The study of Green Supply Chain Management
A case study of BYD, a Chinese car manufacturer

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Aug 2010

Bachelor’s Thesis in Industrial Management and Logistics

Study Programme for a degree of bachelor of Science in Industrial Management and Logistics
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Abstract

Traditional manufacturing industries develop the contradiction between human beings and the environment is becoming more and more serious. In order to solve this problem, the establishment of green supply chain management can to be a way, to introduce the idea of sustainable development in practice. The pollution from the car industry is a problem today, so developing green supply chain management is important. The purpose of this thesis is to establish green supply chain management supplier evaluation index system by taking BYD as an example. In this thesis, we study the problem by using primary and secondary data, by combining the reality with the theories. First, we introduce the principle and basic situation of green supply chain management in China now, then we analyze the aspects that green supply chain management should include in BYD. We propose a plan for the improvement of green supply chain management in BYD and construct the GSCM performance index system. Eventually we proformce a plan for the establishment of green supply chain management in BYD.

Key words: BYD, GSCM, green supply chain management, green design, green production, green market.
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1 Introduction

1.1 Background

In the 21st century, by the impact technology progress and global economic integration, the supply chain between different countries and different regions are becoming more and more common (Christopher, M. 2005). Meanwhile, the conflict between the natural environment and the manufacturing are becoming increasingly serious. The problem has two aspects: on one hand, with the expansion of supply chain manufacturing industries affect more on natural environment; on the other hand, the environmental problems also bring more constraints and limitations to manufacturing company (Handfield, R. et al, 2002). All the related companies of the supply chain are affected. Therefore, in order to solve the environmental problems, it is necessary for all companies to work closely together to improve environmental performances.

China is a country with large scale of manufacturing yet still not very mature. The manufacturing industry has not paid enough attention to environmental protection. As a result, the consumption of resources is too high, utilization rate is low, and the pollution problem is serious. China's automobile industry is also facing this problem. But the improvement of environmental performance can not achieve by a manufacturer independently. Even an internal management is strictly carried out by an enterprise, still upstream and downstream partners are needed to achieve the goal of environment protection. That means the environmental factors should be considered in supply chain management.

At present, some foreign automobile manufacturers such as Volkswagen and Ford have already taken environment as social responsibility (Simpson, D. et al, 2007). Meanwhile, this action is also transformed into the competitive advantage of themselves.

In China, most automobile manufacturers still do not introduce green supply chain management. In the evaluation and selection of suppliers, they continue the
tradition method and have not paid enough attention to environmental factors. The fast development of economics makes the conflict between environmental and economic benefits more and more serious.

The research of green supply chain management involves the following three parts: supply chain management, environmental protection, and resource optimization (Mandal, M. 2006). As the auto industry is developing fast in China these years, the pollution from vehicles has caused lots of damage to the environment and resources. The automobile manufacturers have to take the social responsibilities of environmental degradation. How to handle the coordination between development of automobile industry and environment? The domestic automobile enterprises have to change the traditional mode of production so that they could maintain sustainable growth.

1.2 BYD in China

BYD is a Hong Kong-listed high-tech private enterprises founded in 1995. Now, with more than 10 years of development, there are 9 main production base around China, covering nearly 1,000 square meters. Also in the United States, Europe, Japan, Korea, India, Taiwan and Hong Kong. There are branches or offices. In 2009, BYD ranked 216 in the top 500 Chinese enterprises.

BYD is an abbreviation for Build Your Dream. Since 2003, BYD began the development of national self-branded car journey and entered the field of automobile manufacturing and sales. In these years, BYD always stick to independent R&D, it created its own brand and intended to "create the best car in the world".

The production yield of BYD automobile is increasing these years (Table 1). Against pollution, BYD introduced Toyota's lean management in the production and use 6-sigma analysis to find the causes. This means that the clean production technologies are carried out and the old production process are changed. Above all, they have achieved a lot now.
<table>
<thead>
<tr>
<th>Year</th>
<th>Yield</th>
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<tr>
<td>2003</td>
<td>about 10000 cars</td>
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<tr>
<td>2004</td>
<td>about 50000 cars</td>
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<tr>
<td>2005</td>
<td>30170 cars</td>
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<tr>
<td>2006</td>
<td>44157 cars</td>
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<td>2007</td>
<td>10149 cars</td>
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<td>2008</td>
<td>19450 cars</td>
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<td>2009</td>
<td>445000 cars</td>
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Table 1: Annual Yield from 2003 to 2009 in BYD


At present, BYD has reached the international advanced level mold development and vehicle research. The industrial structure is gradually improving. It is said that China's domestic auto brands will enter the U.S. auto market and BYD had been officially announced to set the company's North American headquarters in Los Angeles. How to handle the coordination between development of automobile industry and environment?

