abstract

At present, various countries have paid more attention to environmental protection. With the introduction of a series of environmental protection policies, the purpose is to reduce environmental pollution while increasing profits. In this paper, from the perspective of international market, combined with the international environment, this paper analyzes the results of implementing environmental protection policies and environmental protection testing from import and export countries, establishes a game model, uses game analysis, constructs game payment matrix and replication dynamic equation, analyzes the necessity of national implementation of green packaging, and proves that the implementation of green packaging is beneficial to the country A measure beneficial to the people can greatly reduce environmental pollution and improve the utilization rate of resources. Based on the analysis results, a series of countermeasures are put forward.

## Keywords

Green packaging, Countermeasures, Game analysis, Payment matrix.

---

## 1. Introduction

The consensus reached by green packaging is environmental protection packaging, and there is no unified meaning in academic circles. Lin zhe [1] thinks that the package that is harmless to the environment and can be reused, regenerated, degraded and differentiated is called green packaging; generally speaking, green package means that the whole process of selecting raw materials, manufacturing products, using, recycling and abandoning packaging products meets the ecological requirements, and will not pollute the ecological environment and harm human body. In addition, the following principles should be followed: (1) reduction, repeatable, recyclable and degradable; (2) in the whole life cycle of production, it should be kept green.

Under the impact of the current wave of environmental protection in the world, environment and development has become a major issue of universal concern in the international community. In the 20th century, some researchers analyzed the problems of trade and environment. For example, duhaime et al. [2] evaluated the packaging used in express delivery through case study. Hellstrom and Johansson [3] evaluated the control of food recyclable packaging strategy through simulation. Zhang Lianzhong [4] confirmed that trade liberalization is conducive to environmental protection through the general equilibrium model; Gao Yunsheng, Zhang Yong'an and others from the perspective of economics believe that the long-term effect of green trade barriers on China is positive [5]; Chen Haojie [6] thinks that green barriers can be set under the premise of ensuring trade through the North-South trade model.

With the continuous growth and growth of China's packaging industry, packaging not only brings convenience and benefits to people, but also causes serious harm to the living environment of human beings. On the one hand, packaging consumes a lot of energy and resources, on the other hand, increasing waste has become the fourth pollution source of human beings, which is second only to marine lake pollution, water pollution and air pollution. Considering the strategy of sustainable development, it is of great significance to develop green packaging materials and widely develop green packaging. This paper analyzes the relationship between green packaging and environment under the current situation by analyzing the current environment and combining with the game model. The game model has long been used by a large number of scholars to solve the corresponding problems. For example, Cowen constructs an evolutionary game model to analyze the influencing factors of transaction cost in free competition [7]. Friedman analyzed the influence between aunt Mo and enterprises in different countries through the game model [8]. Based on evolutionary game theory, barari and Agarwal analyzed how to maximize the benefits between producers and middlemen [9]. The results of model analysis show that the implementation of green packaging measures can greatly reduce environmental pollution and increase the utilization rate of resources.

## 2. Model Construction

The participants are two bounded rational players, i.e. exporting country (E) and importing country (I). Now we assume that there are two kinds of strategic spaces for exporting countries, SE = (implementing green packaging exports, not implementing green packaging exports); and importing countries have two strategies SI = (implementing green packaging testing, not implementing green packaging testing). Among them, "implementing environmental protection export" refers to that the exporting country strictly follows the export requirements of green packaging products in the process of export, while "not implementing green packaging export" is the opposite. In importing countries, "implementing green packaging inspection" means that the imported products are tested in strict accordance with the environmental protection requirements of products, while "not implementing green packaging testing" is the opposite. In the following models, "environmental protection" is used instead of "green packaging".

### 2.1 Model Assumptions

Hypothesis 1: under the initial conditions, the probability of exporting countries choosing to actively implement environmental protection export supervision is  $x$  ( $0 \leq x \leq 1$ ), on the contrary, the probability of choosing not to implement environmental protection export is  $1-x$ ; the probability of implementing environmental protection inspection in the initial condition of importing country is  $y$  ( $0 \leq y \leq 1$ ), otherwise, the probability of choosing illegal operation is  $1-y$ .

