

5-26-2012

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Recommended Citation

Xu, Ai; Hu, Xiangpei; and Gao, Shufeng, "Review of Green Supply Chain Management" (2012). *Eleventh Wuhan International Conference on e-Business*. 5.

<http://aisel.aisnet.org/whiceb2011/5>

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Review of Green Supply Chain Management

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Abstract: Today green supply chain management (GSCM) has caused increasing emphasis, as a kind of modern management mode which takes environmental impact and resource efficiency into a comprehensive consideration within the entire supply chain. A systematic literature review of green supply chain is presented in this paper, from the perspectives of concept and connotation, operations, performance evaluation and the applications in specific industries. The paper also identifies some research fields need to be studied in the near future.

Keywords: green supply chain (GSC), green supply chain management (GSCM), supply chain (SC), review

1. INTRODUCTION

Since the beginning of the 21st century, the topic of protecting ecological environment and realizing sustainable development is achieving increased concerns. Many governments in the world have paid great attention to environmental problems to guide their economic construction and social development basing on the idea of sustainable development. The green supply chain management (GSCM) emerged under these circumstances, which emphasizes on strengthening the environmental factors in the supply chain (SC).

The growing importance of GSCM is driven mainly by the escalating deterioration of the environment, e.g. diminishing raw material resources, overflowing waste sites and increasing levels of pollution. However, it is not just about being environment friendly. It may be about good business sense and higher profits. In fact, it is a business value driver and not a cost centre. In addition, the regulatory requirements and consumer pressures are driving GSCM. Hence, the scope of GSCM ranges from reactive monitoring of the general environment management programmes to more proactive practices implemented through various Rs (Reduce, Re-use, Rework, Refurbish, Reclaim, Recycle, Remanufacture, Reverse logistics, etc.)^[1].

Sufficient literature exists about various aspects and facets of GSCM. This paper focuses on the research results about GSCM at home and abroad in order to analyze and evaluate the research status and the development trends.

2. ADVANCES IN GSCM RESEARCH

The summarization of the research status of GSCM will be presented from the following aspects:

2.1 Concept and connotation of GSCM

Green supply chain (GSC), is also called Environmentally Conscious Supply Chain (ECSC) or Environmentally Supply Chain (ESC), which has its roots in both environment management and supply chain management literature. Adding the “green” component to supply chain management involves addressing the influence and relationships between SC management and the natural environment.

In 1996, the National Scientific Funds (NSF) in USA provided \$400,000 financial aid to the Manufacture Research Consortium (MRC) in Michigan State University to conduct a research project named “Environmental Responsible Manufacture” and then the definition of Green Supply Chain was proposed firstly^[2]. From then on,

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many researchers have presented different views about GSCM on a wide range. Walton et al. (1997)^[3] point out that GSCM refers to join suppliers to the environmental management of enterprises. Sarkis (1998)^[4] further points out that GSCM should include inbound logistics and procurement, materials management, outbound logistics, packaging and reverse logistics. Beaman (1999)^[5] develops a concept model of GSCM, adding activity flows of remanufacturing (reuse), recovery and recycling to SC. He also puts forward some new operational indicators such as recovery rate of resources, ecological effectiveness, etc. Karlberg (2000)^[6] studies the GSC of electronic industry and proposed a GSCM concept model, which adds recyclers to GSC. Van Hoek (2002)^[7] develops a concept model of GSCM, making service agencies members belong to GSC. Srivastava (2007)^[11] defines GSCM as 'integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life'.

Domestic scholars began to research GSCM around the year of 2000. Dan and Liu (2000)^[8] think GSC involves suppliers, manufacturers, distributors and users, with the purpose to make the environmental impact (negative effect) minimum and resource efficiency maximum during the whole process from material acquisition, processing, packaging, storage, transportation, usage to scrapping. The basic objectives of GSCM are to protect environment and make use of resources effectively. Ma (2002)^[9] introduces the concept and connotation of GSCM, analyzes the integration characteristics of GSCM and proposes an architecture of GSCM. Wang et al. (2003)^[10] construct a concept model of GSC, analyze the strategic objects of GSCM and divide GSC into four basic systems, i.e. production system, consumption system, society system and environmental system, consisting the components of suppliers, manufacturers, distributors, consumers and recyclers. Wang and Shen (2004)^[11] define GSCM as 'a modern management model which designs SC in ecological method from the view point of product life cycle'. Zhu (2004)^[12] regards GSCM as considering and strengthening the environmental factors in SC management to optimize the overall performance in the whole process and improve the environmental performance and economic performance simultaneously.

