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Single or dual sourcing: decision-making in the presence of supply chain disruption risks

Haisheng Yu[a], Amy Z. Zeng[b,*], Lindu Zhao[a]

[a]*Institute of Systems Engineering, Southeast University, Nanjing, Jiangsu 210096, PR China*
[b]*Department of Management, Worcester Polytechnic Institute, Worcester, MA 01609, USA*

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Abstract

The focus of this paper is placed on evaluating the impacts of supply disruption risks on the choice between the famous single and dual sourcing methods in a two-stage supply chain with a non-stationary and price-sensitive demand. The expected profit functions of the two sourcing modes in the presence of supply chain disruption risks are first obtained, and then compared so that the critical values of the key factors affecting the final choice are identified. Finally, the sensitivity of the buyer's expected profit to various input factors is examined through numerical examples, which provide guidelines for how to use each sourcing method.
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1. Introduction

It has been observed that the relationships between suppliers and their immediate buyers have evolved from fragmented, scattered links to today's integrated, interdependent supply chain networks. Although such a change has led to numerous benefits related to efficiency and productivity, it may also result in severe problems, one of which is the risk of supply chain disruptions that has been witnessed by the entire world in the past few years. For example, Toyota production line would have been shut down for two weeks when their sole supplier of the brake-fluid proportioning valves had a big fire in 1997 [1]; the Taiwan earthquake of September 1999 created a panic and huge losses for many electronic firms that use Taiwanese manufacturers as suppliers [2]. The March 2000 fire at the Philips microchip plant in Albuquerque, NM, sent their major buyers, Nokia and Ericsson, to chaos. Fortunately, Nokia learned of the impending chip shortage in just three days and took advantage of its multi-tiered supplier strategy to obtain chips from other sources. Ericsson, however, could not avoid a production shutdown because it was sourcing only from that plant. As a result, the company suffered $400 million in lost sales [3]. A devastating shortage of flu vaccine in the fall of 2004 occurred in the US after 46 million doses produced by Chiron, one of the only two suppliers, were condemned of bacterial contamination [4]. This shortage led to rationing in most states and significant price increases in many places. In summary, since the tragedies of 9-11 and many

* Corresponding author. Tel.: +1 508 831 6117; fax: +1 508 831 5720.
E-mail address: azeng@wpi.edu (A.Z. Zeng).

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subsequent disastrous events, it is becoming increasingly clear to the business world that risks, both predictable and unpredictable, exist in every link of a supply chain and that effective risk management should be on top of every management's agenda.

A quick review of the companies' reactions to supply disruptions mentioned above reveals that dual sourcing or using multiple suppliers can be an effective tool in dealing with unexpected supply breakdowns. Even though the debate on single and multiple sourcing has been around for a couple of decades, the objectives of the research in this area are primarily focused on cost reduction and service level improvement. The effort of examining these two sourcing methods in the context of supply chain risk management is still limited. In this paper, we would like to study how to select between single and dual sourcing modes in the presence of supply chain disruptions.

Scholarly works have also confirmed that supply chains can be vulnerable. For example, Wong et al. [5] have found that today's supply chains are built to be lean and efficient, but if they are unable to find alternatives quickly for unexpected disruptions, the chains will be susceptible to system shocks and disruptions. The studies by Christopher and Towill [6] and Tang [7] suggest that as many firms implement various initiatives such as lean, agile, outsourcing, customized, and global networks to gain cost advantage and market share, their supply chains become more vulnerable at the same time, because there tends to be very little inventory in the system to "buffer" any interruptions in supply. As a result, any disruption can have a dramatic impact on the entire chain.

With many instances of supply chain failures observed in the past, managers and decision-makers are becoming aware of the impacts of supply chain disruptions risks but are still struggling in finding ways for efficient supply chain disruption management. Although there have been numerous discussions and studies over the years that have examined business risks and disruptions in the contexts of financial planning, new-product development, and demand changes, quantitative studies on risks associated with suppliers and the supply networks are still sparse.

This paper is focused on studying a two-stage supply chain where a supply and a purchase take place. This is an essential transaction that occurs in every supply chain network. We consider such a two-stage chain that the buying firm faces a non-stationary, price-sensitive demand of a critical component for its final products and that two suppliers (primary and secondary) are available. The two suppliers can be geographically different and offer two wholesale prices. The supply disruption risk is captured by a known probability. We then formulate a set of expected profit functions (EPFs) with the consideration of supply disruptions when the buying firm uses single and dual sourcing strategies, respectively. Based on these EPFs, we compare the performance of these two sourcing methods and identify the critical factors governing the choice between the two sourcing alternatives. The results shed lights on how to design an appropriate sourcing method when supply disruption risk exists in a supply chain.

The remainder of the paper is organized as follows. Section 2 contains a review of relevant literature from two perspectives, one examines supply chain risk and disruption, and the other analyzes single and dual sourcing strategies. Section 3 presents and analyzes the EPFs in the presence of supply chain disruption risks. A set of numerical analysis of the EPFs and discussions of the associated results are given in Section 4. Finally, the managerial implications of the research results, the limitations of the proposed model, and some possible future research directions are reported in Section 5.

2. Literature review

There exists a large body of literature related to sourcing strategies, risk management and decision-making under uncertainty. Considering the relevance, we review two streams of recent research efforts here: one is focused on supply chain risk and disruption management and the other compares single and dual sourcing methods.

2.1. Supply chain risk and disruption management

Since the tragedy of 9-11, there has been a rapidly increasing trend in research efforts that study the supply chain risks and disruptions both qualitatively and quantitatively. With such a heightened awareness, Cranfield Management School [8] conducted a large-scale research project on the global "supply chain vulnerability". The vulnerability is defined as "an exposure to serious disturbance, arising from risks within the supply chain as well as risks external to the supply chain". In the study, all types of risks, whether it is a supply disruption, demand uncertainty or the so-called "internal risk", are included. Another research effort by Tang [7] combines the definitions developed by others (e.g., Jüttner et al. [28] and Deloitte and Touche, http://www.deloitte.com) and defines supply chain risk management as "the management of supply chain risk through coordination or collaboration among

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