Int. J. Production Economics 139 (2012) 58–64

Contents lists available at SciVerse ScienceDirect

Int. J. Production Economics

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

Supplier risk management: An economic model of P-chart considered due-date and quality risks

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ARTICLE INFO

Article history:
Received 30 August 2009
Accepted 3 March 2012
Available online 15 March 2012

Keywords:
Supply chain risk management
Quality management
Control chart
keiretsu

ABSTRACT

We present a quality risk management model for a supplier–assembler structure supply chain. To mitigate quality risks, supply chain members are coordinated by sharing their information. A good example of such supply chain is the *keiretsu* of Japanese automobile industries. To be able to quick respond to the assembler's feedback (e.g., quality problems) has become a key point of a supplier's competitive edge. This ability is also useful for removing bottlenecks among a supply chain. In the setting of a due-date to treat an assignable cause, because idle risk and delay risk have a trade-off relationship, find out the optimal due-date becomes a problem of great interest to the supplier. We develop a P-chart solution model to help suppliers find out the optimal due-date that minimizes the total cost. We also clarify the relations among various risks by analyzing proposed model. We find that a longer due-time should be set when either the sampling interval is longer or a high quality is demanded.

1. Introduction

Today's business can be described by a single word: turbulence. Turbulent markets have the following characteristics: short product life cycles, uncertain product types, and fluctuating production volumes, which have led to a complicated supply chain that was simple in the early years (Yin et al., 2011a). A complicated supply chain usually involves various risks. Supply chain risks can have huge negative impact on a firm's short-tem performance. Previous studies have summarized several examples that include the Ericsson's crisis in 2000, the 9/11 terrorists' attack, the SARS outbreak in 2003, and the Taiwan earthquake in 2006 (Oke and Gopalakrishnan, 2009; Tang and Musa, 2011). In 2011, the world's leanest and largest carmaker – Toyota – dropped to the third place behind General Motors and Volkswagen Group. Toyota's supply chain was disrupted by 3/11 Tohoku earthquake, Tsunami hit, and Thai flood. Supply chain risks can have significant effects on a firm's long-term financial performance as well (Tang, 2006). For example, Hendricks and Singhal (2005) report that the average abnormal stock returns of firms that experienced supply chain disruptions is nearly minus 40%.

Over the last 10 years, how to identify and mitigate risks, uncertainties and vulnerabilities within a supply chain have attracted a lot of attention amongst academics and practitioners. Tang (2006) defines Supply Chain Risk Management (SCRM) as "*the management of supply chain risks through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity*". Based on the definition of SCRM, it appears that one can mitigate risks by adopting appropriate policies of the 3c (coordination, collaboration, and cooperation).

A company (e.g., an assembler) in a supply chain usually holds a win–win or lose–lose relationship with its upstream players (suppliers) and downstream players (customers). They are partners and need to coordinate together to achieve win–win and avoid lose–lose by mitigating supply chain risks. An example of strong coordination relations among supply chain players is the structure of the assembler–supplier relation of Japanese auto makers. This structure is called as "*keiretsu*", which enables Japanese auto assemblers to remain lean and flexible while enjoying a level of control over supply chain akin to that of vertical integration (Ahmadjian and Lincoln, 2001; Schonberger, 2007; Yin et al., 2000). Toyota and its partners (suppliers such as *Denso*) are conspicuous example of a *keiretsu* structure. *Keiretsu* is an excellent example of SCRM. Many publications (Smitka, 1991; Clark and Fujimoto, 1991; Nishiguchi, 1994; Liker, 2004) describe the *keiretsu* as a supply chain of high trust cooperation, strong leadership, long-term purchasing relations, intense collaboration,

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doi:10.1016/j.ijpe.2012.03.004

cross-shareholding, and the frequent exchange of personnel and technology.

In one of our recent studies (Yin et al., 2000), we developed an analytical model to study how a serial supply chain (e.g., *keiretsu*) avoids risks and gets benefits from the coordination between an assembler and its suppliers. We found conditions under which optimal coordination policies should be taken by the assembler. A distinct drawback of our study is that we did not consider and analyze suppliers' coordination policies. The aim of this paper is to fill this gap. We propose a model to study the coordination policies from a supplier's side.

