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Improving performance by coordinating a supply chain with third party logistics outsourcing under production disruption

B.C. Giri [a,*], B.R. Sarker [b]

[a] Department of Mathematics, Jadavpur University, Kolkata 700032, India
[b] Department of Mechanical and Industrial Engineering, Louisiana State University, Baton Rouge, LA 70803, United States

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ABSTRACT

Third Party Logistics (TPL) is playing a significant role in today's supply chain management. Business organisations require the service of this company to outsource part or all of their supply chain operations to reduce the burden of logistics activities and achieve customer satisfaction and overall performance. The paper aims to improve, through coordination, the performance of a supply chain consisting of a monopolistic manufacturer, a third party logistics service provider (TPLSP) and multiple independent retailers. The demand at each retailer is uncertain but sensitive to retail price; unexpected production disruption may occur at the source. Buyback and revenue sharing contracts are implemented in the proposed model and the associated contract parameters are designed so as to coordinate the decentralized supply chain. The participating entities' strategic decisions which increase the profitability of the whole supply chain are determined. It is observed from the numerical study that production disruption and TPL service have significant impacts on supply chain's performance, and the effects of buyback and revenue sharing contracts tend to emerge indifferent for relatively high probability of disruption.

1. Introduction

Business organisations today are increasingly looking for effective logistics and supply chain management that can provide competitive advantages. Outsourcing logistics can effectively reduce logistics cost, extra burden of services and delay risk in delivery. Companies outsource their logistics functions to third party logistics service providers (TPLSPs) in order to concentrate on their core business activities. A TPLSP is an independent enterprise who does not own the product(s) or service(s) but participates in the supply chain and provides logistics services under a contract to the manufacturer, retailer(s) and/or consumers of a product or service. The third party logistics (TPL) and its alliance with the clients, therefore, play an important role in modern supply chain management. In the US and Europe, TPL has shown its great potential; it is now close to its maturity stage of life cycle. In Asian countries like China, Japan and India, TPL is in the path of high growth stage. Today's TPLs are not just carriers or storage companies but they perform various value-added activities and offer diverse services such as returning of goods, (re/dis)assembly, order processing, customized packaging, labeling, bar coding/RFID, etc. (Modarress, Ansari, & Lockwood, 2010). They focus only on their own businesses and, therefore, there may arise unavoidable conflicts of interests with the other members of the supply chain. Besides outsourcing, supply chain collaboration which includes integration of members, joint planning and coordination is very important to work with external partner(s) of the chain. Coordination may be required in performing different functions such as inventory management, logistics, etc. and in different interfaces such as supplier-manufacturer, manufacturer-retailer, etc. especially when the supply chain system is prone to disruption. It is indeed a challenging task to design an appropriate contract that can achieve supply chain coordination without impeding participating entities' individual interests in such a scenario.

2. Literature review

We review the literature on the following two main streams of research relevant to the present study.

2.1. TPL and contractual agreement in supply chain

Research on integrated production and outbound distribution has been growing rapidly in recent time (Agnetis, Aloulou, & Fu, 2014; Chen, 2010). Vining and Globerman (1999) provide a conceptual framework for understanding outsourcing decisions in a

* Corresponding author.
E-mail addresses: bcgiri.jumath@gmail.com (B.C. Giri), bsarker@lsu.edu (B.R. Sarker).

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simple supply chain model with linear trend in demand. They suggest that outsourcing can be mitigated by contractual agreement and strategies associated with the outsourcing. Lie, Wang, and Fan (2006) consider a TPLSP with concave cost function for a supplier-buyer channel and analyze the impact of coordination and pricing policies on supply chain profitability when the market demand is price-sensitive. Jharkharia and Sankar (2007) provide a comprehensive methodology for the selection of a logistic service provider. Their propose methodology consists of two parts: preliminary screening of the available providers, and analytic network process (ANP)-based final selection. Fabbe-Costes, Jahre, and Roussat (2009) study the role of logistic service providers in supporting supply chain integration and clients' performance. Their research suggests that "TPLSPs must be included in the clients' chain but sometimes the clients must also be integrated in the chain of TPLSPs". Pinna, Carrus, and Pettinao (2010) demonstrate that information technology alignment between two supply chain entities such as supplier and TPLSP has direct impact on strategic and operational performances. They argue that the success of logistic outsourcing relationship greatly depends on the third party's technological ability to improve the supply chain's reactivity. Evangelista (2011, chap. 5) focuses on analysing the inherent factors behind adopting information and communication technology (ICT) (which is an essential enabler of supply chain coordination and synchronization) by small third party logistics service providers in supply chain. He, Li, and Nie (2013) consider a situation where different logistics service levels can influence the market demand. They discuss the pricing strategies, service levels as well as coordination and cooperation strategies of two logistic enterprises in the supply chain system. To investigate the impact of third party logistics customer service, Leuschner, Carter, Goldsy, and Rogers (2014) employ a meta-analytic approach to review the empirical literature and identify key constructs surrounding the third party logistics customer relationship. They also investigate the patterns of potential relationships between these constructs.

