

# Stakeholder System and Analysis of Extended Producer Responsibility Based on Game Theory

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**Abstract:** Extended producer responsibility (EPR) is an effective environmental policy principle in terms of motivating responsible corporate to enhance their product's life-cycle environmental performance. However, on the other hand EPR also challenges greatly the core companies into a complicated and dynamics product life-cycle stakeholder system. In this paper, the structures and features of product life-cycle stakeholder system under EPR is analyzed according to stakeholder theory. Primary and secondary stakeholders are identified followed by their inter-relationships discussed. A two-entity static game model is set up accordingly. Mixed-strategy equilibrium is analyzed and key influential factors are studied in detail. Adaptive decision-making suggestions are made in brief for companies facing EPR in several specific scenarios with the dynamic of the above key factors and information.

**Keywords:** adaptive management; extended producer responsibility; car industry

## 1 Introduction

With rapid industrialization, modernization and urbanization, there are billion tons of wastes including used and discarded products produced every year worldwide. These wastes not only deteriorate the already seriously polluted environment but also make numerable useful resources dumped to "wrong places", the landfills. As a result, natural resource exhaustion and environmental pollutions are deteriorated to be major obstacles for sustainable development. Based on practical experiences of waste management and cleaner production promotions, T. Lindqvist initially raised the concept of extended producer responsibility (EPR) in 1988 [1], which proves to be an effective policy principle to motivate effective source solutions for "end-of-pipe" problems.

Within the past two decades, EPR has drawn nearly 20 countries' wide attentions, and has been applied in the product waste management of about 20 industries. EU members, Japan [7] and other countries have established a relatively perfect system of mandatory EPR policy. Countries that characterized by voluntary agreement, such as United States and Canada, have also embarked on the study of EPR policies and regulations, and started the transferring process from voluntary agreements to more mandatory regulations management. Those countries who have not yet established a system for EPR policies and regulations are also actively exploring the formulation of relevant laws and specific implementation plan. From 2004, China has also begun to explore the application of EPR principles in the field of waste management, as well as the applications in the electronics and automobile industries. EPR principles have been incorporated in the "Solid Waste Law" and "Circular Economic Law" (refer to the following six literatures: China "Solid Waste Law", "Circular Economic Law", "Two Regulations of Electronic Industry" and "Two Regulations of Automobile Industries"). Throughout the world, EPR presents its different characteristics in different countries, industries and periods of time, as well as the diversity of applications.

However, as in its infancy, the implementation of EPR is also facing various problems. One of the most important ones is the participation of single company. T. Lindqvist [2] indicates that individual company's active participation to achieve product life-cycle improvement is critically important for successful

EPR implementation. And product life-cycle system is complicatedly composed by various stake-holders in the dynamic market environment. Unfortunately, recycling-related knowledge and fast system learning capabilities processed by producers are mostly limited. As a result, a number of companies behave passively, which highly hinders the implementation of EPR programs. As important as the problem is, few in-depth studies or effective solutions have been intended or provided to enhance individual company's actively responding capabilities from more systematic and integrated life-cycle point of views yet [3].

It is concluded in our previous research that, the greatest challenges that EPR brings to the core enterprises is the extended responsibilities, which are beyond the original scope of enterprises' business. The extended responsibilities require the enterprises not only adjust the existing supply system, but also integrate the recycling relief with the production process. From the management perspective, this involves plenty of unknown knowledge for the enterprises, and increases the uncertainty of enterprise management. Just because the involved life-cycle stakeholder system is diverse, complex and dynamic, the enterprises must re-examine the existing system from a new perspective to understand the functioning mechanisms of the new scenario. In other words, to investigate the challenges core companies are facing under EPR within a more systematic framework and to study their responsive strategies from more integrated and dynamic viewpoints would be more practically significant for responsible companies as well as for smooth implementation of EPR.

Although the problem of "free-rider" has always been paid attention to from the beginning stage that EPR was introduced [4], few researches carried out studies from systematic level. Recent years, the difficulties for companies taking their responsibilities are concluded as the following aspects: (1) the financial deficiency; (2) the lack of technological solutions [3][5]; (3) unnatural development of the related supply chain system [5]; (4) difficulty in finding an efficient and effective method for collecting their own products [6]; and (5) less scale economy of the returning wastes to be recycled.