Hypothesis 2: the goal of the exporting country is that the export can pass the testing standard of the importing country. When the exporting country "implements the environmental protection export" strategy, the degree of the realization of the export country's goal is 1; when the export country does not implement the environmental protection export strategy, the realization degree of the regulatory target is  $a$  ( $0 < a < 1$ ). When the importing country adopts the strategy of "implementing environmental protection testing", the degree of realization of the target is 1 in the exporting country, and  $\beta$  ( $0 < \beta < 1$ ) when the strategy of "no environmental protection testing" is implemented.

Hypothesis 3: when the importing country adopts "environmental protection testing", it will produce positive environmental protection benefits to its domestic society, and the economic benefit is set as  $R_t$ . When the importing country adopts "environmental protection testing", it needs to pay the cost of  $C_t$ .

Hypothesis 4: the revenue of the exporting country is set as  $R_d$ , the exporting country needs to pass the environmental protection standard verification when choosing the strategy of "implementing environmental protection export", and it needs to invest the cost of  $CD$  to achieve the verification. Due to the existence of these additional costs, some exporting countries prefer not to implement environmental protection export strategy. However, if the exporting country chooses the strategy of

"implementing environmental protection export", the importing countries will give positive comments on it, which will increase its international reputation, and other importing countries will increase their willingness to import their products. This part of the income is recorded as  $e$ .

Hypothesis 5: when the exporting country adopts the strategy of "not implementing environmental protection export", if the importing country adopts the regulatory strategy of "implementing environmental protection testing", the export country's substandard export products must be found, and the exporting country needs to pay the penalty amount of  $P$ . If the importing country adopts the regulatory strategy of "not implementing environmental protection testing", the probability of non-compliance operation of exporting country is  $\theta$  ( $0 \leq \theta \leq 1$ ) to be found by non-governmental organizations, and the loss caused by the discovery is recorded as  $P_t$ .

### 2.2 Constructing Game Payment Matrix

According to the above assumptions, the game payoff matrix can be obtained as follows:

Table 1. game payoff matrix

importing country	Exporting countries	
	Implement environmental protection export(x)	No environmental protection export(1-x)
Implementation of environmental protection testing(y)	$R + R_t - C_t - r; R_d - C_d + r$	$\beta R + R_t - C_t + P; R_d - P$
No environmental protection testing was carried out(1-y)	$aR + R_t - C_d; R_d - C_d$	$a\beta R + R_t - \theta P_t; R_d$

### 2.3 Construction Of Replication Dynamic Equation

According to the hypothesis, the expected return of exporting country E is as follows:

$$Et_1 = (R - \beta R - P - r)x + \beta R + R_t - C_t + P \tag{1}$$

The expected returns of exporting country E are as follows:

$$Et_2 = (aR - a\beta R + \theta P_t)x + a\beta R + R_t - \theta P_t \tag{2}$$

The average income of exporting country E choosing the mixed strategy of "implementing environmental protection export" and "not implementing environmental protection export" is as follows:

$$\overline{Et} = yEt_1 + (1 - y)Et_2 \tag{3}$$

The expected benefits of importing country I choosing "environmental protection testing" are as follows:

$$Ed_1 = (r + e)y + R_d - C_d \tag{4}$$

The expected benefits of importing country I choosing not to implement environmental protection testing are as follows:

$$Ed_2 = -Py + R_d \tag{5}$$

When importing country I chooses the mixed strategy of "implementing environmental protection testing" and "not implementing environmental protection testing", the average income is as follows:

$$\overline{Ed} = xEd_1 + (1 - x)Ed_2 \tag{6}$$

According to Malthusian equation, the replicated dynamic equation  $F(y)$  for exporting countries to choose "implementing environmental protection export" strategy and  $G(x)$  for importing countries to choose "implementing environmental protection testing" can be obtained:

$$G(x) = \frac{dx}{dt} = x(Ed_1 - \overline{Ed}) = x(1-x)[(r+e+P)x - C_d] \tag{7}$$

$$F(y) = \frac{dy}{dt} = y(Et_1 - \overline{Et}) = y(1-y) \left\{ \left[ \begin{matrix} (1-a)\beta R \\ -C_t + P \\ \theta P_t \end{matrix} \right] + \left[ \begin{matrix} (1-\beta)(1-a)R \\ -P-r-\theta P_t \end{matrix} \right] y \right\} \tag{8}$$

