Available online at www.sciencedirect.com
ScienceDirect
European Journal of Operational Research 186 (2008) 1158–1174
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH
www.elsevier.com/locate/ejor

O.R. Applications

The risk of second-tier supplier failures in serial supply chains: Implications for order policies and distributor autonomy

Thomas Kull *, David Closs

Department of Marketing and Supply Chain Management, Eli Broad College of Business, Michigan State University, N370 North Business Complex, East Lansing, MI 48824-1122, USA

Received 15 February 2006; accepted 15 February 2007
Available online 24 March 2007

Abstract

As organizations decrease inventory, the potential impact of a supply disruption increases. However, due to supply chain structural changes, the likelihood of a disruption may be less. Additionally independent supply chain actors may react to policy changes, changing supply chain configurations and perhaps reducing loss magnitudes. If risk is a product of likelihood and magnitude, does higher inventory reduce an organization's supply related risk? This paper examines the supply risk issue within the context of a second-tier supply failure, and is grounded in inventory and resource dependency theories. By evaluating risk assessment in a simulation environment, exploratory findings suggest that increased inventory in a tiered supply chain can sometimes increase supply risk rather than decrease it. Managerial insights into the effects of supply chain stability and coordination are provided. By taking a systems perspective of supply risk management, organizations will be better able to manage supply risk concerns.

Keywords: Supply chain management; Risk management; Simulation; Resource dependence

1. Introduction

Organizations desiring effective supply chain management are often faced with two seemingly contradictory goals. That is, ensure the continuity of supply (Burt et al., 2003) and eliminate wasteful inventory (Suzaki, 1987; Schultz et al., 1999). One recent example involved supply shortages in the US of such items as coffee, oysters and diesel fuel when hurricane Katrina struck Lousianna (Stone, 2005). The effects of which were felt even by school children in Georgia as superendendents shut down schools due to a lack of bus fuel (Hubbard, 2005). Moreover, minor shortages can also occur due to a supplier's poor information linkages and inflexible production systems (Vachon and Klassen, 2002). One approach to mitigating upstream uncertainty is the use of buffer – or safety – inventory (Milgate, 2001), while another strategy is to increase order size (Gurnani et al., 1996). Upstream uncertainty is associated with the concept of supply risk or ultimate supply failure (Zsidisin, 2003a). Therefore, there should be a correlation between inventory

* Corresponding author. Tel.: +1 517 353 6381; fax: +1 517 432 1112.
E-mail addresses: kull@bus.msu.edu (T. Kull), closs@bus.msu.edu (D. Closs).

0377-2217/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.ejor.2007.02.028

level and supply risk. Although research has been done associating inventory with supply uncertainty for dyadic relationships, there has been limited research on second-tier supply dynamics and supply risk.

In fact, it has been noted that there is little understanding of what risk means in a supply management context, and only recently has a grounded definition emerged (Zsidisin, 2003a). This definition of supply risk provides an operational construct which is useful for investigating questions such as: (1) Does increasing inventory always decrease the impact of supply risk? (2) Does increased inventory improve performance for various types of supply failure? and (3) How does supply chain configuration impact supply risk? Additionally, research has shown that supply risk often involves second-tier suppliers; that is, companies which provide products to an organization's immediate suppliers (Zsidisin, 2003b). This results in the question regarding whether the situation changes when a second-tier supplier is involved.

Many past studies have examined supply uncertainty in a dyadic relationship (Gurnani et al., 1996; Parlar, 1997). These studies have approached the analysis assuming supply to be probabilistic and continuous. Although this is a useful assumption for analytical purposes, it does not represent the discrete nature of many supply chain issues, such as fill rates (Kleijnen and Smits, 2003) and supply failures (Gupta, 1996). As such, the current analysis allows for discrete-events, particularly the on/off nature of supply failures.

Using inventory and resource dependency theories, this research demonstrates the interaction of inventory and supply risk on system performance. Simulation modeling is used because it offers a systematic approach to understanding the relative and interactive impact of factors within given scenarios (McClelland, 1992). Our somewhat counterintuitive experimental findings demonstrate that in a decentralized supply chain, higher inventory can increase an organization's supply risk exposure. Exploratory results reveal that the methods used to manage inventory significantly influence supply risk vulnerability. This finding has managerial implications for organizations seeking to assess and manage supply risk. Accompanying this finding is a demonstration of how a simulation tool can be used for evaluating exposure to supply risk. Overall, this study provides validation for a systems thinking approach to supply risk management, which posits that "the performance of a system is not the sum of the independent performances of its parts. It is the product of their interactions", (Gharajedaghi and Ackoff, 1984). The following sections synthesize the literature, describe the theory, detail the research approach, review the findings and observations, and finally discuss the managerial implications.

2. Literature review

The following section briefly overviews relevant literature and discusses its relevance to supply risk. Relevant supply chain models are examined.

Kraljic (1983) presents issues regarding supply risk and sourcing instability in one of the earliest works in which purchasing is viewed as supply management. From Kraljic's view, risk includes supply scarcity (e.g. availability), material substitution, market complexity, and supply importance. Furthering the issue of supply availability within the context of supply risk was Noordewier et al. (1990), who used transaction cost analysis (TCA) to help explain the association between uncertainty and supplier delivery performance. Further enhancing the understanding of supply risk was a literature review performed by Zsidisin (2003b) listing the multi-faceted characteristics of supply risk which included capacity constraints, cycle time, disasters, inbound transportation, inventory management, availability of suppliers, and supply availability.

A few varying definitions of supply risk have been proposed (Harland et al., 2003; Zsidisin, 2003a). The Zsidisin (2003a, p. 222) grounded definition is used for this study. Specifically,

> "Supply risk is defined as the probability of an incident associated with inbound supply from individual supplier failures or the supply market occurring, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety."

A tool was proposed by Harland et al. (2003) by which supply risk could be managed, focusing on risk assessment as a crucial component. Concurrently, Zsidisin et al. (2004) reveal simulation methods are sometimes used by organizations to obtain insight regarding inherent supply risk. White's (1995) review of risk management techniques also suggest simulation models, termed Hertz-type and Monte Carlo, are used in assessing risk. Furthermore, White (1995) states regarding modeling entire