As complicated and dynamic the life-cycle stakeholder system is, this research introduces the concept of adaptive management into companies' strategy making process under EPR. Distinct from previous studies on decision-making support in providing the best management strategy with the current knowledge the companies have, this research is trying to forward an adaptive framework by following which companies could continuously learn about the related life-cycle stakeholder system and adapt their management strategies in accordance with the development and dynamic process of this system.

## **2 System Analysis**

### **2.1 Stakeholder mapping framework**

As a concept used in corporate administration or project management, stakeholder is viewed as any person or organization that can be positively or negatively impacted by, or cause an impact on the actions of a company. In order to clarify the consequences of envisaged changes, or at the start of new projects and in connection with organizational changes generally, analysis needs to be carried out to all the stakeholders including the primary stakeholders, secondary stakeholders and more significantly those identified as the "KEY" stakeholders. Different method of stakeholder mapping are developed for different analytical aims and system situations.

In this research, stakeholder analysis is carried out with three aims: (1) to analyze each stakeholder's features and major influences on core producer; and (2) to identify the "KEY stakeholders" and important interaction during the implementation and strategy-making of EPR. Therefore, based on the theory of stakeholder analysis, a three-dimensional framework is adapted for this research including attitude, power and interest. Attitude describes the manner a stakeholder is related to EPR program as well as major functions it has during the whole process. In this dimension, discussion will be focused on whether a stakeholder is an active influencer or passive influencee for core producer's responsive strategies. Power des-

cribes strengthens of the influence a stakeholder has on the design and results of the manufactures' strategy. Whether a stakeholder could strongly influence the core producer's strategy making and the potential outcome as well will be judged in this dimension. **Interest** describes the extent to which a stakeholder is willing to get involved and informed. With the understanding of whether higher or lower involvement and informing level more acceptable for a certain stakeholder, suitable management measures for each stakeholder will be identified. Three types of key stakeholders are intended to be identified. The active influencers with strong power and higher interest are primary key stakeholders. The passive influencees with strong power and higher interest are secondary key stakeholder. The passive influencees with strong power but lower interest are also key stakeholders who need special incentives to keep them playing positively cooperative roles.

## 2.2 The proposed stakeholder system

As discussed above, implementation of EPR not only changes the original supply chain system, but also introduces new stakeholders to formulate a new stakeholder system. As shown in Fig.1, taking car Industry as an example, traditional supply system in car industry includes suppliers, a core manufacturer, distributors and retailers and the customers. To escape the recycling fees, many end-users dump their used cars in forests or natural fields, where traditional waste management measures failed to solve the problems of land pollution and resource inefficiency caused by end-of-life cars as shown by the broken arrow in Fig.1.

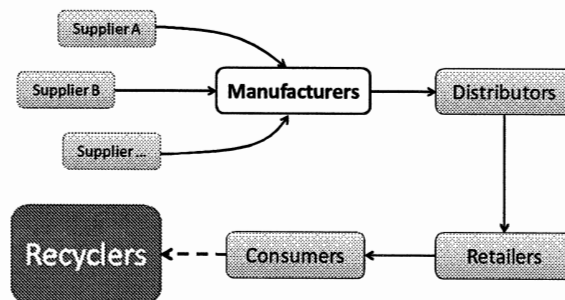


Figure 1 Flow of Car Production and Recycling without EPR Programs

Our proposed life-cycle stakeholder system under EPR program implemented in car industry is demonstrated in Fig.2. As implementing EPR, the government intervenes in the market in a more comprehensive way that assigns full or major end-of-life cars management responsibilities to manufactures and at the same time sets new requirements to other stakeholders, as shown by red arrows in Fig.2. New stakeholder relationships are coming into being as a result. Under the collecting-related requirements, end users are supposed to return their used cars through the distributing system to the recyclers. Under the recycling-related requirements, suppliers are also got involved to make the design improvement to increase car recyclability. Last but not least, third-part organizations are set up to serve financial, physical or informative responsibilities. All these induced relationships are represented by blue arrows in Fig.2. Meanwhile, some new some of the newly emerged relationships are indirect but also significant. For example, customer behaviors highly influence the manufacture's performance of soundly taking the extended responsibilities as the same as the recycler performance does. The R&D capabilities of the suppliers affect the designing improving results and indirectly influence the recycling performance. This could impliedly explain why a government is very slow in carrying out a new or higher environmental requirement sometimes (talk with David Feldman 22 Jan. 2009). In Fig.2 broken arrows represents the above indirect important relationships.