**1.3 Purpose**

The purpose of this thesis is to establish green supply chain management supplier evaluation index system by taking BYD an example. By the evaluation index system, we will balance the environmental benefits, economic benefits and social benefits. Also take BYD as example, we will start from the practical situation of China and melt the environment index into the operation into the part of suppliers, so that the evaluation and selection of suppliers can be to the suppliers comprehensive and effective.
1.4 The scope of this thesis

This thesis will include the following aspects. First, we will describe the main conception, the origin and development of GSCM. Secondly, we will analyze the problems of environment protection in the production process of BYD. Based on that, we intend to establish green supply chain management system in BYD and also we will develop an index system to evaluate the performance of GSCM.
2 Literature review

2.1 The traditional SCM

Traditional supply chain is chain structure models. It connect the suppliers, manufacturers, distributors, retailers and the user together by control of the information flow, logistics and capital flow (Huang, P.S. et al, 2009). It begins from procurement of raw materials and finally until distribute the users. To some extent, green supply chain management includes all the enterprises related to the production progress. It is not only the financial chain, the material chain and the information chain that connect the suppliers, the manufacturers and the users together, but also a value chain. Because of the value of material increases during the processing, packaging, and transportation process in the supply chain, the enterprises benefits from it (Lu, L.Y. et al, 2007). In the supply chain, generally there is a core enterprise. It is the organizers that organize and joint the production, distribution, retail process together. Because of this, the core enterprise plays an important part in the supply chain management.

Supply chain management mainly includes four basic elements: plan, procurement, manufacturing and distribution (Zhu, Q.H. et al, 2005). We will introduce it in detail below.

Plan: This is a strategic part of the SCM. A good strategy is needed to manage all resources to meet customer demand. By good plan, it is able to establish a method of monitoring the supply chain, enabling it to delivery high quality and high-value products or services effective.

Procurement: It is the step to choose suppliers of goods and services, to establish a set of pricing, delivery and payment processes and to create methods of monitoring and improving management, also it is essential to combine the suppliers' goods and services together, including delivery, verification of invoices, transfer of goods to your manufacturing and approved payments to suppliers (Huang, P.S. et al, 2009).

Manufacturing: Arrangements for the production, testing, packaging and delivery
preparation are included in the progress. It is the largest part of the SCM progress, including testing the level of quality, product yield and productivity of workers and other measurements (Drumwright, M.E. 1994).

Distribution: It is usually known logistics, which includes adjusting the user's order receipt, the establishment of warehouse network, delivery, the establishment of invoicing system and receive payments.

The progress of achieving an integrated supply chain can be seen in figure 1.

![Diagram](image)

**Figure 1: Achieving an integrated supply chain**


In the figure above, there are 4 stages in the development of supply chain management. That's to say, this figure directly show us an image of supply chain. Stage 1 is an ordinal state, in this stage, every part of supply chain including purchase, material control, production, sales and distribution are separate. Then companies
gradually realize the importance of cooperate so integrate in some parts, which forms stage 2. In stage 3, a supply chain is preliminarily formed. And then the supply chain continues to develop, gradually external integration forms that are stage 4 in the figure.

### 2.2 An introduction of GSCM

The concept of green supply chain was first arisen by the Michigan State University in 1996 during an "environmentally responsible manufacturing" research. It was proved to be an effective way of management by the scholars in Michigan State University. Later they found the establishment of green supply chain management in these enterprises such as IBM effectively solved the conflict between economic interests of environmental protection, so people admires it (Lu, L.Y. et al, 2007).

Green supply chain origins from the idea of supply chain management and sustainable development theory. It is a new subject, people have not studied it deep enough. Until now, there is still no unified, clear, authoritative definition. The green supply chain management is a system. It includes the process of material acquisition, processing, packaging, warehousing, transportation, sale and use to the end of life treatment, recycling (Bacallan, J.J. 2000). The process is guided by the principle of optimization allocation of resources, enhancing benefits, achieving the goal of the compatibility with the environment. Generally speaking, it is a green system combines by the suppliers, manufacturers, distributors, retailers, consumers, environment, rules and cultural element. It is also the combination of logistics, information flow, cash flow, knowledge flow.

Generally speaking, green supply chain management is a supply chain that guided by the sustainable development theories. The purpose of it is to achieve the goal of improving welfare, achieve compatibility with the environment and material optimization by improve the speed, certainty and other related channel. As a result, short-term benefits and long-term benefits can not be well dealt with. So it is necessary to establish green supply chain management, so that the enterprise can have sustainable development (Murphy, P.R. et al, 2003).
The implementation of green supply chain management is a complex system, from the aspect of participants, it includes suppliers, manufacturers, distributors, retailers, customers and logistics providers.

Green supply chain management mainly began from product design, and end in final product recycle. It mainly includes the following 5 aspects (Sarkis, J. 1998). We call them green procurement, green design, green manufacturing, green distribution, green logistics, green consumption and green recycling.

2.2.1 Green design

Study shows that about 70%-80% of the product performance is determined in the design stage. However, the while the design usually cost only 10% of the total cost. Therefore, is should give full consideration to the ecological and environmental impacts in the design stage of products. So the designs can minimum energy consumption and environmental pollution.

Green designs mainly include the research about standardized, modular, removable and retrievable design (Benson, P. 1992).

1) The standardized design makes parts of the structure are relatively fixed, so that the difficulty of processing and energy consumption will be reduced. Also it can reduce the complexity of technological equipment.

2) The modular design is intended to meet the requirements for rapid development of green products, by that the product will be easy to assemble, disassemble, and easy to maintain.