**2.4 Equilibrium And Stability Analysis Of Evolution Process**

According to the stability theorem of differential equation, the equilibrium point of the evolutionary system can be obtained by making the copy dynamic equation of both sides equal to 0

$$\begin{cases} G(x) = \frac{dx}{dt} = 0 \\ F(y) = \frac{dy}{dt} = 0 \end{cases} \tag{9}$$

The five local equilibrium points of the game between the importing country and the exporting country are obtained: (0,0), (0,1), (1,0), (1,1), (x\*, y\*),

$$\begin{cases} x^* = \frac{C_d}{r+e+P} \\ y^* = \frac{(a-1)\beta R + C_t - P - \theta P_t}{(1-a)(1-\beta)R - P - r - \theta P_t} \end{cases} \tag{10}$$

In the analysis of local stability, we only need to determine the positive and negative of determinant and trace of Jacobian matrix.

If the determinant value (|J|) and trace (TrJ) is positive, the point is unstable (|J|); If the determinant value (|J|) is negative, the point is a saddle point; If the determinant value is positive and the trace is negative, the point is stable, that is ESS. Let Jacobian matrix be J, we analyze the stability of the five equilibrium points of the game system. The Jacobian matrix J of this system is:

$$J = \begin{bmatrix} \frac{\partial F(y)}{\partial y} & \frac{\partial F(y)}{\partial x} \\ \frac{\partial G(x)}{\partial y} & \frac{\partial G(x)}{\partial x} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \tag{11}$$

Among them,

$$a_{11} = (1-2y) \{ [(1-a)\beta R - C_t + P + \theta P_t] + [(1-\beta)(1-a)R - P - r - \theta P_t]x \} \tag{12}$$

$$a_{12} = y(1-y)[(1-a)(1-\beta)R - P - r - \theta P_t] \tag{13}$$

$$a_{21} = x(1-x)(r+e+P) \tag{14}$$

$$a_{22} = (1-2x)[(r+e+P)y - C_d] \tag{15}$$

The values in Jacobian matrix corresponding to the five local equilibrium points can be obtained as shown in the table below.

It can be seen from the table above: at point (0,1), when  $a_{11} < 0$ , no matter how the variable changes, the point is a saddle point; conversely, it is an unstable point; at point (1,0), when  $a_{22} < 0$ , no matter how the variable changes, the point is a saddle point; on the contrary, it is an unstable point; at point (1,0), the point is a saddle point, regardless of how the variable changes. At point (1,1), When  $a_{11} \times a_{22} < 0$ , there will be two situations: (1)  $a_{11} > 0$  and  $a_{22} < 0$ ; (2)  $a_{11} < 0$  and  $a_{22} > 0$ , no matter

how variable changes, this point is saddle point; when  $a_{11} > 0$  and  $a_{22} > 0$ , this point is unstable point. Through  $a_{11} < 0$  and  $a_{22} < 0$  to analyze the cooperation boundary between the two countries. It can be seen from the above that when the two countries are in (0,1) and (1,0), it means that only one country chooses environmental protection export or environmental protection detection, then the whole system is in an unstable state, and when the two countries adopt the same strategy, it reaches a stable state. In other words, the implementation of "environmental protection inspection system" in exporting countries tends to be unstable. However, due to the fact that the exporting countries will have to pay extra fees when they do not implement environmental protection export policies, at the same time, according to the current economic policies, the two countries are more inclined to jointly implement environmental protection export and testing.