Motivation of our research was raised by an industrial case of our study sites. We investigate how to mitigate quality risks by determining the optimal due-date, a topic has strong industrial backgrounds (see Funaki (2012) for how Hitachi designed its supply chain with due-date based demand). In detail, we propose an economic model of P-chart for a supplier in consideration of the due-date and quality risks of its products. In the supply chain shown in Fig. 1, prompt response of the supplier to the feedback problem from the assembler is important, and not only has become a key point of the supplier's competitive edge, but it is also useful for solving the bottleneck problem of the whole supply network. In the setting of a due-time to treat an assignable cause, because idle cost and delay cost have a trade-off relationship, find out the optimal due-date becomes a problem of great interest to the supplier and assembler. The trade-off relationship is shown in Fig. 2, which will be explained in Section 3.

2. Literature review

SCRM is a structured and synergetic process throughout the supply chain, which seeks to optimize the totality of strategies, processes, human resources, technology and knowledge. The aims of SCRM are to control, monitor and evaluate supply chain risk, and to safeguard continuity and maximize profitability. Since SCRM is a very broad topic, several authors have attempted to classify risks based on various aspects (Spekman and Davis, 2004; Tang, 2006; Hallikas and Karvonen et al., 2004; Chen and Paulraj, 2004; etc.). Dow Chemical Company examined the following factors of a supply chain: supply market risk, supplier risk, organization risk and supply strategy risk (Hackett Group, 2007). Neiger et al. (2009) proposed a value-focused process engineering methodology for process-based supply chain risk identification with the aim to increase value to supply chain members and supply chain as a whole. Sabine et al. (2009) analyzed a supplier risk management framework that focuses on supplier development using a benchmarking approach. Trkman and McCormack (2009) presented preliminary research concepts regarding an approach to the identification and prediction of supply risk. Wang et al. (2010) explored a model in which a firm can source from multiple suppliers and exert effort to improve supplier reliability. In this article, we propose an economic model of P chart for facilitating suppliers' quality risk management.

To improve customers' satisfaction, the P control chart is often used in manufacturing processes as a control tool for monitoring

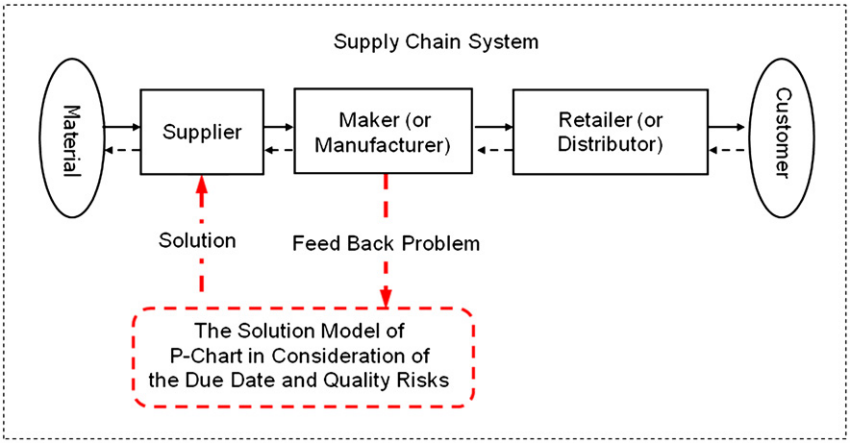

Fig. 1. The solution model of P-chart for supply chain network.

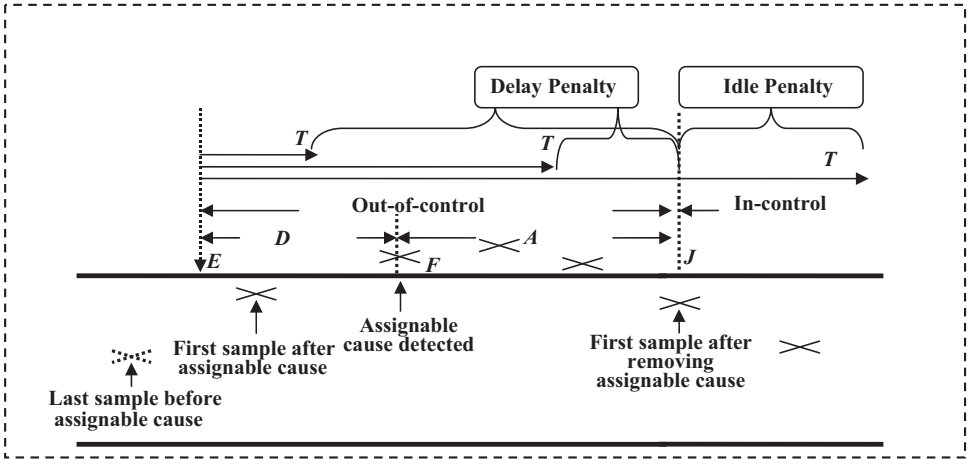

Fig. 2. The solution model of the P-chart for a supply chain system.