3) The removable design means all parts structure design is reasonable, accessible and separate coupling structure, which is easy to remove without damage to parts so that will reduce environmental pollution.

4) The recyclable design is the design that achieves maximum reuse of component.
2.2.2 Green procurement

The procurement is the purchase of raw materials (Christopher, M. 2005). It is concern about the supplier and logistic. In order to keep the whole routine clean and safe, a lot of aspects should be considered. In order to ensure that the entire supply chain will be carried out successfully, both the supplier and the logistics should be considered.

2.2.3 Green production

In the process of green production, the input and output of the manufacturing process, the resource consumption and environmental impact should be considered. That includes the material flow, resource consumption as well as waste production. Green production mainly should be considered in the following aspects.

1) Green crafts. In the process of plan selection, the environment factors should be considered first.

2) Productive resources. With the higher level of processing technology, the reduction of waste and scrap material should be considered.

3) Enhance the humanity in manufacture, by adjusting working hours and reducing labor intensity and other measures to enhance the work of staff enthusiasm and creativity to increase productivity.

4) Attach importance to environmental protection.

2.2.4 Green marketing and transport

Green marketing and transport is in the stage of the marketing of the products. Green marketing is the ecological management of sales of enterprise, which includes distribution channels, the choice of brokers, on-line trading and sales promotion of the evaluation. Green transport is mainly based on the logistic process, with the dramatic increase in the amount of logistics and increase of traffic flow, the atmospheric environment was severely contaminated. Green transports mainly include evaluation
of centralized distribution and consumption of resources and reasonable transportation route planning (Christopher, M. 2005).

2.2.5 Stage of recycle

With the improvement of technology, the products become more complex, while product life cycles are becoming shorter and shorter, which result a growing number of consumer waste. Not only caused serious resource and energy waste, the solid waste also becomes a main source of environmental pollution. There is a need of a green recycle system to deal with this problem (Christopher, M. 2005).

2.3 GSCM and automobile industry

The research of green supply chain management involved the following three parts, supply chain management, environmental protection and resource optimization. As the auto industry is developing fast in China these years, the pollution from vehicles has caused lots of damage to the environment and resources. The automobile manufacturers have to take the social responsibilities of environmental degradation. How to handle the coordination between development of automobile industry and environment? The domestic automobile enterprises have to change the traditional mode of production so that can they maintain sustainable growth.

In China, the systemic research of green supply chain management has only been carried out in the resent years, so the implantation is not so mature. However, they still achieved to an extent (Li, J.W. 2010). By the research of strategy mode and the implantation of green supply chain management based on the reality of Chinese enterprise and the international competition, the first green supply chain management was established in 2007 (Zhu, Q.H. et al, 2007).

In 2003, General Motors introduced the concept of green supply chain management in China. It is intended to promote the development of green supply chain management in China's automobile industry. It is the first step that General Motors take to support the development of Chinese automobile industry.

The green supply chain mainly includes two aspects (Lee, H. et al, 1997a).
First, the key point of the internal management and strategy is to minimize occupied resources and increase the productivity as well as maritime the profit.

Second, the company, the suppliers and other partners should cooperate and to share experiences in order to lower the cost, so the environment protection ability can be improved.

In addition, the government should regulate the role between car enterprise and environment (Zhu, Q.H. et al, 2005). Green supply chain management should be identified as a modern business model of car enterprises. By the establishment of it, we can control the waste of resources and create a savings society.

The environment protection is becoming the sustainable strategy of every enterprise, so the research of green supply chain management will be researched and carried more frequently then (Zhu, Q.H. et al, 2005).

### 2.4 Environmental effects from vehicles

Currently, China has become the world's fourth largest car producer. State departments forecast that the recent annual growth rate of China's auto production will remain at the 20%. In the present and for a long time, most of the cars are all with fuel burning engine, the rapid intense burning car would have harmful gas emissions. As a result, each car is a mobile source of pollution. Automobile pollution has done harm to the environment and will continue to do that in the future. During the entire process of automobile production, the pollution to atmosphere, water and soil is always a big problem.

The deteriorating environment has brought challenges to the automotive industry. According to a research, automobiles have reached 800 million in 2008 in the world (Mandal, M. 2006). And 60% of energy is consumed in the progress of transportation; In global carbon dioxide emissions, about 17% comes from road transport.

In the production of automobile, many factors can do harm to the environment and can be improved. If the technology can be improved, the pollution can be reduced and the resource can be less used. Take a car tire for an example. Under normal circumstances, 20% of motor fuel is used to overcome rolling resistance of tires. If
add silica in the tire, the rolling resistance can be reduced and more fuel can be saved. As a result, carbon dioxide and other emissions also will be significantly reduced (Reck, B.K. 2010).

Fuel prices have boomed today, with the green gel formulation of new tire and other products, the cost of vehicle fuel costs and other costs will be reduced, and the implementation of environmental protection also will be achieved.
3 Methodology

In this thesis, we research the problem by using primary and secondary data, by combining the reality with the theories. As one of the first Chinese automobile manufacturer, BYD achieved a lot in just a few years. However, just in these years, BYD also is facing in unprecedented challenges. This challenge comes not only from a strong competitors, but also from the serious pollution, deteriorating environment and the increasingly demand for environment friendly vehicles of the consumers. So BYD have to take social and moral responsibility while meeting the investor's profit.