Lim (2000) develops a game-theoretic model with a contract between a TPL buyer and a TPL provider in which the quality of service and the cost of providing the service are private information to the latter. Chen, Hum, and Sun (2001) analyze multi-period third party warehousing contracts under random space demand in which the contract is specified by a starting space commitment along with provision for a limited number of modifications of the contract. Alp, Erkip, and Gulu (2003) consider the problem of designing parameters of a given transportation contract between the manufacturer and the transporter. They decompose the problem into three subproblems (vehicle dispatching problem, inventory control problem and contract value problem) and exploit their interactions. They consider various combinations of contract parameters to select the one which minimizes the expected total cost of the manufacturer. Dan, Qing, Zhang, and Xiao (2007) design a revenue sharing contract between a TPLSP and a client enterprise, and show by dynamic game theoretic approach that the contract can form a sound internal incentive mechanism. Huang and Li (2008) coordinate the TPL under revenue sharing contract. Gong, Li, and Lu (2008) derives the pricing and coordination policies in a three-echelon supply chain consisting of a manufacturer, a retailer and a TPLSP. Hartmann and Grahl (2012) examine the effects of customer partnering behavior (sharing benefits and burdens, operational information exchange, etc.) on the supply chain performance at the interface between customer firms and TPLSPs.

2.2. Disruption in supply chain

Even though the logistics outsourcing satisfactorily enhances the supply chain performance, the entire supply chain's excellence largely depends on the accurate supply flow of the materials from upstream to downstream. Any kind of disruption at any stage in the pipeline may jeopardize the objectives. It is true that supply disruption due to machine failure or breakdown, process shift, labor strike and natural calamities (e.g., flood, earthquake, tornado, hurricane and snow storm) is an infrequent risk but it has great impact on the whole supply chain (Ellis, Henry, & Shockley, 2010). Parlar and Berkin (1991) and Berk and Arreola-Risa (1994) consider disruption in the classical EOQ (economic order quantity) model. Paul, Sarker, and Essam (2015) study a single-stage imperfect production-inventory system for managing single/multiple disruption(s). Qi, Shen, and Snyder (2009) extend the inventory model to include disruptions at both the supplier and the retailer. Iyer, Deshpande, and Wu (2005) assume a monopolist supplier whose supply to multiple retailers is disrupted and the retailers face backorder costs that are unknown to the supplier because of asymmetric information flow in the supply chain. Tomlin (2006) discusses three general strategies for coping with supply disruptions: inventory control, sourcing, and acceptance. Chopra, Reinhardt, and Mohan (2007) develop a single period model with dual sourcing by integrating two types of supply uncertainty - supply disruption and random yield. Yu, Zeng, and Zhao (2009) study the impacts of disruption risks in the single and dual sourcing channels in a two-stage supply chain with a non-stationary and price-sensitive demand. Hou, Zeng, and Zhao (2010) model a supply chain under supply disruption where the buyer coordinates with the backup supplier through a buyback contract. Li, Wang, and Cheng (2010) investigate the sourcing strategy of a retailer and the pricing strategies of two suppliers in a supply chain under supply disruption. Giri (2011) considers a single-period dual-sourcing inventory model with a primary supplier who is unreliable in the sense that supply disruption may occur from this source, and a secondary supplier who is perfectly reliable. Xanthopoulos, Vlachos, and Lakovou (2012) propose newsvendor policies for a dual-sourcing supply chain network with unconstrained and under service level constraints where both the supply channels are subject to disruption risks. Schmitt and Snyder (2012) consider a multi-period (infinite horizon) inventory system which is subject to yield uncertainty and complete supply disruptions. They develop both single and two-supplier models and compare the optimal results with those of the single period model. In a newsvendor setting, Ray and Jenamani (2013) determine optimal order allocation decisions of two-echelon supply chain with multiple capacity-constrained suppliers under supply disruption. Hishamuddin, Sarker, and Essam (2013) develop a two-echelon supply chain model considering transportation disruption. Chen (2014) investigates optimal procurement design in a supply chain considering heterogeneous beliefs in supply disruption between the buyer and the supplier. He analyses economic trade offs between exploitation over heterogeneous beliefs and supply chain efficiency. Xu, Zhuang, and Liu (2016) consider a sequential defender-attacker game in military supply chain in which defender's performance is affected by disruption in resource supply chain. They show that the defender can benefit from the utilization of risk management tools such as capacity back up, inventory protection, etc.

It is evident from the above literature review that the TPLSP selection and coordination issues between TPL service provider and TPL service demander have been addressed in the literature considerably. However, the impact of disruption on the optimal decisions of a supply chain which consists of a TPLSP has not been paid adequate attention. In this paper, we consider a supply chain system which is made up of a monopolist manufacturer, a TPLSP and multiple independent retailers. The manufacturer who is susceptible to the risk of production disruption, outsources a TPLSP for logistics services to retailers. We investigate the decentralized sys-