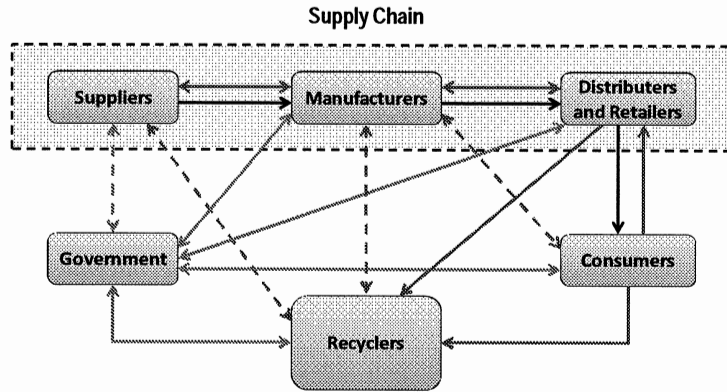


Figure 2 Life-cycle Stakeholder System Under EPR Program Implemented in Car Industry

Actually, the mutual relationships and interactions among the life-cycle stakeholders under PER is far more complicated than what is explained above. For example, in different countries the government could be further divided into the central government and municipalities as in federal regime as the US. However as trying to clearly describe this system and inside relationships, simplicity is also an important criterion to set up the theoretical framework with only key interrelationships being focused as shown in Fig.2.

### 2.3 Stakeholder Analysis and Features

According to the above three dimensional analytical framework, five stakeholders will be analyzed including government, suppliers, distributors and retailers, customers, and recyclers.

#### *Attitude analysis:*

Government is the only active initiator of EPR programs. With the increasing environmental problems caused by end-of-life products and growing resource detraction pressures, more and more government are implementing EPR to incentive upstream manufactures into the product life-cycle environmental performance management especially the post-consumption wastes. As the government starts conceiving to adopt EPR, core producers will firstly get involved into the communicating process. As for the other stakeholders such as customers, recyclers, suppliers and so on are involved after a real EPR program is implemented. In other words, both producers and the other stakeholders except government will be passively influenced by EPR.

However, the introduction and implementation of EPR is quite an interactive process, where communication and negotiation between government and major producers could be several-year long before a specific EPR program is finally introduced to an industry. During this process, producers' awareness is educated and economic system gets time to make necessary preparation before the regulation gets through. On the other hand, status and willingness of the whole economic system greatly influence the process resulting in some voluntary programs and even no EPR at all. In other words, how an EPR program is designed and implemented is resulting from the bout between the environmental problems managed by government and status and capabilities contained by the economic system. In some special cases, producers will actively engage into the end-of-life products recycling and managing driven by attractive economic benefits. For example, Ford GM and Chrysler co-founded an R&D center to increase the recyclability of automobiles in Detroit. Ford also merged some recycling companies in Europe [8][9].

#### *Power analysis:*

The power of government for an EPR program is up to whether it is commendatory or voluntary one. In such areas with comparatively less land space and large populations as Europe and Japan, commendatory programs are adopted through environmental laws and regulations. In this case, government has the strongest power.

Recyclers also have strong power since the technological capabilities and operating performances greatly affect the realization of the final recycling performances both ecologically and economically. Thus as producers making their responsive strategies, they must take the current recycling level and potential improvement possibilities into consideration, where some of the questions are not technological but political and managerial. A side-effect worth of attention here is that a disordered recycling market could be a big hindering factor for EPR implementation even if sounder eco-design and recycling technologies are ready in the market.

Another stakeholder with strong power is suppliers because almost all the design improvement practices need participation and cooperation of the suppliers. R&D ability of suppliers and the possibility of changing new suppliers are consequently a decisive factor of the source design improvement by the producers not only in terms of R&D competency but also concerning the economic issues.

Roles supposed to be played by the customers and distributors are important but not so strong, since a certain economic incentives and institutional arrangement will soundly ensure the involvement distributing system and customers. Comparatively, secondary market for used products is an important factor though an external factor as well. Discussions on this issue is very significant for some economies but beyond the scope of this research.

*Interest analysis:*

Government has the highest interest in EPR programs than any other stakeholders. Not only the design of an EPR program at the starting stage but also how it is monitored and improved during the implementation process is desired by the government. Recyclers could be interested if well-informed of the details of product structure, component and materials adopted would contribute to higher recycling performance and earning. On the contrary, suppliers are always lack of interest in EPR programs as extra costs will be caused, though suppliers have also strong power. The supply-demand incentives will drive the suppliers to cooperate. The public with higher environmental awareness and environmental NGOs also have higher interest in the process of EPR and the strategies taken by core producers, or the green image. It has contributed to a driving factor for company’s environmentally friendly actions in for example Europe and Japan [10] etc.