Table 2. local stability analysis process of game system

Equilibrium point	$a_{11}$	$a_{12}$	$a_{21}$	$a_{22}$
(0,0)	$(1-a)\beta R - C_t + P + \theta P_t$	0	0	$-C_d$
(0,1)	$(1-a)R - C_t - r$	0	0	$C_d$
(1,0)	$(a-1)\beta R + C_t - P - \theta P_t$	0	0	$r + e + P - C_d$
(1,1)	$(a-1)R + C_t + r$	0	0	$-r - e - P + C_d$
$(x^*, y^*)$	0	$a_{12}^*$	$a_{21}^*$	0

### 3. The current situation and problems of the application and development of green packaging in China

China's packaging industry has been developing for more than 20 years since 1980. Nowadays, China has become a big packaging country, and is moving towards a packaging power. The packaging of products ensures that the products can avoid all kinds of external damage in the process of circulation. It has the functions of convenient storage, transportation, sales and use, conveys the brand information of commodities and enterprises, plays a good role in promoting sales, and expands the market popularity of products. However, in addition to the positive effect, some packaging problems such as unscientific design, lack of environmental protection materials and resource saving are increasingly prominent. At present, the development status of green packaging application in China mainly has the following problems:

#### 3.1 The Development Of Green Packaging In The Domestic Market Is Low

With the prosperity of modern commercial economy and the continuous change of people's life style, enterprises take packaging as an important means of marketing competition. However, China's packaging industry started late, there are few relevant laws and regulations, and the constraints are relatively poor; the domestic packaging industry structure is unreasonable, research and development capacity is weak, and the technology is backward. The knowledge and understanding of green packaging of production enterprises and consumers is far from enough. These are the important reasons for the slow development of green packaging in China. Irrational packaging, such as non green packaging, excessive packaging, value-added packaging and so on, is flooding the domestic market. About 30% of the production cost of high-end packaging products exceeds the standard of ordinary food packaging. For example, as reported by domestic media, the super large and super luxury packaging is used to improve the quality of the products. The packaging of "Du" is more expensive than "Pearl", which attracts a part of consumers with strong vanity. It makes a lot of profits for manufacturers and makes packaging go to the other extreme. The foam plastic lunch boxes and plastic foam fast food boxes, which are widely used in the domestic market, are used as packing wastes after being used. Moreover, the waste can not be recovered or degraded, forming a pollution

source and seriously polluting the ecological environment. Although China has carried out the campaign of "banning white garbage" in the mid-1990s, it is still prohibited repeatedly, even more and more. According to relevant data, China accounts for 8 of the 10 cities with the most serious garbage pollution in the world, and more than 200 cities in China are surrounded by garbage, which is difficult to recover and degrade. It has seriously damaged the ecological environment of the earth and endangered human health. At present, although China has also promulgated the "general principles for the treatment and utilization of packaging waste" and other relevant laws and regulations, there is still no special packaging management regulations. And because of the lack of mandatory binding force from the administrative departments, it is difficult to achieve the desired purpose.

### **3.2 The Comprehensive Utilization Rate Of Green Packaging Products Is Low**

Due to the poor management of green packaging in China, a large number of packaging containers and contents are discarded every year. The direct economic loss is more than 15 billion yuan, of which 70% is caused by transport packaging. For example, the breaking rate of cement is 15% - 20%, and the annual loss is about 3 million tons; for glass, the average damage rate is about 20%, and the annual loss is even 450 million yuan. In addition, according to the statistics of foreign trade department, due to the backward level of green packaging technology of export commodities, the country loses at least 10% of foreign exchange income every year. For example, at present, China's express industry packaging is still concentrated in six categories: express waybill / express electronic waybill, plastic bag, woven bag, packing box (corrugated box), envelope and tape. The use of green packaging is very small. In 2017, the actual recovery rate of cardboard and plastic used in packaging and express delivery was less than 10%, and the overall recovery rate of packaging materials was less than 20%. According to estimates, behind the huge transaction volume of "double 11" in 2017: the recovery rate of packaging materials in express delivery industry is very low, and 40.6 billion express delivery products produce about 8 million tons of waste, accounting for 2% of the total domestic waste in China. Among them, more than 16 billion plastic bags, 34 billion meters of tape, 20 billion boxes and 6 billion bubbles were consumed. This also means that behind the huge transaction volume of "double 11": the recovery rate of packaging materials in express delivery industry is very low, packaging waste can fill nearly 400000 football fields, and sealing tape alone can cover more than 800 circles around the equator.

