ARTICLE IN PRESS

Transportation Research Part E xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Transportation Research Part E

journal homepage: www.elsevier.com/locate/tre

Impact of decision sequence on reliability enhancement with supply disruption risks

Guo Li [a], Lijun Zhang [a], Xu Guan [b,*], Junjun Zheng [b]

[a] School of Management and Economics, Beijing Institute of Technology, Beijing 100081, China
[b] School of Economics and Management, Wuhan University, Wuhan, Hubei 430072, China

ARTICLE INFO

Article history:
Received 26 June 2015
Received in revised form 14 September 2015
Accepted 24 September 2015
Available online xxxx

Keywords:
Decision sequence
Reliability enhancement
Supply disruption risks
Game theory

ABSTRACT

This paper considers a supply chain that consists of a manufacturer and a supplier who faces disruption risks. We investigate the impact of decision sequence on the supplier's endogenous reliability enhancement and the firms' equilibrium pricing strategies. The supply chain reliability achieves a higher level under the supplier–leader game, but this does not always lead to a higher payoff for the supply chain. Each firm prefers to make the decision first, while any decision sequence can become dominant for the supply chain. We also show that the supply chain can achieve coordination via the revenue sharing contract.

1. Introduction

Disruptive events that halt production can result in severe business consequences if not appropriately managed (Dong and Tomlin, 2012). The American Production and Inventory Control Society (http://www.apics.org/) considers supply disruption as one of the most significant supply chain risk. Another report from Veysey (2011) shows that more than 85% of companies have suffered supply disruption at least once. As a result, both practitioners and scholars have proposed and applied many measures to prevent such risk and alleviate its negative effects. Among these measures, one of the most prevalent solutions for supply chain disruption (Tang et al., 2014; Meena et al., 2011) is the adoption of multi-sourcing strategies. For example, General Electronic Healthcare (GEHC) (http://www.ge.com/cn/) is a leading producer of medical apparatus in China. According to its sourcing strategy, GEHC orders from its own qualified supplier, Beijing Sinbon (http://www.sinbon.com/), and requests the supplier Bizlink (http://www.bizlinktech.com/) to form its backup, in case that the former encounters a disruption. The Philips plant fire in 2000 presents another example of multi-sourcing. The two buyers (Nokia and Ericsson) of Philips have faced different outcomes after the incident owing to their different sourcing strategies. Specifically, Nokia placed an emergency order from its backup suppliers, whereas Ericsson went to a virtual standstill with a 400 million dollar loss because of its single-sourcing strategy.

Aside from multi-sourcing, the supplier may invest on new technologies to enhance its supply reliability and to prevent disruption. However, this method is relatively unknown (compared to multi-sourcing strategy) and is highly influenced by the interaction between the supplier and manufacturer. Gurnani and Shi (2008) indicate that the supplier can improve its reliability at some cost and the efforts of the supplier in improving its reliability depend on its price negotiations with

* Corresponding author.
E-mail addresses: liguo@bit.edu.cn (G. Li), lijun@bit.edu.cn (L. Zhang), gavinguan@whu.edu.cn (X. Guan), 99zhengjunjun@163.com (J. Zheng).

http://dx.doi.org/10.1016/j.tre.2015.09.008
1366-5545/

the manufacturer. Hu et al. (2013) examine the restoration enhancement strategy, in which the manufacturer uses price or order quantity incentives to stimulate the restoration investment decision of the supplier.

In this paper, we aim to investigate the voluntary reliability enhancement strategy in a decentralized supply chain setting. In particular, we examine how decision sequence affects the equilibrium strategies of firms and the overall performance of the supply chain. Note that the variety of decision sequence is prevalent in practice and has attracted considerable attention from the academic community (Gurnani and Erkoc, 2007; Klastorin and Tsai, 2004). However, only few scholars have related this issue with supply chain disruption. To address such gap, we develop the following research questions: How does the supplier choose her optimal reliability enhancement level and production quantity under the two decision sequences? How does the manufacturer decide his wholesale and retail prices under these decision sequences? How does the decision sequence influence the supply chain reliability enhancement level and the performances of the firm and the supply chain? How can contracts be used to achieve supply chain coordination?

