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Quality supervision and coordination of logistic service supply chain under multi-period conditions

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ABSTRACT

Quality supervision and coordination are critical in realising successful cooperation in the logistics service supply chain (LSSC). To build a closer partnership in the supply chain, collaboration in the LSSC presents multi-period features. Therefore, the study on the quality of decision-making problems under multi-period conditions in the LSSC is practical. Logistic service quality is not easy to measure. Hence, this paper proposes a multi-period quality coordination model based on the single-period quality coordination model in a two-echelon LSSC, and establishes a new model in a three-echelon LSSC when the logistics service integrator (LSI) is punished. Simulation results indicate that under multi-period cooperation conditions, the LSI tends to make rapid decisions when punishment intensity is below the critical value. Moreover, for the three-echelon LSSC, the final equilibrium between sub-LSI and ultimate FLSP is not associated with punishment intensity that the LSI sets against the sub-LSI.

1. Introduction

The logistics service supply chain (LSSC) is a new type of service supply chain with the basic structure: functional logistic service provider (FLSP)→logistics service integrator (LSI)→manufacturers or retailers (Liu et al., 2011). The LSSC provides flexible logistic service to the manufacturing supply chain. FLSPs refer to traditional third party logistics firms such as transportation enterprises, storage enterprises among others. The LSI classifies them as suppliers when a domestic or an international service network is established because of singularity, normality and regionality. Baogong Logistics Company of China, for example, integrates more than 500 storage companies, 1200 highway transportation companies, and 500 manual loading and unloading companies as its FLSPs. With these FLSPs, Baogong provides comprehensive logistics services to several famous manufacturers such as Procter & Gamble, Unilever, etc.

Service quality coordination plays a great role in LSSC management. To meet the quality requirement of customers, LSI supervises FLSP after the LSI outsources the logistics business to FLSP. Normally, the LSI tends to establish a partnership with the FLSP to achieve long-term cooperation. The partnership reduces the hesitancy of the FLSP to do business. Moreover, the cost and risk of the LSI to search for a new FLSP diminishes. The LSI should then schedule multi-period quality supervisions on the FLSP. Therefore, research on quality cooperation under a multi-period term is more significant than that under a single-period. However, current research on quality cooperation focuses on the manufacturing industry and on a single-period perspective. As a result, the problem of multi-period quality supervision in the LSSC has not been studied. This problem will be discussed in this paper. This paper aims to answer the following important questions:

1. It is difficult to measure logistics service quality because logistics services are invisible (Nie and Kellogg, 1999). Hence, how can this feature be considered in the LSSC quality game model?
2. In a two-echelon LSSC consisting of one LSI and one FLSP, LSI supervises after outsourcing the logistics business to the FLSP. FLSPs may be penalized when they cannot complete the logistics business with the required quality (i.e. FLSP takes a fraudulent strategy). Compared with the single-period, how does the LSI design the quality control and punishment strategy in the case of multi-period relationship?
3. The LSSC is often characterized by multi-echelons. What is the difference for the quality control strategy of the LSI between the two-echelon and the three-echelon LSSC? Will the number of cooperation periods affect the quality of the decision of the LSI?

2. Literature review

In recent years, the service supply chain has become an interesting topic, and the quality coordination of the service

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supply chain has caught the attention of many scholars. Since the LSSC is one branch of the supply chain, this literature review will cover the research progress of quality coordination of both the supply chain and the LSSC.

2.1. Supply chain quality coordination

Supply chain quality management is a system-based approach to the performance improvement that integrates supply chain partners and leverage opportunities created by upstream and downstream linkages, and focuses on creating values and achieving satisfaction of intermediate and final customers (Foster and Thomas, 2008; Robinson and Malhotra, 2005). The relevant literature focuses on three perspectives, which are the supply chain quality management framework (Fynes et al., 2005; Robinson and Malhotra, 2005; Kaynak and Hartley, 2008; Li et al., 2011; Tan and Tse, 2012), the relationship between supply chain quality and organization performance (Lai et al., 2005; Stanley and Wisner, 2001; Seth et al., 2006, Gyan and Kripa, 2008; Han et al., 2011), and the quality supervision and coordination decision (Lin et al., 2005; Balachandran and Radhakrishnans, 2005; Hu et al., 2010; Hsieh and Liu, 2010; Xie et al., 2011). Among the three, many scholars are mostly concerned with the last one. Several research achievements have been made in this field.

