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Research on pricing and coordination strategy of green supply chain under hybrid production mode

Cheng-Tang Zhang [a,b,*], Hong-Xi Wang [b], Ming-Lun Ren [a]

[a] School of Management, Hefei University of Technology, Hefei 230009, PR China
[b] Institute of Science, Anhui Agricultural University, Hefei 230036, PR China

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ABSTRACT

In order to investigate the pricing and coordination issues of single-period green supply chain, we base our work on the market demand that green product and non-green products co-exist with and substitute each other, and examine respectively the equilibrium results for two production modes in cooperative game and non-cooperative game. Theoretical analysis indicates that different production costs will post impact on the choice of production modes by manufacturers when consumers have different valuations of the products. Furthermore, system performance in cooperative game is apparently better than that in non-cooperative game. The cooperative pricing strategy coordinated by Rubinstein bargaining can realize the pareto optimization of supply chain system profits and member profits under different production modes, with a 33.3% increase in system profits from that in non-cooperative game. The numerical examples further validate the validity of this coordinated pricing strategy.

1. Introduction

With economic globalization and environmental resources issues becoming increasingly prominent, the theory and practice pertinent to green supply chain (El Saadany & Jaber, 2010; Karakayali, Emir-Farinas, & Akcali, 2007; Sheu, Chou, & Hu, 2005; Zhu & Cote, 2004) are attracting more eyes of scholars and market governors. Proceeding from the sustainable development of society and enterprises, green supply chain management (GSCM) intensifies learning and cooperation between various enterprises of the supply chain, improves the green level of the entire supply chain, and realizes the organized and coordinated management of green supply chain by way of supplier training, environmental forums, green promotion and relevant policies and regulations. Therefore, GSCM is a modern management model focusing on the coordinated development of economic benefits and ecological environment.

Due to the self-interest behaviors of participating enterprises within the supply chain, their activities and decisions are often in conflict with the overall benefits of the supply chain, while green supply chain faces even more complicated questions and have more goals to achieve. Therefore, the green supply chain decision-making involves many aspects. Multiple elements, including environmental and business performance (Green, Zelbst, Meacham, & Bhadauria, 2012; Testa & Iraldo, 2010; Tsai & Hung, 2009) and the interests of multiple behavior subjects, need to be taken into comprehensive consideration. The following two issues should be attached importance to.

1.1. Green supply chain management

One of the first issues considered by market governors is the relationship between external environment (including government behavior (Steurer, 2010; Zhu & Dou, 2007), choice of consumers (Nagurney & Toyasaki, 2003), rival enterprise and non-governmental environment organizations, etc.) and green supply chain operation. Various studies and experimentation have shown that customer pressure not only helps to improve the quality of products but also enhances the profit margins of the manufacturing unit. Nowadays the increasing concern of customers for environment is really a matter to be considered for the decision makers. The various behavior subjects of green supply chain often have to increase hidden costs and investment so as to take actions that are compatible with the environment. This is the case for upstream and downstream node enterprises as well as consumers. Although green products are not completely dominant in the market, there are still a considerable number of consumers, when making consumption decisions, have stepped up from considering the price and quality of products to taking into account of various

* Corresponding author at: School of Management, Hefei University of Technology, Hefei 230009, PR China. Tel.: +86 55165636712.
E-mail address: zct@ahau.edu.cn (C.-T. Zhang).

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factors, including price, quality, compatibility with environment, etc. By using green products, customers cater to their security needs psychologically, without having to worry about the negative impact that products may bring in terms of security. Furthermore, the use of green products results in sense of pride and psychological satisfaction of the customers, as they can reduce the negative impact on environment and gain social recognition by consuming green products and bearing certain social responsibilities.

Laroche, Bergeron, and Barbaro-Forleo (2001) using various statistical analyses, investigated the demographic, psychological and behavioral profiles of consumers who are willing to pay more for environmentally friendly products. Simpson, Power, and Samson (2007) explore the moderating impact of relationship conditions existing between a customer and its suppliers on the uptake and effectiveness of the customer's green supply chain performance requirements. In a setting of automotive supply chain, they find that suppliers were more responsive to their customers' environmental performance requirements where increasing levels of relationship-specific investment occurred. Mu and Li (2005) proved that when the cost of environmental quality increased, and consumers have different preferences on the environmental impacts of products, manufacturers that produce clean products can gain more profits than those produce pollution products-adopting differentiation strategy to improve competitiveness. Similar issues were explored by Meuwissen, Van Der Lans, and Huirne (2007), Dumrongsiri, Fan, Jain, and Moinzadeh (2008). Thus, the choice of consumers is directly related to the pricing of green supply chain products, thereby affecting channel performance. Since green supply chain products feature important heterogeneity characteristics that differentiate them from common supply chains, consumers' valuation of green or non-green products will affect the production model of manufacturers; therefore, considering consumer preferences is an important factor for GSCM that cannot be ignored.

