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Competition of two green and regular supply chains under environmental protection and revenue seeking policies of government

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ABSTRACT

In recent years, many socially responsible governments employ economic incentives and deterrents to manage environmental impacts of enterprises. We develop a price competition model of two green and regular supply chains under the influences of government financial intervention. The supply chains that each consists of one manufacturer and one retailer provide different types of a product which are partially substitutable in market. We formulate the problem as a game theoretical model in the form of six scenarios based on government tendencies and decision-making structures of supply chains. We analyze the effects of government's tariffs on the players' optimal strategies and we find that there are specific boundaries for tariffs which guarantee stable competitive market. Numerical results reveal that the environmental protection and social responsibility tendencies of the government have measurable impacts on the government's revenue as well as supply chains' and their members' profits.

1. Introduction

With the evolution of green technologies, the companies have decided to include environmental aspects in a new concept of products quality and manufacture "eco" version of their regular products. Putting eco version of products on market, customers have new alternatives beside regular ones. Therefore, regular and green types of products reach a new market share equilibrium based on their features and environmental protection tendency of customers. For instance, new eco versions of vehicles have emerged in automotive industry in recent years. Japanese automakers pioneered in launching hybrid vehicles, and have been followed by several automakers such as Ford and GM corporations (Dijk & Masaru, 2010). The most of internationally well-known automotive firms have explored the green segment of consumers and launched successful hybrid eco vehicles (e.g. Prius and Insight). In spite of extra weight of the electric motor and battery, a typical eco (e.g. hybrid or electric) vehicle is still considerably more fuel efficient than a regular internal combustion engine vehicle of equivalent size and performance (Chen, 2007). Diamond (2009) identified various factors such as the government monetary incentives, gasoline price, and vehicle miles traveled that directly influence total eco vehicle adoption in US. Although the production of hybrid-electronic vehicles has experienced a significant rate of growth in the last 10 years (Dijk & Masaru, 2010), the market equilibrium between internal combustion engine and eco vehicles will evolve depending on technological progress as well as governmental and social trends.

A supply chain (SC) includes a broad variety of collaborative agreements and contracts among independent firms, which integrates them as a collaborative network (Kogan & Tapiero, 2007, chap. 1). Recently, adding the 'green' components to the conventional concept of supply chain management (SCM) is gaining a dramatically growing interest from both academia and industrial society (Sarkis, Zhu, & Lai, 2011). It involves analyzing the interactions between SCM and natural environment. Therefore, the green supply chain management (GSCM) is defined as 'integration of environmental issues within SCM, comprising product design, material sourcing and selection, manufacturing process, and delivery of the final product to consumers as well as end-life management of the product after its useful life' (Srivastava, 2007). The increasing significance of GSCM is mainly driven by regulatory requirements, consumers (market) pressures, and escalating deterioration of the environment for example reducing raw material resources, overflowing waste sites, and growing levels of pollution. The interactions between SC's members are deeply affected by their corporate social responsibility behaviors, as well (Ni & Li, 2012). Comprehensive reviews on GSCM (Srivastava, 2007), sustainable SCM (Seuring & Müller, 2008), environmental footprint

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of manufactured products (Gaussin et al., 2013), and organizational theories of GSCM (Sarkis, Zhu, & Lai, 2011) have been published.

Responsible governments take on the duty of maintaining sustainable development respecting the environmental issues. In this regard, for instance, the most of European governments and their North-American counterparts as well as the Japanese government in particular often employ green legislations and financial instruments to further the awareness of producers of their weighty responsibilities (Robeson, Copacino, & Howe, 1992; Sheu & Chen, 2012). Such governments typically impose green taxes on producers and pay direct or hidden subsidies to the recycling industry to promote ecologically sustainable activities (Luke, 2005).

This paper studies how competing SCs respond to policies of the government. Specifically, this work attempts to answer the following research questions:

1. With respect to the different decision-making structures of SCs and government policies, how can interaction between government and rival SCs be formulated?
2. How do government's tariffs affect the competitive market, and should specific boundaries for tariffs be considered by the government?
3. What are differences between centralized and decentralized SCs with respect to responses to government's tariffs?
4. How do environmental protection and revenue seeking policies of government influence the competitions between SCs as well as their members?

The reminder of the paper is organized as follows. The related literature is reviewed in Section 2. The prerequisites and assumptions are presented in Section 3, then the formulations of problem are given in Section 4 in the form of six scenarios. Moreover, Section 4 derives optimal solution to characterize interaction between government and SCs. Analytical results and sensitivity analysis are discussed in Section 5. Concluding remarks and some directions for future research are provided in Section 6.