3.1 Research approach

3.1.1 Qualitative

Qualitative research is analysis that based on the "quality" of the object (Punch, K. 2005). That is a research that use induction, deduction, analysis and to seek the essence of things, reveals the inherent laws. Qualitative research is intended to find out the explanation of problems. There is qualitative research almost every day in every workplace and learning environment.

3.1.2 Quantitative

Quantitative research is scientific research to determine the amount of certain provisions of things (Punch, K. 2005). It quantify the phenomena and use data to analyze and explain the problem. Quantitative research is mainly based on the levels of the object. Quantitative research is closely related to experimental study, and the quantitative science is produced with the experimental method.
3.2 Data Collection

Data is mainly used to support the total research, so the collection of data is the main part of our paper (Lee, H. et al, 1997b). In this research, we mainly use primary data and secondary data, the detail will be introduced below.

3.2.1 Primary data

Primary data, also known as raw data, is mainly obtained through the interview and survey (Gene, V. 1976). By primary data, we can have strong proofs to solve the problem. The primary data usually can answer the questions that secondary data can't answer, and primary data are usually more timely and credible. In this thesis, we get the primary data from the research carried out by ourselves. By the facility of geography location, we get the primary data by interviews for employee of HR department in BYD. In order to get first hand data, we have done interview to the employee in BYD, by the interview, we also got useful information, which support the research in this thesis.

3.2.2 Secondary data

Secondary data is the collected data from the net and the literature (Gene, V. 1976). It is for collected for certain purposes. The analysis of secondary data is an important part for the definition of problem. Only after a full analysis of secondary data can we start the research and collecting primary data. In this thesis, we mainly get the secondary data by the website. By searching the net, we get sufficient statistical data to support the discussion of this research. Before writing this thesis, we first studied plenty of literature about car industry and green supply chain management. Also we got a lot of useful secondary data by documentary research.
3.2.3 Validity

We get the first primary data from data from a HR employee of BYD. He works for BYD for 5 years, and he helped us to collect data in BYD. So, the data we get is reliable. Also the secondary data are collect seriously, we collect it on the net. All the data comes from research papers and official web-site, so the validity of secondary data can be guaranteed by the enterprise. Additional, before using them we checked them carefully to keep the validity of the data.

3.2.4 Reliability

We write this thesis, do the analysis and research based on the theories of tradition supply chain management and modern green supply chain management. Both of them are established by authoritative professors, they have been developed for several years. The theory of supply chain management have been applied in many companies, and it really does work typically. The theory of green supply chain management are based on traditional supply chain management, and it has also been introduced by several companies. The effect of it on the protection of environment are obvious. So, we can confirm that the research of our thesis are reliable.

3.3 Critical reflection

BYD was established in 1995. As an enterprise with high technology, now it has 9 products basis around China, and there are working organizations around the word. It is developing fast these years and it is on the billboard of top 500 enterprises in China in 2009.

Through the establishment of green supply chain system, BYD solved the environmental problems that existed in daily operation. As a result, the development and environmental protection to achieved the harmony. Thus the product competitiveness in world market will be enhanced and sustainable development strategy will be established well.
In the writing process, we have learned the following progress. First, we obtained the skill of writing thesis which never has before, including the skills of searching reference and collection data. Additional, during this period, we also learned how to communicate with others and get useful information while chatting. As an enterprise, some of the information in BYD will not be proclaim publicly. In order to solve this problem, we communicated with an employee in HR department in BYD, and got lots of useful materials.

However, there are still shortcomings in this progress that we need to improve. As we know, BYD is a large company, so the discussion of its production, and supply chain is a little difficult due to the lack of data. We mainly get data from the Internet and by an interview of a manager form BYD. By that way, the information we get may not be so precise, which probably could affect the result more or less.
4 An analysis of GSCM in BYD

4.1 Analysis of product GSCM

In these years, the consumption of automobile car is increasing (Figure 2). In the figure we can see that during the past 10 years, Chinese have bought more and more cars. BYD automobile is a part of the whole market, and its production also increases these years.

![Graph: The sales of car in Chinese market.](image)


Through the establishment of green supply chain system, BYD has solved the environmental problems that existed in daily operation. As a result, the development and environmental protection aimed to achieve the harmony. Thus the product competitiveness in world market will be enhanced and sustainable development strategy will be well established.

The fast development of car industry also brings much pollution. With the rapid development of China's automobile industry, car ownership is at an explosion, which led to growing urban space, Shanghai, Guangzhou and other big cities, automobile exhaust on air pollution share rate of over 60% (Quick, J.C. 2010). Car ownership in China has reached more than 30 million now, and carbon dioxide emissions of China
ranks second in the world.

The green product process is implemented successfully in BYD. Early in the design program, they emphasized on environment protection (From interview, 2010). In detail, they take the following measures. Before the design of a new product, they will ensure that car which is friendly to the environment, the word friendly means less fuel consumption and pollution. Also they try their best to minimize the damage to the environment in the course of automobile use.