To answer these questions, we build a two-echelon supply chain setting in which a supplier (she) provides the component for a manufacturer (he) who sells the final product in the marketplace. The market demand is price-sensitive and observable to both the supplier and manufacturer. When the supplier encounters a supply disruption risk, she can mitigate such risk by making costly investments on reliability enhancement. We specially consider two scenarios, which differ in terms of decision sequence of the firm: the supplier–leader game versus the manufacturer–leader game. Under the supplier–leader game, the supplier first decides the wholesale price and reliability enhancement level before the manufacturer determines the retail price. Under the manufacturer–leader game, the manufacturer simultaneously offers the wholesale price to the supplier and determines the retail price, and then induces the supplier to determine her reliability enhancement level. Both scenarios are prevalent in practice and may have different effects on equilibrium pricing, procurement, and reliability enhancement strategies of the firm in a supply chain with disruption risks.

Our analysis yields some interesting results. First, a higher supply chain reliability is observed under the supplier–leader scenario than under the manufacturer–leader scenario. This finding indicates that the supplier develops a strong incentive to enhance reliability by possessing a higher supply chain power than the manufacturer. However, a high reliability level does not necessarily guarantee a high supply chain payoff. Second, the preference of the firm to the decision sequence is aligned with its decision position in the supply chain. In other words, the supplier prefers the supplier–leader game, whereas the manufacturer prefers the manufacturer–leader game. Third, the highest supply chain payoff can be achieved under either of the decision sequences, which further depends on reliability enhancement cost. When the reliability enhancement cost is sufficiently low, the manufacturer–leader game becomes dominant in the supply chain. Otherwise, the supplier–leader game results in a higher supply chain payoff. Fourth, a non-monotonic relationship exists between the payoff and initial reliability level or reliability enhancement cost of the supplier. Surprisingly, a high initial reliability level may hurt the supplier, whereas a medium enhancement cost may benefit the supply chain under the manufacturer–leader game.

The rest of the paper is organized as follows. Section 2 briefly reviews related literature. Section 3 describes the model. Section 4 presents the optimal pricing and reliability enhancement decisions under different decision sequences. Section 5 explores the coordination issue. Section 6 highlights the main implications of our findings and concludes the paper.

2. Related literature

Our work is related to the vast literature that investigates how firms respond to supply disruption risks. One stream focuses on the multi-sourcing strategy of manufacturers, and the other stream focuses on the self-driven product reliability improvement of suppliers. Regarding the multi-sourcing strategy, Anupindi and Akella (1993) address the operational issue of quantity allocation between two uncertain suppliers and discuss the effects of three delivery contracts. With regard to the catastrophic events disruption, Meena et al. (2011) develop an algorithm for selecting the optimal number of suppliers and derive the optimal number of supplier decrease in supplier management cost and super-event probability. Torabi et al. (2015) adopt the two-stage stochastic programming model, but they tend to explore multi-sourcing strategies by considering the established business continuity management system (e.g. recovery times). Notably, Wang et al. (2010) find that the dual sourcing approach is better than the supply reliability enhancement approach. This comparison assumes that the buyer has developed a close relationship with the supplier, which will affect the adoption of a particular production process in the production facility of the supplier.

Unlike these studies, Tang et al. (2014) find that manufacturers prefer to use the subsidy option for supply reliability improvement rather than multi-sourcing. Following this path, we focus on the self-driven product reliability improvement of suppliers. Bohn and Terwiesch (1999), Terwiesch and Bohn (2001) believe that these activities can lower production cost and increase capacity, which in turn significantly improves yield. The assumptions of Baiman et al. (2000), who study a moral hazard issue in which suppliers can prevent or weed out defective items, are partly identical with ours. Surprisingly, Fisher et al. (2006) demonstrate that supply availability can significantly affect downstream demand; therefore, the retailer gains the incentive to reduce execution errors and improve supply reliability. Similarly, Gurnani and Shi (2008) examine the influence of process improvement efforts and show that the associated marginal cost determines whether the supplier will expend extra efforts in improving its reliability than its pricing mechanism. Hou et al. (2010) propose optimal solutions for order quantity and return price under the demand uncertainty and supply disruptions. Madadi et al. (2014) examine how supply quality disruption risk and sending tainted materials to consumers can be curbed by introducing

Please cite this article in press as: Li, G., et al. Impact of decision sequence on reliability enhancement with supply disruption risks. Transport. Res. Part E (2015), http://dx.doi.org/10.1016/j.tre.2015.09.008