In general, there are some common characteristics among these concept and connotation, although no agreed-on definition of GSCM exists, which focus on the integration of management strategy, environmental consciousness and SC management, i.e. emphasize the environmental attributes of SC and decrease the consumption of energy and resources. GSCM also combines the multi-dimensional operating objectives and the environmental management to the entire lifecycle of the product. These research results provide a foundation for the other studies of GSCM.

2.2 Operations of GSCM

The research about the operations of GSCM is mainly about two perspectives, i.e. motivation and influence factors and operational decision-making.

2.2.1 Motivation and influence factors of GSCM

The research of this field is to explore why enterprises adopt GSCM and what factors will influence the effectiveness of GSCM. The purpose of the research is to promote the effectiveness of the operation of GSC.

Sarkis (1995)^[13], Nagel (2000)^[14] and Hwa (2001)^[15] discuss the incentive factors, motivation and obstacle factors of GSC, most of which come mainly from the market pressure and some risks from pollution or disposal of the waste, etc. Some other factors will hamper the operation of GSC, e.g. increased cost, communication conflict, unclear environmental standards and complicated reporting requirements, exposure risks, technology and knowledge obstacles, reduced flexibility, etc.^[16]. Lippman (1999)^[17] emphasizes the importance of the involvement of executive leaders for the implementation of effective environmentally conscious SC. Green et al.(2000)^[18] points out that the cooperation relationship and cooperation method between organizations are critical factors for promoting, motivating and forcing the enterprise to GSCM. Vermeulen and Ras (2006)^[19]

think marketing communication, effectiveness and cost of information have become the primary obstacles for greening of the products in the global range. Lee et al.(2008)^[20] point out that the limited capabilities and resources available within many small and medium-sized enterprises frequently hamper an effective response to environmental pressures, which in turn hurts large buying firms (i.e., customers). Through several specific mechanisms, buyers' GSCM can initiate and then enable the improvement of suppliers' environmental capabilities. Walker et al.(2008)^[21] points out that the inherent barriers for the operations of GSC consist of the increased costs and noncooperation of suppliers, while the external obstacles include the lack of social regulation and specific characteristics of some industry. They prove that the motivating factors are greater than the obstacle factors based on an empirical study of seven private business and state enterprises of the UK.

2.2.2 Operational decision-making of GSCM

Nagurney and Toyasaki (2003)^[22] point out that the decision-making of GSC is typical a kind of multi-objective decisions. They study the decision-making behavior of GSC members and set up a multi-objective decision-making model by using game theory and network model. Sarkis (2003)^[23] presents a strategic decision framework that will aid managerial decision-making and details the components and elements of GSCM and how they serve as a foundation for the decision framework. He explores the applicability of a dynamic non-linear multi-attribute decision model, defined as the analytical network process, for decision making within GSC.