### 4.2 Analysis of suppliers GSCM

Due to the lack of resources and the maintenance of oil, iron and steel prices, the suppliers for car factories and manufacturers of raw material under a embarrassment (Reck, B.K. 2010). On one hand, the suppliers have to carry out price increases; on the other hand, the car enterprises have to find new materials, new energy product to deal with this situation.

More than 50% of the raw materials used in automotive manufacturing are iron, steel, which is a non-renewable resource in BYD (figure 3). By the figure we can see that the main material proportion of automobile car is metal and petroleum product, which will bring a lot of pollution during production.

![Material Proportion of BYD products](http://www.zol.com.cn)

Figure 3: Material Proportion of BYD products

BYD has several factories around China, which is located in Guangdong, Xi'an, Ningbo, Beijing, Shanghai and Changsha (www.byd.com.cn, 2010). So they can integrated the amount and to achieve the scale of procurement in the purchase of raw material. Because of a good business reputation and the big procurement capacity, they attracted a lot of raw material producers and will take more active at the negotiating table position. Benefit from the headquarters of the global procurement policy, BYD can test the materials according to environmental standards of Europe and the United States, which can ensure the quality of raw materials, and also ensure that their products and services meet the environmental standards (From interview, 2010).

In addition, in the context of science and technology development, automobile enterprises can achieve information sharing with suppliers through the electronic platform. Raw materials, product technical data should accept the automatic identification of systems before leaving the factory. Any disqualified products will be locked by the system and inform the related department, which also can ensure the reliability of products (From interview, 2010).

4.3 Analysis of production GSCM

Traditional manufacturing is progress that transfers the available resources into the industrial products or consumer goods. In long time, the goal of production is to reduce the costs and to increase productivity, and to maximize benefits, but never consider the impact of product progress on the natural environment. Producers manufactured products of the raw materials, released the waste into the environment after use. In industrial processes, a lot of exhaust emissions, waste water and solid waste are released in to the environment, which is the main environmental pollutant.

In the view of the public, heavy industry such as BYD car industry is main cause for pollution (From interview, 2010). It is true that they will produce many harmful substances in the production process. In many car factories, even if not into the shop, you can smell the pungent smell of rubber. Much of the dust will be produced during the transportation of materials. Many long-term workers in certain positions will
suffer from a variety of diseases more or less. Besides, residents near the factory's complaints are also happened again and again.

Because of this, BYD has consider to introduce clean production evaluation index system in the automotive industry in the recent years, which use resource and energy consumption indicators, indicators of product characteristics, pollutant indicators, indicators of resource utilization and health and safety indicators to evaluate the environment levels of car factories (From interview, 2010). By that, enterprises can no longer yield and expansion in pursuit of profits and do whatever they want in the production. The motto of "people-oriented and harmonious development with nature" will gradually become strategic policy of automobile enterprise.

### 4.4 Analysis of market GSCM

The concept of green marketing require BYD to comply with the requirements of sustainable development, to focus on global ecological and environmental protection, and to promote the coordinated development of economy and ecology in order to achieve business interests, consumer interests, social interests as well as environmental interests. The products of BYD, automobile cars are products that have higher safety requirements and will have more impact on the environment (From interview, 2010). The quality and performance have direct impact on life and property safety of consumers, meanwhile restricting the improvement of the environment and development. So enterprises must pay more attention to consumers’ demand, including the demand on health, safety, the demand for a better living environment. So BYD needs not only to meet the demand, but also to guide the demands of the consumers and to guide the consumers to do reasonable consumption. Meanwhile the irrational production and consumption patterns caused by unreasonable demands should be avoided (From interview, 2010).

As to automobile industry, the establishment for the concept of green marketing is important. BYD need to coordinate demand and supply of natural resources. By the establishment for the concept of green marketing environment, BYD should guide
environmental protection as one marketing activities, to concern about human needs for environmental quality, to implement it throughout the business activities of enterprises, so that the green marketing process can be achieved.

4.5 Analysis of recycle GSCM

Compared to the production and distribution process of enterprise channels, the recycle of product is one kind of reverse process. As to BYD, there will be plenty of used cars that need to recycle in the next several years (From interview, 2010). If they can do that job well is key to the success of green recycle.

As to automobile, the green recycle mainly include the following three aspects.

The first problem is how to recycle. That is associated with the change of frequency of product and manufacturing complexity, which impact a lot to the recycle process (Huang, P.S. et al, 2009). If the part of car have high frequency of life, the product life cycles will be rather short, so there should be a large amount of them. As to automobile cars, the life of each car is certain, and due to the large production every year. The recycle amount will be large in the next several years. So it is better to establish a centre for recycle. As the manufacturing complexity of high value product such as car, the value exist in the product, even the used car have worthy parts, so we should reuse the useful part so that we can achieve green recycle.

The second problem is to select proper channel by the combination of situation of company. Generally speaking there are three channels for recycling: charged by manufacturers charging, manufacturers outsourcing and third-party commitment recovery mode (From interview, 2010). As to automobile industry, it is better to adapt third-party recovery. The advantage of third-party recovery is that it can fix assets to full use. In other modes, a considerable amount of fixed asset should be investigated so that they can achieve the goal. As third parties would not cost so much. By the application of agents of different manufacturers, they can make full use of recovery systems to reduce the marginal cost of recycling. Actually, that is not always correct, because of the production of different products, different area, and different enterprises, they should be select proper recovery channels based on the actual
situation of their own.