2. Literature review

This paper is closely related to GSCM, SCs competitions, and governmental financial intervention. There are several researches which point out that the competition level in markets is evolving from the competition among the enterprises to the competition among SCs (Nagurney & Yu, 2012; Rezapour & Farahani, 2010; Sheu & Chen, 2012; Zhang, 2006; Xiao & Yang, 2008). To exemplify, in the competitive market of smart phones, Microsoft (software supplier of Windows) and Nokia (device manufacturer) constituted an SC to compete with other SCs such as Google (software supplier of Android) and Samsung (device manufacturer). Nagurney and Yu (2012) established a theoretical game model for competition of fashion SCs in the case of differentiated products with the inclusion of environmental concerns.

Governments often use incentive and deterrent policies to exert external positive and negative effects on enterprises, respectively (Sheu, 2011; Sheu & Chen, 2012). Murphy (2000) analyzed the impacts of government's policies on the performance of GSCM from various viewpoints. He explained the green legislations dictated by the government motivate technical innovation in environmental supportive technologies. Similarly, Tsireme, Nikolaou, Georgantzis, and Tsagarakis (2012) showed that in some cases the environmental legislations, market-based instruments, and self-regulated incentives play significant role in managers' decisions to adopt GSCM.

Several studies have been conducted on game theory to investigate the influence of the government financial involvements on enterprises of the green SC. Mitra and Webster (2008) developed a two-period game-theoretical model between a manufacturer and a remanufacturer where the government shoulders the responsibility for collection and disposal of products. They found that the manufacturer would be motivated to design appropriate products for remanufacturing, if the government grants reasonable level of subsidy. Du, Ma, Fu, Zhu, and Zhang (2011) proposed a game-theoretical model on the basis of newsvendor problem to study the impact of emission 'cap-and-trade' mechanism on emission-dependent SC under legislations imposed by government. Sheu (2011) established a Nash bargaining model for analyzing the negotiation between producers and reverse-logistics suppliers under financial interventions of government. He showed that green financial legislations adopted by the government boost the relative bargaining power of enterprises in the green SCs. Similarly, Zhang and Liu (2013) investigated coordination mechanism in a three-level green SC when government influences the bargaining power of its members to promote the smooth operation of GSC.

Jin and Mei (2012) constructed a game-theoretical model for strategies taken by government and suppliers in a green SC. Sheu and Chen (2012) investigated the influences of governmental financial interventions on the competition of green SCs. Their analyses based on a three-stage game model revealed that the integration of forward and reverse SCs would be improved, if the government gets involved as a facilitating mediator. Zhao, Neighbour, Han, McGuire, and Deutz (2012) utilized game theory to analyze the strategies adopted by manufacturers of SCs to decrease life cycle environmental risk of materials and carbon emissions. They hypothesized whether the penalties and incentives of government influence the strategic choices of the manufactures. Additionally, several researchers such as Xu, Hu, and Gao (2011), Nan, Sheliang, and Bo (2011), Zhou and Zhang (2007), Grimes-Casey, Seager, Theis, and Powers (2007) used the game-theoretical model to analyze the interaction between a green SC and government in a special industry.

To the best of authors' knowledge, no research was found that considers the effects of government's policies on competition of green and regular SCs. This paper proposes a game-theoretical model for competition of two green and regular SCs under environmental protection and revenue seeking policies of the government. Therefore, there are four main contributions in this study. For the first and foremost, we consider the government authority as a leader player in a competitive market. The government decision is integrated with SCs' decisions in a bi-level programing structure. Secondly, it is considered that the government may adopt revenue seeking or environmental protection policies in a competitive market. In the third place, this paper concentrates on the competition of one green SC and one regular SC that provide partially substitutable product types in the market. Eventually, the competitive SCs may have different decision-making structures, that is, the centralized or decentralized configuration. Therefore, we investigate the problem in the form of six different scenarios with regard to government policies.

3. Prerequisites and assumptions

For lucidity and simplicity, we utilize the subscript "g" to denote the green product, retailer, or manufacturer, and "r" for the regular ones. Moreover, symbols and notations used through the paper are discussed as follows ($i = r, g$):

α_i the market baseline for product type i;
c_i the unit production cost of type i product manufactured by the corresponding manufacturers, where, $a_i \geqslant c_i > 0$, $c_g > c_r$;
d the substitutability coefficient of the green and regular types of products, $0 \leqslant d \leqslant 1$;