



Distribution of profit in a smart phone supply chain under Green sensitive consumer demand

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ABSTRACT

This research work studies a two-member supply chain (that deals in smart phones) consisting of the manufacturer (positioned upstream) and the telecom service provider (positioned downstream). Customers can purchase smart phone handset and service either separately from the two members (free channel) or as a package (bundled channel) from either of the members. The smart phone manufacturer invests in the greening improvement of the product and the customers are sensitive to the greening improvement level. The study considers three power structures for the bundled channel (Manufacturer is the Stackelberg leader - MS, Telecom Service Provider is the Stackelberg leader - TS, and where both the players possess equal power i.e. Vertical Nash- VN) to characterize the optimal decisions of the manufacturer - the smart phone handset unit retail price, the greening improvement level and the optimal decision of the telecom service provider - the amount of subsidy to pay to the handset manufacturer. The novelty of this study comes from the insights derived from the analysis of the green smart phone supply chain. The supply chain player with superior power earns more profit but is dependent on a condition that is a function of greening investment by the manufacturer, customer sensitivity to greening improvement level and customer sensitivity to prices. Also under similar conditions, the study shows that the balanced power structure (VN) is best for the supply chain i.e. supply chain profits are the highest. The insights derived from analysing the impact of greening investment and customer sensitivity to greening on the optimal subsidy amount are new and have not been studied before.

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1. Introduction and literature review

1.1. Introduction

In recent times addressing environmental issues have become primary focus for firms and in particular manufacturing firms. Consequently, in an era where supply chains compete with each other to gain supremacy in the market place, managing the chains efficiently (economically and environmentally) has become a challenge. Globalization, pressures from different stakeholders and stringent environmental regulations (passed by governments) have forced firms to adapt environmentally conscious or green technologies (Govindan et al., 2014, 2015). Majority of the path breaking concepts in supply chain management in the 20th century was conceived with the idea of reducing wastage (i.e. focus on economic efficiency) rather than environmental efficiency. It is only at the beginning of the 21st century that firms started to wake up to the

idea of green technologies (Govindan et al., 2014). As a result, there has been a huge body of literature that have tried to study the management of green or environmentally conscious supply chains. Rostamzadeh et al. (2015) describes primarily six types of green technology initiatives that can be adapted by global supply chains - green design (ensures green compliance at the design stage itself), green purchasing (purchased raw materials are not hazardous in nature or rather environment friendly), green production (improve production processes to the extent that they do not impact air, water or land), green warehousing (ex: environment friendly packaging), green transportation (use eco-efficient transportation that do not emit harmful gasses) and green recycling (collect back used products for the purpose of recycle, reuse, re-manufacture, safe disposal and so on).

Past literature on green supply chain management (GSCM) is vast and encompasses diverse topics of interest. Bose and Pal (2012) showed that GSCM initiatives create value for those manufacturing sector firms that have high research and development investments. Firms that are early adapter of green technologies, experience

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increase in stock prices on the day of announcement (of the adaptation of green initiatives). Then there are other studies that have explored the relationship between GSCM practices and performance of firms. [Laosirihongthong et al. \(2013\)](#) analyze the impact of pro-active and re-active GSCM practices on the performance of firms (environmental, economic and intangible). This study found that re-active mechanisms like regulation have a significant impact compared to pro-active mechanisms like reverse logistics practices. On the same lines [de Sousa Jabbour et al., 2015](#) studied the impact of GSCM practices on operational and environmental performance indicators. Creating eco-friendly procedures and programs, clean production initiatives, cooperation in the form of response to audits and information sharing with clients are some of the practices suggested by [de Sousa Jabbour et al., 2015](#) that will help to improve operational and environmental performance. [Azevedo et al. \(2011\)](#), [Rao and Holt \(2005\)](#) are some of the other prominent studies that attempt to show that GSCM practices improve organizational performance (environmental, operational and financial).

Moving on, it is worth mentioning that there are other studies which investigated the key driving factors, pressures and barriers related to the implementation of GSCM by firms. [Govindan et al. \(2014\)](#) identified 47 such barriers (related to outsourcing, knowledge, financial, involvement & support) and used Analytic Hierarchy Process (AHP) to prioritize them. The study by [Dubey et al. \(2015\)](#) primarily investigated the enablers of GSCM whereas [Wang et al. \(2016a\)](#) tried to bring to the fore the barriers to GSCM in the packaging industry. [Drohomeretski et al. \(2014\)](#) is another prominent study in this branch of literature. “Guanxi” is a Chinese term that translates to “relationships and connections” in English. According to [Geng et al. \(2017\)](#), a Chinese supply chain manager may select suppliers based on personal relationships, whereas in the West personal and business relations are dealt with separately. [Geng et al. \(2017\)](#) studies the impact of Guanxi on GSCM in Asian Emerging Economies (China, Taiwan, India, Thailand and so on).

