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Transportation disruption risk management: business interruption insurance and backup transportation

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ABSTRACT

Business interruption (BI) insurance and backup transportation have been widely used in distribution centers' daily risk management. If disruption occurs, a firm (distribution center) can exert efforts to resume its transportation, although its unit transportation cost during the recovery process is uncertain. This paper studies how ex ante BI insurance can affect the ex post transportation recovery, and compares BI insurance with the ex post action—backup transportation. We investigate four strategies: basic strategy, BI insurance strategy, backup transportation strategy, and mixed strategy (integration of the last two). The distribution center that seeks the least profit loss prefers the mixed strategy to other three strategies. However, the mixed strategy might in turn require longer transportation recovery time than the BI insurance strategy. The BI insurance and transportation recovery are complementary, but the BI insurance and backup transportation are substitutable, the backup transportation and the transportation recovery are also substitutable. We also find that the choice of BI insurance strategy and the backup transportation strategy depends on transportation market, insurance market and distribution center's operational environments.

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1. Introduction

Supply chain disruption has become common as firms are exposed to a myriad of risks, mainly caused by a diverse range of events, such as natural disasters, accidents, terrorism, war, financial crisis, supplier bankruptcy, and transportation delays. A lot of strategies used by the firms to mitigate disruption risks include multi-sourcing, emergence purchases, backup sourcing, and reliability improvement of supply process. These strategies have been extensively studied in the operational and production management field (see Yang et al., 2009; Tomlin, 2006; Hu et al., 2013; Tang et al., 2014). However, transportation disruption, as a type of supply chain disruption, arising when the actual flows are interrupted between two echelons in a supply chain, has received less attention, although transportation disruptions are costly and increasing because of economic globalization and increased outsourcing (Wilson, 2007).

In October 2000, for example, two typhoons damaged the oil gas pipeline belonging to Shanghai Petroleum Natural Gas Co., Ltd. in China, leading to a 178-day service disruption of oil gas. This disruption resulted in profit loss amounting to more

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than 58 million RMB.¹ In June 2007, a freighter hit Jiujiang Bridge in China, which caused damage to the bridge. The company responsible for the bridge had to close the bridge for two years, which led to a major loss of approximately 100 million RMB. In 2008, the Wenchuan earthquake destroyed approximately 14,207 plants, factories, and traffic facilities causing a profit loss amounting to 2 billion RMB.²

In practice, BI insurance is an important tool to transfer the business disruption risk. BI insurance can protect the income of a company and assist the company to resume its normal operation. For example, the insurance company paid Shanghai Petroleum Natural Gas Co., Ltd. an income loss amounting to 33.40 million RMB, accelerating the pipeline repairs in an oil gas disruption. In March 2000, lightning caused a fire that disrupted the production of the supplier of Ericsson, which resulted in a disruption of Ericsson's mobile phone production. Insurance companies compensated Ericsson's business interruption costs amounting to approximately \$200 million (Norman and Jansson, 2004). Moreover, the 9/11 attacks resulted in approximately \$40 billion in insured losses, of which one-third of the insured loss was caused by business interruption (Jasen, 2011).

Backup transportation is also an important and popular strategy which is widely used in logistics after the realization of disruption. With backup transportation, the disrupted distribution center authorizes other distribution centers to transport all or part of its products to the company or its customers when a disruption occurs. These companies can be competitors or subsidiary companies, which may charge a higher price than the normal price because of the additional costs caused by the adjustment of delivery schedule, the charge of work overtime, other additional fees, etc.

This paper examines both the BI insurance—that is, the distribution center purchases BI insurance in advance of a potential disruption—and backup transportation in the context of transportation recovery. In practice, once the disruption occurs, firms usually try to recover their businesses and in most cases, their operation process can be restored. In other words, the amount of products delivered to customers and the recovery process are largely determined by the disrupted firm rather than an exogenous factor. This motivates us to study the problem of managing transportation disruption in the presence of endogenous recovery. Furthermore, BI insurance can assist disrupted companies to resume their normal operation and attain the same profits enjoyed before the disruption event.³ Therefore, the problem of joint transportation recovery and BI insurance purchase decisions becomes relevant and important. Given that the backup transportation and BI insurance both serve to avoid/reduce the profit loss, it is of the distribution center's interest to identify the most efficient combination of BI insurance and backup transportation.

We will focus on the transportation disruption problem faced by the distribution center. A distribution center that might encounter transportation disruption can choose one of the following four strategies: basic strategy (neither BI insurance nor backup transportation), BI insurance strategy (only BI insurance), backup transportation strategy (only backup transportation), and mixed strategy (both BI insurance and backup transportation). We study the following research questions:

Research Question 1: Which one of the above four strategies should a distribution center adopt to cope with the transportation disruption conditional to minimize the profit loss?

Research Question 2: How does the distribution center determine the BI insurance purchase and the transportation recovery jointly?

Research Question 3: How does the backup transportation affect the distribution center's disruption risk management?

Considering the uncertainty of the transportation cost in the recovery process, we establish a model with the distribution center that purchases property insurance and BI insurance. We assume that the delivery quantity per time period will fall down to zero if a disruption is due to physical damage, which results from a disaster covered by the distribution center's property insurance policy. Moreover, after a disruption, the distribution center exerts efforts to recover the transportation and/or uses backup transportation, while the insurance company compensates the profit loss of the distribution center based on the BI insurance policy. Our analysis indicates that the BI insurance and the transportation recovery are complementary, but the BI insurance and the backup transportation are substitutable. Comparing the mixed strategy with other three strategies, we find that mixed strategy performs the best. However, the distribution center using the mixed strategy may have to take longer time to resume its normal transportation capability than the one using BI insurance strategy. Backup transportation strategy dominates BI insurance strategy if the time sensitive coefficient is high or if the disruption probability or the uncertainty of transportation cost is low. Contrary to what one might expect, although the use of backup transportation can reduce the profit loss, the transportation recovery can be slowed down.

The remainder of the paper is organized as follows. The related literature is reviewed in Section 2. The mathematical model is developed in Section 3. The decisions of the distribution center under different strategies and strategy preference are analyzed in Section 4. Section 5 discusses the impact of some key parameters and Section 6 concludes this study.

2. Literature review

The research on business disruption risk management has been rich. One may refer to Tang (2006) and Snyder et al. (2012) for a variety of strategies that have been used to manage disruption risk. However, the studies on disruption risk management in logistics are relatively scarcer. Chung et al. (2015) focused on the problem nature and the application

¹ <http://finance.sina.com.cn/b/20020325/184842.html>, 2002-03-25.

² <http://news.hexun.com/2009-05-07/117455658.html>, 2009-05-06.

³ Brookes, Mark; Goodridge, Scott. Keeping Good Companies (14447614). Jun 2011, vol. 63 Issue 5, pp. 303–305. 3p.

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