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Competition, cooperation, and coopetition of green supply chains under regulations on energy saving levels

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ABSTRACT

We develop price-energy-saving competition and cooperation models for two green supply chains (GSCs) under government financial intervention. First, we study the best response strategies of the chains for the given tariffs of a government. Second, we formulate 16 mathematical programming models regarding governments' energy-saving, social welfare, and revenue-seeking policies. We find that the government can orchestrate GSCs to fulfil the financial, social, and environmental objectives by an appropriate tariff mechanism. Moreover, cooperation in a GSC and between GSCs may facilitate the government's sustainable development policies. A comprehensive analysis on case study of brick production GSCs reveals some important managerial insights.

1. Introduction

Regarding the global energy system, hopes and expectations are in danger of not being met (World Energy Outlook, 2014). Turmoil from oil shocks in the Middle East, gas conflicts between Russia and Ukraine, uncertainty over the security of nuclear power, and environmental considerations about non-renewable energy sources are some concerns with regard to local and global energy systems (World Energy Outlook (WEO-2014) offers detailed explanations). Meanwhile, energy production and consumption are non-uniform and unfair throughout the world such that two-thirds of the population of sub-Saharan Africa has no access to electricity (WEO-2014). According to statements by the International Energy Agency, although developments in technology and efficiency are promising, considerable political endeavors and commitments will be necessary to improve the energy production and consumption trends (IEA, 2015). Recognizing the hazard of irreversible climate change to human societies and the entire planet, on December 12, 2015, U.N. climate talks in Paris culminated in a valuable intergovernmental agreement that encompasses commitments on emissions, adaptation, finance, and transparency, in addition to practical steps to boost carbon trading. This political agreement clearly committed all governments to making "nationally determined contributions" (NDCs) and to taking steps and actions at a domestic level toward achieving these goals.[1]

Energy-saving efforts are often identified as methods of saving money; however, they simultaneously contribute to decreases in greenhouse emissions, a reduced impact on the environment, the creation of a sustainable energy supply, and social welfare such as job creation. Most of the environmental innovations (e.g., energy-saving efforts) in production processes and product features have been arisen from either government regulations or "market demand" (Howes et al.,

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[1] see "Outcomes of the U.N. climate change conference in Paris", at <http://www.c2es.org/international/negotiations/cop21-paris/summary>

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2013). Data centers of big technology companies such as Microsoft, Google, Facebook, and Apple use 1.5% of all energy in the world. On the other hand, the consumers of IT services are becoming more aware of the need to protect the environment; thus, the technology companies are starting to reduce their energy usage and carbon footprint with clean energy-powered data centers. With the aim of boosting corporate image (green brand), a competition between big technology companies has taken place to offer IT services with the least energy consumption. For example, Facebook and Google prefer to move data centers to colder countries; however, Microsoft pursues energy-saving aim by moving the data centers to the cold water under the sea.[2] Government institutions may offer financial and technical support and also facilitate the coordination of supply chain (SC) members (Lee and Klassen, 2008). For instance, the national and regional agencies of the governments of South Korea (Lee and Jang, 2003) and the United Kingdom (Holt et al., 2000) have employed green initiatives to expand energy-saving and cost-effective environmental technologies.

"Coopetition" is a neologism derived from the combination of "cooperation" and "competition"; it denotes hybrid behavior that includes competition and cooperation between decision makers (players). This behavior refers to the collaborative efforts of competitors with the aim of achieving mutually beneficial results. In business environment, coopetition often occurs when independent companies that exist in the same market work together in the exploration of knowledge, research and development (R&D), and technologies of new products, and they simultaneously compete for market-share and in the exploitation of the knowledge gained (Information Resources Management Association (IRME), 2014). Coopetition has been widely employed in politics and economics to analyze the cooperative behavior of competitors. Establishing relationships with coopetitors is sometimes necessary because they may be sources of innovations (Ahuja, 1996), knowledge and capabilities (Khanna et al., 1998; Dyer and Nobeoka, 2000; Ghobadi and D'Ambra, 2011). Therefore, the competitive advantage of a firm may be based on inimitable and harmonious cooperative relationships with successful coopetitors (Afuah, 2000). Pathak et al. (2014) conceptualized coopetition concept in a SC network and used the micro-process based on evolution framework to evaluate the overall relational dynamics throughout the SC. Applying the coopetition concept, we consider coopetition between green supply chains (GSCs); i.e., we investigate how cooperative energy-saving efforts may improve the performance of rival GSCs. Other research questions are as follows:

- Regarding the various orientations of GSCs (cooperation/competition/coopetition), how can the interactions between GSCs and the government be modeled?
- What is the response of GSCs to different government policies?

This paper is organized as follows. Section 2 reviews the related literature. Section 3 provides prerequisites and assumptions. Section 4 proposes formulation of GSCs competition/cooperation/coopetition in addition to government models. Section 5 presents numerical examples and derives some managerial insights. Eventually, concluding remarks and directions for future research are given in Section 6.

2. Literature review

This research is related to the competition and cooperation of SCs (GSCs), governmental regulation, and energy-saving efforts in GSCs; thus, we review these subjects in the following subsections.

2.1. The competition and cooperation of SCs (GSCs)

Various studies have stated that the competitive environment of industries is changing from competition among independent firms to competition among SCs (Xiao and Yang, 2008). Bernstein and Federgruen (2005) studied the competition among decentralized SCs under demand uncertainty and compared the results with the competition among centralized SCs. Nagurney (2010) considered Nash–Cournot equilibrium conditions for competitive network design problem of several profit-maximizing firms with multi-tier structures. She used variational inequality formulation to compute closed form solution of the network structure. Similarly, Nagurney et al. (2014) investigated SC network competition among profit-maximizing firms with multi-tier structures; however, they utilized the variational inequality formulation to evaluate the competition in time-sensitive markets. Masoumi et al. (2012) developed an oligopoly competition model for pharmaceutical SCs and used variational inequality theory to determine the equilibrium product flows, the equilibrium product demands, and the incurred product prices. Focusing on fruits and vegetables production SCs, Palsule-Desai (2015) established a game-theoretic model for competition between network farmers including a coordinator and decentralized SC including a set of fringe farmers.

There are some studies that have concentrated on competition of two SCs. Zhang (2006) proposed variational inequality formulation for the competition problem of two SCs. He also investigated some quantitative properties; e.g., existence and uniqueness of the equilibrium. Similarly, Rezapour and Farahani (2010) used variational inequality formulation to evaluate equilibrium properties (such as existence and uniqueness) between one existing SC and one new SC with the centralized structures. Xiao and Yang (2008) established a game-theoretic model for price-service competition between two SCs. They

[2] http://www.theverge.com/2016/2/1/10883866/microsoft-underwater-data-centers.