A single-period case is always assumed when the problem of supply chain quality supervision and coordination decision is studied. The content mainly consists of the quality game of moral risk (Balachandran and Radhakrishnan, 2005; Liu, 2009; Hsieh and Liu, 2010), the quality improvement in case of an imperfect product (Hu et al., 2010; Zhang and Wang, 2008), and the risk and quality control in the supply chain that considers the competiveness of suppliers, etc. The research methods include the game theory method (Balachandran and Radhakrishnan, 2005; Liu, 2009; Zhang and Wang, 2008; Hsieh and Liu, 2010), surveys (Tapiero, 2007), bi-level programming (Franca et al., 2010), among others. Hu et al.(2011) presented an approach to quality control under a multi-period dynamic game. The results of the studies mentioned above show that manufacturers supervise and increase investments in quality inspection to avoid fraud among its suppliers.

2.2. LSSC quality coordination

Recent advances in LSSC pay more attention on quality coordination. Firstly, many methods in the study of the LSSC have been used such as game, bi-level programming, and principal-agent theories, among others. The research contents vary from a basic game model for quality supervision based on capacity cooperation (Liu et al., 2006) to complex models such as bi-level programming (Guo et al., 2007), double principal-agent (Yan and Li, 2009), Bayesian Nash equilibrium (Zhang et al., 2010), and quality coordination under quality completion (Bai and Zhang, 2010). The problems of quantity coordination based on capacity cooperation under multi-period conditions in LSSC (Liu and Xu, 2012; Liu et al., 2011) have been considered. However, the quality coordination of the two- echelon and three-echelon LSSC with multi-period orientations has not been discussed. Moreover, logistics services, which is difficult to measure, have not been considered in the existing quality game model of the LSSC and manufacturing supply chain. Hence, it is necessary to build a new game model that considers its difficulty.

The literature reviewed above shows that study of supply chain quality coordination focuses on the single-period condition lack of multi-period cases. Three points should been considered in building the quality coordination model of the LSSC: the first point should consider how to reflect the difficulty in measuring logistics service in the quality game model; the second point should show how to represent reasonably the correlation between the previous and the rear periods under multi-period circumstances; and the third point should present how to extend the model of the two-echelon LSSC to the three-echelon structure.

The paper is organized as follows: Section 3 explains the research methodology used in this paper. Section 4 develops a multi-period game model (Model I) based on a single-period quality game model in the two-echelon LSSC that could extend to the three-echelon LSSC (Model II). In Section 5, a numerical method is adopted to identify the properties of the Nash equilibriums. Section 6 discusses the management implication of the two models, and presents the main conclusions and future studies.

3. Research methodology

With the game theory, this paper intends to analyze the problem of quality coordination of LSSC under multi-period conditions. By establishing the revenue matrix of quality game model in single-period two-echelon LSSC, a mixed strategy Nash equilibrium is firstly obtained, and then through the introduction of the correlation between the previous and the rear periods, the multi-period mixed equilibrium is drawn. By means of numerical study, the mixed equilibrium solution to different parameters is achieved. Then the quality game model of three-echelon LSSC is proposed on the basis of the former two-echelon LSSC model. Further, the multi-period mix equilibrium variation tendency is given. Finally, the conclusion of the article after discussion is reached and future perspectives is given.

4. The model

4.1. Model I: multi-period quality coordination model in the two-echelon LSSC

4.1.1. Sequence of events

Suppose that a two-echelon LSSC is composed of one LSI A and one FLSP B. For simplicity, assume A outsources all the logistics business to B. Then B displays trusty collaboration and deceives two types of behavior, whereas A correspondingly reveals the quality to B with or without supervision. Once A is not satisfied with B for his deceiving, one of the following strategies would be adopted in next cooperation: (1) enhance the punishment intensity for a better quality, namely rapid punishment strategy; (2) adjust the punishment intensity after N periods instead of right now, for encouraging B to improve the quality, namely delay punishment strategy. The sequences of events with rapid punishment strategy and delay punishment strategy are shown in Figs. 1 and 2.

The sequence of events with rapid punishment strategy is described as followed:

(1) LSI A sets the punishment intensity θ_t based on his satisfaction with the performance of FLSP B in the $(t-1)$th period.
(2) Since punishment intensity θ_t has been set, A chooses the optimal probability of supervising x_t, meanwhile B chooses the optimal probability of trusty cooperation y_t in the tth period.
(3) A achieves the expected revenue $U(x_t y_t)$.
(4) By comparing with the lowest acceptable revenue, A acquires the satisfaction degree with the cooperation, which would affect the next cooperation.