At last, the good inventory management is essential. It is the key in the process of green recycle. As the recovered product is mainly recycled raw materials or energy, the reuse of them can be adapted in different products or even different industry. Generally speaking, as long as prices and costs permit, the recycling process is economic. At that time that recycled products should be produced as much as possible to get more profit.
5 Discussion measures to improve the GSCM in BYD

In this paper, we combined the literature knowledge with the BYD green supply chain management experience. By analyzing the various stages of BYD resources and environmental issues, as well as analysis of key stakeholders, we find the key factors that influence the green supply chain management and develop further measures of it.

In order to study the problem of green supply chain management in BYD, we combine the theory with the present situation and develop relative strategies. The automobile industry has already brought so much stress to the environment. Pay attention to the natural sources and to pay more attention to the environment is always right. As a successful automobile enterprise BYD should not only seek profit and the expansion of its scale, but should also take responsibility to the environment problems, and to seek the harmony between people and nature. As one of the largest automobile enterprises in China, BYD should advocate green management idea, actively develop innovative technology, pursuit of excellence quality of products and eventually spread environmental protection concept to all the steps of car production. Correspo to the problems in green supply chain management of BYD and the analysis of it, we develope related strategies to the process for the establishment of green supply chain management as well as the index system. In the following part, that will be described in detail.

5.1 Green design

From the previous research of green supply chain management, we know that the profit of an enterprise is mainly achieved by the design process (Mandal, M. 2006). By analyze of BYD, we know that in the car industry the process of car design is also essential. The material and the structure determine the raw material that will be used in production. So it is useful to let procurement personnel attend in the initial design. For example, BYD can choose the existing suppliers to cooperate with and to develop
new green environmental-protection material, so that they can reduce the cost and can make sure for the establishment of green supply chain management.

According to the theory of green supply chain management, traditional theories and methods of automobile design are based on the peoples needs and regisseunests. They manly intended to satisfy people's needs and solve existing problems, but ignore the subsequent production and use of the process of resource consumption and environmental impact (Benson, P. 1992). So, to BYD it is essential to reforme and be innovative in the product development and design process. The green design, which helps to reduce energy waste and environmental pollution, should be adapted.

Green design is required for the entire product life cycle. That is, early in the concept design stage we must give full consideration to the product selection, manufacturing, sales, use and impact on the environment after the end of life, and make sure that the product (the BYD cars) easily can be recovered and not produce toxic side effects.

5.2 Green procurement

According to the theories above (Christopher, M. 2005) the supply chain managers play key roles in the business of green supply chain management. In BYD it requires that all the suppliers should be evaluated in the technological and environmental stage. The sample provided by the supplier must be tested in the factory for up to 6 months. The company has strict procurement process requirements. The company's technology department must annually come to the supplier's factory to investigate. So even a small change of the supplier's supply chain will cause a re-evaluate process.

Before the factory test, supplier can not provide materials to BYD. For example, all chemicals used in the factory should be assessed before the procurement and the technical data sheets should be delivered to the relevant departments. Any hazardous chemical constituents will be turned away. BYD considers the key supply providers as the long-term business partner. Through long-term collaboration, they can reduce the product cost and improve product quality.
From the description above we can see that in BYD's green supplier management, environmental indicators of suppliers are the company's basic policy. That means they will consider the environmental performance of suppliers a lot. For example, the following questions will be raised. Will the supplier be fined by government because of potential environmental problems? Will the suppliers use green packaging? As in BYD at least 80% of its supplier have achieved ISO4001 standard of environmental management systems. In BYD purchasing department cooperate with design department, production department and marketing department, and to decide which material should be select and which of green suppliers should be chosen. As a result they can reduce the use of hazardous materials and improve material recycling and reuse.

### 5.3 Green production

In this part we will give some suggestions for green production after study the green supply chain management theories and the research of BYD present situation. Dust and smokes can not be seen in BYD factory due to the use of advanced equipment in manufacturing processes. For example, against the flue gas BYD set hood ventilation system to concentrate the gas and to deal with before release (From interview, 2010). The cooling water are recycled, the waste water is regularly tested to ensure that the quality can meet the national emission standards.

The production process usually will produce a strong noise, which is a major problem. So it is necessary to control and reduce noise. In BYD the procurement of new equipment has already added the noise canceling requirements; to old equipment they stamp the noise with enclosures. To prevent mechanical and static electricity, pressure and high temperature pipes and other damage caused by security incidents BYD also take protective measures. Furthermore, the new factory of BYD will use the world's most advanced automotive manufacturing equipment and processes to achieve safety production.

BYD have special environment-related sectors. According to environmental principles and policies formulated by the headquarters, they carry out environmental
safety audits every day. Safety and environmental protection is the company's first topic. Once the eco-security risk is found, the entire company and all the workshops will analyze and summarize the risk and develop effective the corrective measures. By that, the incidents of pollution will be effectively avoided.

5.4 Green sale and transportation

By studying theories we know that customer demand, market competition and the introduction of various environmental laws will prompt enterprises to take a green development (Christopher, M. 2005). By analysis we can see the problems which are existed in the process of car industry. In order to solve these problems, it is essential to adapt green supply chain management, so that the competitiveness of the enterprise can be strengthened and they can achieve sustainable development. As to BYD Company, they have already begun the exploration of green supply chain management, but still, they lack of the green supply chain management practices.