From the above discussion it is clear that lot of diverse work has taken place in the field of GSCM. Now let us look at the different industrial sectors that GSCM research has addressed. [Brandenburg et al. \(2014\)](#) provided a comprehensive review (related to quantitative modelling) on sustainable supply chain literature. Table 10 in [Brandenburg et al. \(2014\)](#) mentions the number of works that have gone into each industry sector. Specifically, the table mentions that 16 studies have been done in the electronics sector. We are interested in the electronics sector because our paper studies GSCM in a mobile phone supply chain. [Bask et al. \(2013\)](#) identified the sustainability features (of a mobile phone) that consumers consider before purchasing the handset. [Sarath et al. \(2015\)](#) discussed in detail the studies that have gone into management of wastes generated by mobile phones and subsequent recycling of the devices. [Welfens et al. \(2016\)](#) studied the drivers and barriers that impact the return and recycle of handsets. The findings of the study showed that monetary incentives, proper communication and education influence sustainability practices. [Jayant et al. \(2014\)](#) proposed a quantitative methodology to select reverse logistics providers by considering the case of mobile phone industry.

Now the question that naturally arises here is that - what is so special about the mobile phone supply chain that has attracted the attention of researchers? Over the years the supply chains have undergone massive evolution. From pure manufacturing, pure service supply chains, we currently have manufacturing plus service supply chains. The uniqueness of mobile phone or smart phone supply chain lies in the fact that it is neither a pure product nor a pure service supply chain. It provides both product and service to the end customer. The manufacturer (producer) delivers the product and the telecom service provider (operator) provides the

associated service. Also the relationship between the handset producer and the telecom service provider (operator) in a mobile phone supply chain is symbiotic. The two players need to support each other for their prolonged sustenance in the highly competitive market environment. Apart from the literature on recycling of mobile phone wastes, there are enough evidences to indicate that manufacturers have considered green design, green purchase and green manufacturing in the mobile phone supply chain. Nokia introduced mobile phones and accessories that are free of PVC, products with no toxic flame retardants ([Layton, 2009](#)). LG did away with harmful beryllium from its phones and endeavours to use environment friendly paints along with bio-degradable plastics ([Layton, 2009](#)).

From the above discussions, it is clear that there is lot of research interest in the implementation of GSCM. Also due to its uniqueness, the implementation of GSCM practices in smart phone supply chain is worth studying. Our research focuses on using mathematical modelling to characterize optimal decisions in the green smart phone supply chain. Through the literature review (in the following section) we intend to show that not much work has been done in the domain of green smart phone supply chain that answers the specific questions that we are going to address.

1.2. Literature review

Since our research uses mathematical modelling in GSCM, we will briefly discuss the associated literature. There have been few review papers written on the GSCM in the last 15 years. [Srivastava \(2007\)](#) provided a comprehensive review of GSCM by considering all the works done from 1990 onwards. This study classified the available literature into the following compartments-importance of green supply chain management, green design (considers entire life cycle of product/process) and green operations (network design, green manufacturing/re-manufacturing, management of wastes). Papers on performance measurement in green supply chains have been reviewed by [Taticchi et al. \(2013\)](#). Since GSCM involves green purchasing, selection of suppliers is a key challenge for supply chain managers. [Igarashi et al. \(2013\)](#) discussed the research works that have been done on supplier selection in the context of green supply chain. This review dealt with 60 research papers (in peer-reviewed journals) published between 1991 and 2011. The main findings of [Igarashi et al. \(2013\)](#) - empirical research on green supplier selection had received less attention, conceptual research that links selection of green suppliers with firm's strategy was also less. The selection of suppliers is a complex problem and multiple criteria need to be satisfied at the same time. Hence Multi-Criteria Decision Making (MCDM) models are favored techniques to solve these problems. The work by [Govindan et al. \(2015\)](#) presented the papers that used MCDM as green supplier selection methodology. MCDM modelling is one of the many analytic techniques that have been used for the study of GSCM. [Brandenburg et al. \(2014\)](#) presented a complete overview of all the analytic techniques that have been used for GSCM. This study by [Brandenburg et al. \(2014\)](#) did a comprehensive job by classifying papers (until 2012) based on the modelling techniques, solution approaches, model type, model purpose, industrial sectors involved and many more. Since we use game theory and non-linear programming as our modelling technique and solution approach respectively, we would like to point out that Table 8 of [Brandenburg et al. \(2014\)](#) mentions that only one study each in game theory and non-linear programming existed (as per the scope of the review done). We would also like to draw attention to the study done by [Fahimnia et al. \(2015\)](#) that classifies the existing GSCM literature into five different research clusters - conceptual development of GSCM (69 papers), empirical studies (63 papers), measuring and evaluation of sustainability (44 papers),

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