Supplier selection problem are considered to be a quite centralized problem among the decisions in GSCM, most of which study the factors to be considered and the corresponding evaluation tools in GSCM context. Noci (1997)^[24] divides tools for supplier selection into five groups, i.e. absolute method, weighted method, matrix method, situation analysis and analytic hierarchy process (AHP). He regards the method of AHP as a useful tool for supplier evaluation and evaluation. By using qualitative research methods for case-based research, Walton et al.(1997)^[25] identify several primary areas for change to increase purchasing's impact on environmental results: materials used in product design for the environment, product design processes, supplier process improvement, supplier evaluation, and inbound logistics processes. Zhu and Geng (2001)^[26] further study the impact of green purchasing on a firm's supplier selection and compare the supplier selection of GSCM in different environment of USA and China. Wang et al.(2001)^[27] put forward the evaluation indexes of supplier based on green manufacturing and set up an evaluation model by using fuzzy decision method. Gauthier (2005)^[28] regards sustainable development and sustainable ability as an integrated body with three aspects, i.e., economic, environmental and social, and puts forward a "triple bottom line" of the evaluation index system. Liu and Zhu (2005)^[29] set up a evaluation systems based on analytic hierarchy process (AHP) and fuzzy comprehensive evaluation, including four kind of criteria, i.e., 15014001 authentication, environmental design of the product, effectiveness of clean technology and the environmental efficiency. Ciliberti (2005)^[30] and Presley (2007)^[31] emphasize some factors beyond business decision-making should be taken into account during the process of sustainable supplier selection, such as internal environment, social problems, enterprise society responsibility, sustainable development strategy and mature level of strategy, etc. Hutchins and Sutherland (2008)^[32] join the environment factor to the evaluation index system for suppliers selecting. Bai (2010)^[33] constructs a sustainable supplier selection model by using rough set theoretic approach and grey relational analysis. Liu (2010)^[34] proposes a two-stage evaluation system for the core enterprise of GSC to select suppliers.

2.2.3 Game analysis of GSCM

GSCM, like traditional SC, is a cooperative system typically needs coordination and management and may be more complex due to its diversifying components and operational objectives. Hence the mutual relationship between the main stakeholders will influence the effective implementation of GSC.

Only a few researchers have conducted some study on the relationships by using game theory. Most of the

existing research results are about the game analysis between governments and enterprises, e.g., Viswanathan (1997)^[35], Zhu and Dou (2007)^[36], Xu and Zheng (2008)^[37] study the relationship between governments and enterprises in GSC, set up game models and analyzed their behavior and equilibrium strategies. Some researchers analyze the relationship between the enterprises in GSC, e.g., Wang and Yan (2009)^[38], or the relationship between enterprises of GSC and those of traditional one, e.g., Hou and Wang (2010)^[39]. A few scholars having tried to conduct preliminary analysis of the multilateral game relationship between government, enterprises and consumers in GSC, e.g., Yu and Liu (2011)^[40], Xu et al.(2011)^[41]. Some scholars analyzed the game relationship in GSC of specific industries, e.g., Zhou and Zhang (2007)^[42], Feng and Wang (2010)^[43] Xu et al.(2011)^[41,44].

It can be found that the research results about the game analysis between the main stakeholders are still limit.

2.3 Performance evaluation of GSCM

The study about the performance evaluation is seen as a hot field in GSCM. Green et al.(1998)^[45] conduct a preliminary study about the relationship between GSCM and enterprise performance. Johnson (1998)^[46] makes some modification to Kaplan and Nortons's balanced scorecard method and concludes a revised model, which is more realistic for evaluating the enterprise performance. McIntyre et al.(1998)^[47] conduct a quantitative study of the relationship between green purchasing and corporate performance and conclude that the business performance of the enterprise can be improved with the improvement of the environmental performance through green purchasing. Van Hoek (1999)^[48] studies the relationship between environmental impact and the value added to SC and develops a method for evaluating the environmental value and business value by integrating Talor's OBIA (overall business impact assessment) and LCA (Life Cycle Assessment). Sarkis (2003)^[23] assesses the strategy of GSCM by the use of network analysis, and points out that the strategy of GSCM can enhance the competitive advantage, improve organizational performance, reduce production cost, protect the physical environment, and so on. He details the main elements and components influencing the GSCM strategy. Using empirical results from 186 respondents on GSCM practice in Chinese manufacturing enterprises, Zhu and Sarkis(2004)^[49] examine the relationships between GSCM practice and environmental and economic performance. Using moderated hierarchical regression analysis, they evaluate the general relationships between specific GSCM practices and performance and then investigate how two primary types of management operations philosophies, quality management and just-in-time (or lean) manufacturing principles, influence the relationship between GSCM practices and performance. Xue et al.(2007)^[50] describe a strategic evaluation framework of GSCM of corporations and adopt the Analytical Network Process to dynamically analyze the internal influence factors of GSCM and build a non-linear multi-attribute evaluation model.