It can be said BYD has always stressed on green marketing objectives, namely environmental goals and objectives of green consumption, which organically combined the economic, social and ecological benefits together. As in practice, BYD will regularly carry out a variety of different distributors’ environmental network training. For example, the green product training is designed to train and to guide the consumers of green consumption habits, to encourage them to adopt green cars so that to reduce environmental pollution and energy consumption. Safe use training process is aimed to promoting the use and maintenance of cars so that to extend the life of the tire and to ensure the safety of consumers. By that the resources can be saved and they can access to a certain economic benefits. Meanwhile, the network training is to avoid the transportation process so that energy conservation can be achieved.

Green packaging is already in use in BYD. In the establishment of green packing, BYD mainly focus on packaging material selection, packaging structures improvement and packaging waste recycling. The parts used in BYD products all use green materials, the stickers are all as simple as possible and the label are intended to reduce the size as much as possible so that they can lower the negative environmental
impact.

In addition, BYD has been working with the tripartite co-operation of logistics, seek the most environmentally friendly logistics solutions. For example, they unusually load during the day and transport at night to improve transport efficiency and to avoid additional environmental pollution caused by traffic congestion.

Overall, BYD have already established a green corporate image by strengthening the concept of green, enhanced green design, green manufacturing, and the implementation of green management. BYD have also shown their efforts in the green region by good public relations and to set a good green image in the public mind. In modern society public awareness of environmental protection has been transformed into the attention to enterprises related environmental behavior. So in order to set a good image among the consumers BYD should take sustainable development of human and social as the goal, pay attention to the establishment green image, and focus on social responsibility.

5.5 The recycle of BYD products

From the analysis above, we can see that in the car's entire life cycle, energy saving and environmental protection is the two main themes enterprises must face. The main problem of green supply chain management is focused on the process of raw material acquisition, the production process and the recycle (Li, J.W. 2010). Since the transition depends on non-renewable energy sources and use of non-environmentally friendly raw materials have increased the company's operating costs and limited the development of enterprises, the establishment of green supply chain management in car industry must be carried out soon. Meanwhile, the environment protection process mainly focus on the production process, consumer use process and recycling processing stages.

Overall, the recycling of used car is to reuse this waste and to change the waste into treasure (Huang, P.S. et al, 2009). This is the basic principle of car industry now and in the future. By the development of science and technology, used car is now different from other solid waste; the products generated by an extension of deep
processing are usually with high added value. In this point, BYD has now paid more
attention to and this has become a new economic growth point.

For example, the reuse of used tire is one of the successful try by BYD. At
present, use the waste tires to product scrap tires is far better than the traditional ways,
when they use recycled waste rubber to produce reclaimed rubber. There will be no
pollution caused by reclaimed rubber and no other secondary pollution. It can be
called as real new industries with high value-added products in line with international
trends, science and technology. In this process, the utilization of waste tires is trying
to reach 100%, which is true recycling, sustainable development.

In short, the last part of BYD's green supply chain management is the re-use of
waste for recycling. To the waste that can not be recycled, they should do
decomposition, to process and achieve zero landfill. The processing of waste should
also comply with environmental requirements which can not produce secondary
pollution to the environment and to humans.

5.6 The index system we carry out for evaluation

Based on the sustainable development strategy and the situation of BYD, we
construct the green supply chain management performance evaluation system.
Generally speaking, we carry out the evaluation from the social services, economic
development, environment protection, and the development of green supply chain
management.

Social services refer the values to the society the supply chain create during
operation, and whether customer can get satisfactory products. The higher the
customer satisfactions, the better the performance of green supply chain management.
The index mainly includes the corporate contributions, service level and the market
share.

Economic development is the second aspect that should be considered. The main
target of green supply chain management is to maximize the profitability. So to
evaluate the economic value is the core. We consider that we should evaluate that
from capital efficiency indicators, capital operation indicators, indicators of debt
capacity and development capacity.

Green environmental protection is also included in the evaluation system. It is mainly about the resource recycling and product life-cycle. If the product recall income index is negative, it indicates that green supply chain cost is greater than that product recovery benefit; and positive index means a good product recycling effect.

It is necessary to enhance the innovation and development of green supply chain management by the performance evaluation. The evaluation indicators are successful development of new products, the value of indicators of human resources and personnel scientific training in our design.
6 Conclusion

In this thesis paper we mainly get the following conclusions.

Conclusion 1: By the analysis of the implementation of green supply chain management and the introduction of the theories about SCM, we conclude that green supply chain management mainly include the following five parts: green design process, green procurement, green production, green marketing and transport, and stage of recycle.

Conclusion 2: Then, by the analysis of the car industry, we conclude that the traditional supply chain management is facing more environmental and resource pressures, so the traditional supply chain management must be reformed. The implementation of the green supply chain management is the necessary requirement of sustainable development of human society, and the way to develop industrial production while environmental protection. Also, we conclude that in the car's entire life cycle, energy saving and environmental protection is the two main themes enterprises must face.