**Table 1 Life-cycle stakeholder mapping under EPR**

	Attitude	Power	Interest
Government	Active	High	High
Recycler	Passive	High	High
Supplier	Passive	High	High
Customer	Passive	Low	Low
Distributors	Passive	Low	Low
Public	Passive	Low	High

Features of each life-cycle stakeholder for the core company in an EPR program are summarized as Tab.1. In concluding the above analysis, government is the most important stakeholder in EPR program. Interaction between government and core producers is significant so that game model will be developed in next

section to further study the key factors for strategy making of companies to respond to EPR. In this game model, Capabilities of recyclers and suppliers could be taken as constraining conditions for producers' trade-offs economically. Meanwhile, information needs to be passed to customers, suppliers, recyclers and their-party organizations, vice versa.

### 3 Game Model and Analysis

#### 3.1 Hypothesis and Pay-off Analysis

Game theory is considered as one of most effective research methods for strategic decision making analysis. From the stakeholder analysis in the previous section, the producer and government are the two significant players that involved in the game analysis. In order to achieve reasonable simplification, our analytical description for the applied game model is based on the assumption for the player "government", that it includes local, national government, or other administration departments of all level, that has the authority to make and the power to enforce laws, regulations, or rules.

We consider for the government that cost of EPR program includes: Administration Cost for running the EPR program, " $a$ "; the expenses for monitoring the environmental performance achieved by companies, " $mo$ ". When adopting commendatory program, the government will penalize " $p$ " the companies which are found regulation violation. Furthermore, government will benefit " $e$ " and " $e^{db}$ " by the well performed companies' environmental achievements via recycling and eco-design improvement respectively.

On the other hand, the producers who implement recycling and collecting have to arrange the corresponding cost, " $rc$ ". In case that the company not only implements recycling but is also self-motivated to do eco-design of new products, an extra expense " $d$ " should be arranged from the company side. While, company may have potential benefit " $m$ " from recycling by the fact that its corporate image can be elevated through the environmentally friendly behavior. Moreover, the extra market benefits " $m^{db}$ " will also be achieved through the innovative investment for eco-design improvement. However, a free rider producer will be found guilty and receive punishment " $p$ ", in accordance with the above description.

#### 3.2 Scenarios

The government players have two strategies for promoting the EPR program: mandatory programs, and voluntary programs. The former is composed of strict standards for recycling percentage, harmful material forbiddance, financial responsibilities and information distribution requirements; any violation of this program will be punished. This program is comparatively effective for implementing EPR. However, the government must effective measures in place to monitor and control the EPR project implementation; and besides, it should conduct a reasonable allocation of funds to carry out the necessary monitoring and regulatory. In general, given a relatively constant management level, the government's management and effectiveness of control is proportional to the allocated funds amount. For the alternative of government strategy, voluntary programs initiate the communication among various stakeholders, especially the producers, with a voluntary agreement for the aim of toxic substances restriction. This initiative is the Government-to-business based on trust arising. Government will only be required to pay the EPR program operating costs, such as publicity, thus the total expenditures can be significantly reduced. Nevertheless, this option is only applicable to the society that has a better understanding on environmental protection, meanwhile the leading enterprises that have a higher awareness of environmental situation.

On the contrary, the producer player has the following strategies: (1) only meet the recycling responsibility; (2) implement recycling and eco-design of the new product; and (3) free rider. For choice (1), the producer only considers the recycling of its end-of-life products' collection and recycling, for which it needs corresponding recycling cost, but has potential marketing profit from the recycling behavior. For choice (2), the implementation for both recycling and eco-design will cause extra development expen-



ditures besides the recycling cost, including environmentally friendly product development, better material requirement for its upstream suppliers. As reward, the producer may have the chance to win new markets share, as well as leading image for its design concept, thus to become more competitive. The last choice “free rider” will not be a wise alternative if the company with enough funds for the improvement of environmental issue, especially under an EPR program that mandatorily carried out by the government. Though this passive altitude can avoid further cost for either recycling or eco-design inputs, it has the risk of punishment, as well as potential loss in market. (In this paper, we do not consider the market loss for the free rider, for the sake of its inscrutability.