Although some of the research results have some conflict with each other, most scholars and enterprises assure that GSCM can enhance the competitive advantage, increase the performance and improve the image of the enterprise.

2.4 Applications of GSCM in specific industries

The foreign researchers pay more attention to the empirical study about the applications of GSCM in specific industries. Most concerns are put into the industry of food, electronics and automobile. Some famous major companies, such as General motors, Ford, HP, P&G, Nike, etc., have actively studied and implemented GSCM. van Hoek (2002)^[51] assess the greening attempts and approaches in two case studies of automotive companies, in terms of both SC practices and relations. It is found that the operations and technological practices in SC are not yet fully developed to realize the strategic approach of greening. Zhu and Cote (2004)^[52] describe the Guitang Group of China and its evolving integrated GSCM model.

The domestic empirical research is very limited. The current studies are mainly about the reverse logistics for Waste Electrical and Electronic Equipment, focusing on the network construction and optimization. Research in

other industries in GSCM context remains qualitative analysis and not enough. Zeng and Zhou (2006)^[53] present a mixed integer programming model to optimize the facility location and the reverse distribution network of scrap computers. In recent years, some scholars study the GSCM problem of home appliance industry, e.g., Yan (2007)^[54] analyzes the barriers in building GSC in electronic appliance industry and presents some relevant countermeasures. Ling and Lai (2008)^[55] introduce the laws and regulations of e-waste in the developed countries, analyze the situation of e-waste handling in China and discuss the construction of GSC in household appliance industry and different method of recovery under the principle of "4R". Xu et al. (2011)^[41,44] conduct some study on the home appliance industry and respectively construct a game model between enterprises and consumers and a three-player game model for the green supply chain.

3. CONCLUSIONS

In general, the GSCM is an effective management approach for enterprises to pursue the strategy of sustainable development and to improve performance and competitiveness. The existing research achievements have expanded the traditional SC management theory and gained some new development. However, the research results are still scattered, more qualitative-oriented and less quantitative-oriented. The research about GSCM is considered to be an emerging field and hard to achieve its own complete theory basis in a short time. The following issues regarding GSCM need attention in the future.

3.1 Extending the resources optimization theory and method based on GSCM

Due to diversifying components and operational objectives, it is necessary to develop the resources optimization theory and method in order to explore how to optimize the effective utilization of resources of GSC. Operations research theory and method can be viewed as a useful and important means and methods in this field, together with the comprehensive application of various modern optimization theories and methods.

3.2 Developing the performance measures for GSCM

Most models handling the problems of performance evaluation have emphasized on single-performance measures, especially the revenue. In the field of GSCM, we should pay the same attention to the environmental and social performance as the economic performance, hence how to evaluate the overall performance effectively by suitable measures need attention. The system dynamics can be applied to confirm the effectiveness of the performance measures for GSC with the help of simulation.

3.3 Innovating coordination theory and models

We can find that the research outcomes about the forward SC are much more than the reversed SC, closed-loop SC and GSC. So the researches in this field need attention, which will meet the requirements of sustainable development of economy. Compared with the general SC, the coordination objects of GSC include not only the supplier and retailers, but also include consumers. The operational objectives will not only focus on the profit maximization, but also consider the environmental performance and other factors. There are many difficulties to establish cooperative relations between GSC members. The degree of information asymmetry in GSC are also much more than the traditional SC. It will be much more complex than traditional SC in the aspect of SC partner selection, coordination management, etc. These will bring many troubles not only to the theoretical study but also to the enterprise practice. So the coordination for GSC will be much more complex and difficult than the traditional SC. How to develop contracts for the GSC coordination will be an important research direction.

3.4 Designing and constructing supervisory system

Because externality and information asymmetry exist in the operation of GSC like the traditional SC, which can not be solved by the market mechanism and the negotiation within the SC members, so it is necessary to design and construct an effective supervisory system closely connected with the characteristics of GSC,

In a word, it is worthy to conduct deeper research in GSCM from the above-mentioned perspectives so as to achieve a proactive environmentally-friendly SC and improve the overall performance of the enterprise, thus to accomplish the sustainable development of the society.

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