Conclusion 3: By taking BYD as example, by the combination of with green supply chain management principle, we conclude that a system of green supply chain management is valuable for the establishment of green supply chain management in BYD. Enterprises should carry out plans by the integration with the actual development of their own situation.

Conclusion 4: Based on the sustainable development strategy and the situation of BYD, we construct the green supply chain management performance index system. We carry out the evaluation system from the social services, economic development, environment protection, and the development of green supply chain management.

From the research point, this paper made an empirical study of a specific industry, which is an important way that scholars research green supply chain management. From this point, we can both study the features of green supply chain and the features of individual enterprise. So the research is useful to the other enterprise of automobile industry. Of course specific companies should improve and adjust the evaluation
system according to their practical situation.

6.1 Future studies

As we know, protect of environment is becoming hot issue these year around the world. No one can ignore the affect of industry on the nature. Many of the lakes, the rivers and the sky in China are polluted in these years. That is to say, China sacrificed a lot for its fast development these years. Now it is time to pay attention to environment while development or we will be punished.

By choosing BYD and studying this automobile enterprise we know the importance of GSCM and an initial image of the implantation of GSCM. However, the establishment of GSCM in BYD, in car industry and in China will be more difficult. To adapt this plan means an enterprise should sacrifice its short time benefit, and may slow its speed of development. So how to convince that GSCM is worth taking and to introduce it in enterprises will be a rather difficult task. That needs to be study in the future.

Does the GSCM also can use for other industry companies and counties?

The research of our thesis, the establishment of GSCM can also be applied in other countries and industries, not only BYD in China. Actually the theory of GSCM is first raised in the United States. Before introduced into China, it had already applied in the Western countries for many years. The result shows to be good. The introduction of it in China showed that GSCM can also be established in developing countries such India, South Africa and Brazil.
7 Suggestion to the establishment of GSCM

After the discussion of every single part of green supply chain management in BYD, it is necessary to discuss about the establishment for green supply chain management in BYD at last. Generally speaking, the establishment of green supply chain management in figure 4. It is based on the present situation of BYD. The steps is included in the establishment of green supply chain management. We will explain that in detail below.

![Diagram of GSCM establishment](image)

**Figure 4: The establishment of GSCM**

(Made by Meizi Wang & Xiyu Luo)
7.1 The establishment of GSCM department

In order to carry out green supply chain management in BYD. At first, the green action group or some similar project team should be organized. They are in charge of the establishment of green supply chain management. The group could contain employee in design, quality control, storage, procurement, technology, production, personnel and other department, which assure the establishment of green supply chain management. BYD should define the project leader and team member responsibilities and rights to ensure the integrity of the project team structure and operational effectiveness. The support from the senior leadership should be obtained to ensure the fully authorized and the required project team resources.

7.2 The selection of successful experience

The successful experience is very important to carry out green supply chain management. At present, there is only a few enterprises that have established successful implementation of domestic green supply chain management. Most of them are still in the exploratory state. Therefore, as to BYD, only through the collection of these successful experiences, can they know how to change to word the green supply chain management. If the company is lack of internal resources, they can hire a professional consulting firm to conduct training and guidance to ensure the successful implementation of the project.

7.3 The research SCM status in target enterprise

In the implementation process of green supply chain management, the understanding of the present situation of supply chain status is the base part of program designe and implementation of follow-up measures. So the investigation of the present status of SCM is very important. The scope of its research including not only judging a company's existing products and the green degree of supply and demand, the "green situation" in the production and management, but should also include the process of recover the materials in the supply chain, the relative
information about the providers and distributors.

### 7.4 Develop GSCM objectives and implementation plans

In this stage, BYD should carry out the goals and the measures of green supply chain in detail. Good risk prevention should be included.

According to the basic requirements of green supply chain, the goals and the plans should be carried out by the combination of the present situation of the supply chain. The design mainly includes the supply chain members, the source of raw materials, production process, distribution tasks and capabilities, information exchange platform and logistics management (including recycling logistics).

BYD should evaluate the plan by the requirements of green supply chain management. The composition of the supply chain is key to the design of green supply chain program, which emphasizing the coordination among members. In addition the design should include the risk analysis and related measures to prevent them.

### 7.5 The implementation of GSCM

In this stage the plan should be carried out in BYD. It should be stressed that before the implementation of this plan, the senior leadership should hold a start-up meeting, as the project's general mobilization and also pave the way for the project launch. Besides the promoting in the enterprise the project should also informe the partner, suppliers and distributors. Only by this way can they be able to establish the entire supply chain and to complete the green supply chain management.

### 7.6 The performance evaluation of GSCM

In the implementation of green supply chain management process in BYD, they should regularly conducte evaluation on the supply chain performance. If the implementation is far from the goal the plan should be timely adjusted. Still, caution
is needed while adjusting the program, because it involves not only the progress and results in BYD but also the other members in the supply chain. So it can only be changed by the permission of the senior leaders.

While the implementation of supply chain is completed it is essential to assess the extent and coordination of green supply chain. If the evaluation results show that the supply chain can meet the degree of green supply chain and can ensure that all members cooperate very well, it can be said that the implementation of green supply chain is successful, otherwise, we must re-modify the implementation.
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