According to the above analysis, a pay-off matrix for this game between government and producer is demonstrated as Tab.1, where six possibilities with respective pay-offs is shown.

**Table. 1 Pay-off Matrix for the game between government and producers**

		Producers		
		Recycle Only	Recycle & Eco-design	Free Riders
Government	Mandatory Program	$-a - mo + e^r$ , $-rc + m^r$	$-a - mo + e^r + e^d$ , $-rc - d + m^r + m^d$	$-a - mo + p$ , $-p$
	Voluntary Program	$-a + e^r$ , $-rc + m^r$	$-a + e^r + e^d$ , $-rc - d + m^r + m^d$	$-a$ , $0$

### 3.3 Game Analysis

The game analysis in this paper is carried out by assuming the government takes “Mandatory Program” and “Voluntary Program” at the probabilities  $\theta$  and  $(1-\theta)$  respectively. So that, from the producer’s viewpoint we have the following equations hold:

$$P_1 = \theta \cdot (-rc + m^r) + (1-\theta)(-rc + m^r) = -rc + m^r \quad (1)$$

$$P_2 = \theta \cdot (-rc - d + m^r + m^d) + (1-\theta) \cdot (-rc - d + m^r + m^d) = -rc - d + m^r + m^d \quad (2)$$

$$P_3 = -\theta \cdot p \quad (3)$$

where,  $P_1$ ,  $P_2$  and  $P_3$  are expected utility functions with respective to each strategy. Concatenating each two of Eq.(1)~Eq.(3), we can conclude that under the Mandatory Program, if the pure profit from the eco-design improvement is positive and greater than the pure profit from recycling, “Recycle & Eco-design” is the best strategy. On the contrary, the producer would rather choose the “free rider” strategy, if the loss by the other two strategies is even worse than the punishment. Because “free rider” is the most undesirable strategy toward the government’s target, punishment should be a considerable value according to the minus environmental performance. On the other hand, in order to avoid punishment, as well as potential loss for strategies 1 and 2, producer should develop effective and efficient ways for implementing at least recycling. In case that the producer has the capability to fund new product’s development, it is wise to take strategy “Recycle & Eco-design” for promising eco-designed product, since the ecological product will be the mainstream tendency for the future society.

## 4 Conclusions

In this research, the life-cycle stakeholder system under EPR is proposed and analyzed. Features and interrelationships of key stakeholders are structured into a game model with core producers and government as the game player and recyclers and suppliers as important influential actors for trade-offs under certain scenarios. Voluntary and mandatory EPR program design are considered as two strategies for

government, under which three strategies are designed for core producers including collecting, collecting and eco-design combining ad free-rider. Three scenarios are identified as conclusion. First, as the recycling performance is too poor to reach reasonable benefits and costs for collection management is higher than government punishment for violations, producers are more likely to escape the desired responsibilities. As the recycling performance and economic system's R&D capabilities for design improvement are satisfying enough to ensure a higher profitability, more actively responsibility taking in terms of recycling and design improving will be the optimal strategy for producers.

For companies in different countries, strategies should be adapted to local conditions. For example in the United States, current environmental pressures are not as big as its European counterparts. "Negotiation and talk" is the dominant manner for environmental regulations making in most states. And there is favorable regulatory and marketing environment for end-of-life recycling business especially for used cars. Therefore, companies with certain capital and technological capacities could actively participate in the recycling business as well as "design for recycling" practices. Those with less capital or technological capacities could ignore the EPR requirements for the time being and reserve safety cash flow particularly during current economic crisis.

On the contrary, in those countries with more limited land space, more urgent environmental protecting requirements and much stricter environmental regulatory systems such as Europe and Japan, a more active strategy should be taken as priority by producers. Strategy of "free-rider" will be considered as the last choice due to the higher punishment than costs required taking the responsibilities. Therefore, companies in Europe, Japan and other mandatory-preferred countries should make more efforts on how to reduce the recycling costs for higher economic profits or how to realize the regulatory recycling goals in more low-cost manner. Meanwhile, active publication should be made in order to set up a more environmentally friendly image, since the public in those countries are normally have higher environmental awareness that could be effectively influence their purchasing behaviors. Under the condition of abundant capital capacities or aggressive company strategy as an industrial leader, investment for greener and more recyclable products would be a sounder strategy. This could be convincingly proved by the past practices of the three automobile magnates in the US, Toyota in Japan and Shanghai GM Ltd in China.

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