### **3.3 Unbalanced Development Of Enterprises**

Different enterprises have different time to implement green packaging, and most of them are export-oriented enterprises. This kind of enterprises are affected by the international market, so they know green packaging early and quickly adjust their packaging strategy. However, the domestic market-oriented enterprises are slow to respond to green packaging, and only in recent years have they started to set foot in green packaging. Secondly, the development of green packaging is not balanced among regions. Green packaging is developing rapidly in economically developed areas. However, for the central and western regions where the economy is relatively backward, green packaging has not been given enough attention and publicity, leading to its slow development. In the treatment of packaging waste, the policies and laws of different regions are inconsistent, resulting in the transfer of packaging pollution to economically underdeveloped areas.

## **4. Countermeasures for the development of green packaging in China**

### **4.1 Develop Green Packaging Technology**

It mainly includes three aspects: (1) The improvement method of packaging materials; (2) cleaner production methods; (3) waste packaging recycling method:

The improvement method of packaging materials: the selection of packaging materials is the material basis for the realization of the three major functions of packaging, namely, convenience function, protection function and sales function. Therefore, the research and development of green packaging

materials is the key to the realization of green packaging. Green packaging raw materials can be considered in two aspects: one is natural materials; the other is ecological materials or ecological transformation of traditional materials. Plastic, glass, metal and other packaging materials waste has become an important factor of environmental pollution, and because of the high energy consumption of resources, non renewable, resulting in high production costs. However, some of the natural biological materials used for packaging, such as wood, bamboo, willow, hemp, rattan and reed, can be made into packaging materials, and some can be made into important packaging materials after simple processing. They can be easily decomposed in the natural environment, will not pollute the ecological environment, and can be renewable resources, the cost is relatively low.

Cleaner production method: Manufacturing technology and processing technology research, any kind of raw materials must be processed to become packaging products. The original processing technology may not consider the environmental problems comprehensively when designing and manufacturing. After the environmental problems are prominent, it needs to be improved to meet the new environmental requirements. In 1989, the Governing Council of the United Nations Environment Programme put forward the concept of clean production, that is, the whole process pollution control mode of production. The meaning is to continuously apply the comprehensive environmental protection strategy of pollution prevention to the production process, product design and product service, starting from the generation of pollution sources, to reduce the risk to human and environment in the process of production and service. In recent years, some progress has been made in the pilot demonstration, publicity, education and training, international cooperation, policy research and development, etc. Green packaging processing and manufacturing should promote cleaner production methods, focusing on the innovation of processing and manufacturing technology, one is to develop pollution prevention technology with zero emission as the goal; the other is to develop end treatment technology aiming at reducing the emission of waste and pollutants, that is, to innovate the original processing and manufacturing technology.

Recycling method of waste packaging: Research on recycling technology, recycling and recycling of waste packaging is the most urgent and realistic choice to promote green packaging. The first is to proceed from the national conditions. China's per capita resource share is very low, and the comprehensive strength of economic development has certain limitations, so we must vigorously recycle and save resources. Secondly, recycling old packaging can effectively reduce and digest packaging waste and reduce environmental pollution. In the packaging industry, the recycling technology of waste packaging is particularly important. For example, "white pollution" has aroused people's strong concern about plastic packaging. Many people of insight believe that the key to solve "white pollution" is recycling and proper treatment. At present, developed countries in the world, such as Japan, Germany, the United States, Switzerland, the United Kingdom, are vigorously developing recycling systems. Among them, the United States and Japan have formed industrialization and commercialization. It formed the fastest growing industry in the 1990s.

#### **4.2 Improve The Utilization Rate Of Green Packaging Resources**

China has a large population, and the total amount of packaging waste is very high. Nowadays, due to the loose management of packaging waste, packaging waste can be seen everywhere in many large and medium-sized cities, along the railway, tourist resorts and river basins, causing serious pollution to the ecological environment. In addition, China is a big developing country, with weak economic strength, insufficient per capita resources and low waste utilization rate; at the same time, China imports hundreds of thousands of tons of pulp with a large amount of foreign exchange every year, resulting in waste of resources and loss of foreign exchange. With the development of China's packaging industry, the total amount of packaging products of plastics, metals, glass and other materials is increasing. If the recovery rate is not increased and the waste is reduced, the degree of environmental pollution will be further aggravated. Therefore, we must make the whole society pay attention to packaging recycling, make full and effective use of various resources, reduce costs, reduce pollution, and reduce trade difficulties caused by packaging problems.