In addition, the implementation of GSCM faces other external pressure and internal impetus. With the implementation of government environmental regulations (Baumann, Boons, & Bragd, 2002; Zhu, Sarkis, & Lai, 2007), the enterprises can maintain good development momentum and competitive edge, only when full consideration is given to the conflicts between enterprises and environment in product management and strategic decisions (Sarkis, 2003). Walker, Di Sisto, and McBain (2008) studied the motive force and barriers of GSCM implementation by enterprises and identified the major types of external and internal impetus in GSCM practices, including organizational factors, management abilities, customers, competitors and social pressure, etc. Green, Morton, and New (2000) pointed out that cooperation between organizations and ways of cooperation are key factors in promoting, encouraging and compelling various enterprises to coordinate their activities with the environment. Carter, Kale, and Grimm (2000), Delmas and Montiel (2009) mentioned external environment in his analysis of impetus and obstacles in green supply chain operation, yet his reference are mainly simple qualitative representations. The main reason for the relatively little relevant literature is the higher living standards of consumers, healthier economic system and better external environment of the developed countries.

1.2. Pricing strategies and coordinating green supply chains

The other issue is the formulation of pricing and coordination strategy in a green supply chain. The pricing decision for green raw materials and green products is critical, as it directly affects the supply and demand of products as well as operational efficiency of green supply chain. For purpose of social responsibilities and higher market competitiveness of products, suppliers and manufacturers need to bear more costs and risks in order to conduct green manufacturing. Green products and non-green products are alternative in terms of function, yet the former are superior to non-green products in terms of quality and environmental requirements. "Green" is a relative concept, which is difficult to define by strict criteria and scope. Green product refers to energy-saving, water-saving, renewable or recyclable product with low pollution and low toxicity, or product whose production process involves the above-mentioned characteristics; it is also the ultimate expression of the application of green technologies. Examples include recyclable packaging bags and rubber products, paint and zinc-air battery with low toxicity and low harm, printers and cars with low emission, energy-saving solar products and electrical appliances, etc. Consumers concern more about the environment than any previous era. However, the prices of green products are often much higher than that of competing non-green products. The reasonable pricing of green products is still an important factor in product purchase for consumers. Therefore, how to conduct reasonable pricing for green products has become the key for green products to dominate the market. There is little extant literature that focuses on the pricing of green supply chain. Chen and Sheu (2009) demonstrate that a proper design of environmental-regulation pricing strategies is able to promote Extended Product Responsibility for green supply chain firms in a competitive market. Bose and Pal (2012) analyze 104 announcements related to GSCM using an event study, and determine what causes statistically significant gain in stock prices for these firms. Zheng, Hu, and Xu (2013) put forward a social responsibility payment factor to represent the price interval that consumers willing to pay more for the green products because they have a preference for it. Get the optimal price of green products by discussion, and make the profits of green supply chain to maximize.

In addition, some scholars focused their researches on coordination strategy. Vachon and Klassen (2006, 2008) mainly based their insightful research on the perspective of optimal allocation of resources within the system, and combined empirical research methods with facts of mobile industry and printing industry in North America. The study indicates that: reasonable and effective coordination strategy can improve the performance of green supply chain operation. Jiao, Xu, and Hu (2006) determined the reasonable intermediate pricing of green supply chain with Rubinstein bargaining model. However, only green production mode was investigated; the demand of the market in which green products and non-green products co-exist lacked in-depth analysis. Swami and Shah (2012) consider the problem of coordination of a manufacturer and a retailer in a vertical green supply chain, and finally, a two-part tariff contract is found to produce channel coordination in this problem. Xu and Zhou (2013) examine the pricing issues of the green supply chain for home appliances industry by using game theory and contract coordination theory. But most of the literature used supply chain contract for coordinating green supply chain. From the perspective of internal operations of green supply chain, using cooperative pricing to coordinate the profits of participating enterprises can better reflect the enterprises' subjective initiative and strategy effectiveness, allowing participating enterprises to achieve cost and benefit sharing, which help enterprises to follow the Triple Bottom Line principle (Elkington, 1998) so as to achieve the integration of corporate profitability, social responsibility and environmental responsibility. In addition, cooperative pricing can effectively eliminate the double marginalization of participating members of green supply chain; bargaining power in the pricing mechanism is reflected by how patient supply chain members are which to some extent is determined by the position of supply chain members and is practically operable. Cooperative mechanism and control system between supply chain members are among the areas of green supply chain that needs in-depth investigations. Relevant studies on these issues are still at an early