### 4.3 Strengthen The Research On Supporting Policies Of Green Packaging

There is a wide range of recycling materials and recycling technology, which need to be coordinated with the organic resources and personnel. At the same time, recycling and environmental protection should be combined. For example, environmental profit and loss analysis should be carried out, and the external loss of packaging waste should be internalized, that is, the environmental cost of packaging waste pollution should be included in the operating cost, which is not only conducive to environmental protection, but also beneficial to income.

### 4.4 Improve The Corresponding Legal System Of Green Packaging

Laws and regulations should be targeted and mandatory. To improve the corresponding green packaging law system, while guiding the packaging industry to attach importance to the development of green packaging, should be able to effectively regulate the production behavior of packaging industry enterprises, the service behavior of packaging service industry and the personal behavior of consumers. Li Aihua et al. [10] pointed out that China's legal system of green packaging needs to be improved, vigorously promote green packaging and improve the competitiveness of China's commodities in international trade. Packaging service industry and packaging industry enterprises are the "source" of packaging waste, which links the environmental cost of packaging waste with the operation of enterprises and service industry, and promotes it to simplify packaging and recycle packaging waste.

## 5. Conclusion

Nowadays, people pay more and more attention to green packaging, the scope of green packaging design is gradually expanding, and people also begin to pay attention to humanistic value and long-term value. China's packaging enterprises need to constantly carry out technological transformation and innovation, improve production efficiency, the utilization of primary raw materials, in order to save more social resources. At the same time, we should also take the first step in the concept of environmental protection, adhere to and learn the advanced concept of green environmental protection, put it into the actual production and operation activities, and take the development path of green environmental protection. The state and government should establish and improve some laws and regulations on green packaging as soon as possible, and increase publicity.

In this paper, through the establishment of the model, the use of game analysis, combined with the results obtained and the current domestic environmental situation, found some problems faced, and put forward some solutions. Because this paper needs to make suitable assumptions and preconditions when building the model, so the model of this paper is not very perfect, for example, it does not consider the freight problem, as well as the loss of transport costs, which still need to be improved.

## References

- [1] Z. Lin :On the establishment of "green packaging" system [J]. Journal of Shanxi University of Finance and economics, 1992, (05): 43-45.
- [2] Duhaime R, Riopel D, Langevin A .Value Analysis and Optimization of Reusable Containers at Canada Post[M]. INFORMS, 2001.
- [3] Hellstrom, D, Johansson, O. The impact of control strategies on the management of returnable transport items[J]. Transportation Research Part E Logistics & Transportation Review, 2010, 46(6):0-1139.
- [4] L.Z. Zhang, T. Zhu, M.Q. Li, et al. The impact of trade liberalization on China's environmental pollution [J]. Nankai economic research, 2003 (03): 3-6.
- [5] Y.S. Gao, Y.A. Zhang: An analysis of the impact of EU's new green barriers on the export of China's small and medium-sized enterprises [J]. Finance and trade economy, 2007 (13): 96-103.
- [6] H.J. Chen: Research on green trade barrier and international trade relations -- Also on China's countermeasures [D]. Xiamen: Xiamen University, 2009.
- [7] Cowen C C .An analytic Toeplitz operator that commutes with a compact operator and a related class of Toeplitz operators[J]. Journal of Functional Analysis, 1980, 36(2):169-184.

- [8] Friedman D., Fung K C. International Trade and the International Organization of Firms: An Evolutional Approach [J]. Journal of International Economics, 1996(41): 45-56.
- [9] Barari S, Agarwal G, Zhang W J, et al. A decision framework for the analysis of green supply chain contracts: An evolutionary game approach[J]. Expert Systems with Applications,2012, 39(3):2965-2976.
- [10] A.H. Li, J.S. Shang: Green packaging legal system needs to be established and improved[J]. Environmental economy, 2010 (z1): 94-97