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Cooperative quality investment in outsourcing

Jingxian Chen [a,b,*], Liang Liang [a], Feng Yang [a]

[a] School of Management, University of Science and Technology of China, Hefei 230026, China
[b] School of Business, Nantong University, 9 Seyuan Road, Jiangsu, Nantong 226019, China

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ABSTRACT

This paper highlights the importance of having a cooperative quality investment (CQI) strategy and proposes a simple proportional investment sharing schedule in the outsourcing of a supply chain, which consists of a contract manufacturer (CM, the supplier) and two competitive original equipment manufacturers (OEMs, the buyers), the demands of which are sensitive to both price and product quality. A three-stage dynamic game-theoretic framework is applied to describe decisions of every entity. Specifically, we analyze three possible decision structures for the quality choice: the CM optimally sets the product quality, and two OEMs cooperatively or noncooperatively set the product quality. By the backward induction approach, we obtain the analytical equilibrium solutions for each decision scenario. We determine that the CM's share of quality investment expenses is sufficiently large, and the CQI strategy will be beneficial to quality enhancement regardless of who sets the product quality level. With respect to the equilibrium payoffs (profits), this study shows that the CM always prefers to have complete control of the quality choice when there is implementation of the CQI strategy, while the OEMs are always hurt by this strategy, except when they cooperate on the quality decision with a rather large CM share. In addition, the whole supply chain's profit can be improved by practicing the CQI strategy. Furthermore, we explicitly propose the conditions for realizing this improvement.

1. Introduction

In the early 1990s, such business gurus as Peter Drucker and Tom Peters challenged companies to "do what you do best and outsource the rest" (Vitasek and Manrodt, 2012). Thereafter, many business leaders took this advice and a rapid increase in outsourcing could be found in the late 1990s and the first decade of the twenty-first century. Currently, outsourcing is a pervasive feature of a supply chain and has contributed significantly to the growth of the global economy. Firms in different industries increasingly consider outsourcing to be a strategic option to reduce the cost, improve the quality, increase productivity, and enhance core competencies (Xiao et al., 2014). A new report has stated that Pacific Rim Countries accounted for 46.6% of the total United States manufactured imports and China accounted for 54.7% (approximately 25.5% of the total manufactured imports) of the United States manufactured imports from Pacific Rim Countries in 2012 (Morrison, 2013).

Many business practices have verified the advantages of having a supply chain outsourcing strategy; for example, Nike has used outsourced providers to help them dominate the footwear market, capturing and building a 47% market share (Vitasek and Manrodt, 2012). However, some argue that more reliance on outside suppliers is likely to lead to a loss of overall market performance due to issues such as the loss of long term of research and development (R&D) competitiveness, incompatible strategy goals, long lead-times, less control on the quality, higher transaction costs, poor delivery reliability, and the loss of in-production capability (Gilley and Rasheed, 2000; Xiao et al., 2014).

As a well-known downside of outsourcing, low control on the supplier's (i.e., contract manufacturer, CM) quality could cause the supplier to have no incentive with respect to the quality investment, which ultimately incurs poor product quality. Therefore, the customer manufacturer (i.e., the original equipment manufacturer, OEM) should define some incentive mechanisms for improving the product quality to enhance the competitiveness in the terminal consumption market. How to encourage the CM to improve the quality in

* Corresponding author at: School of Business, Nantong University, 9 Seyuan Road, Jiangsu, Nantong 226019, China. Tel. +86 13962967110; fax +86 513 85012561.
E-mail addresses: jxchenms@vip.163.com (J. Chen), lliang@ustc.edu.cn (L. Liang), fengyang@ustc.edu.cn (F. Yang).

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outsourcing? This question is an interesting but challenging topic that is a management focus. In practice, strengthening quality inspection is always used to implement quality control on the supplier's quality. Although a more rigorous quality standard would be beneficial to the OEM for enhancing the quality competence in the end market, it could deeply hurt the CM and even disrupt the supply chain due to the pressure of a standard implementation. For example, one factory of the giant CM Hon Hai Limited (also known as Foxconn Technology Group) in the Chinese mainland underwent a large-scale strike that was triggered by the instruction to strengthen quality inspections for iPhone 5, which was given by the OEM customer Apple Inc. (Elmer-DeWitt, 2012). Some procurement and supply chain managers suggest that the OEM should pay for the CM's quality improvement (Tencent Technology, 2012). With consideration of this advice, this paper will propose a simple vertical quality cooperation schedule for encouraging quality improvement and exploring its effects on quality choice and supply chain performance.

Cooperative quality investment (CQI) is not a novel definition in the literature: Banker et al. (1998) have studied the impact of quality cooperation on product quality. Moreover, as these authors cited in their paper, the Big Three automakers practice this cooperation in battery technology for electric vehicles (Section 3, page 1185). The cooperation discussed in their study is between two enterprises that are at the same echelon of the supply chain, i.e., a horizontal cooperation. However, this paper will focus on vertical quality cooperation strategies and aim to provide insights by studying the interactions among the players in supply chain outsourcing. To the best of our knowledge, this type of quality cooperation strategy has received little attention in the extant literatures. However, it is commonly observed in practice such as Toyota Motor Co., Ltd. beginning to cooperate with its supplier for improving the product quality since 1970 (Toyota, 2012).

A recent study considered a cooperative R&D strategy in supply chain and analyzed the members' cooperative behavior under three common options: an R&D cartel, a research joint venture, and a research joint venture cartel (Ge et al., 2014). In contrast to Ge et al.'s concentration on cooperation in a supply chain with one supplier and one manufacturer, we consider CQI in the outsourcing of a supply chain that consists of a CM and two competing OEMs. In addition, we consider two OEMs that compete both on price and on product quality. For example, Nokia and Apple competitively sell cell phones that have different prices and quality levels at the same end consumer market in the Chinese mainland, while most of their cell phones are assembled by a common CM Foxconn Limited (Luk, 2013).

In this study, we employ the game-theoretic approach to model the CQI strategy in supply chain outsourcing and use the backward induction technique to derive equilibrium solutions of quality, prices and profits for each member. In our model framework, we propose a simple proportional sharing schedule for quality investment, i.e., each OEM will share partial quality investment expenses for compensating CM's quality expenditure. Thus, the following question can naturally arise: who controls the quality choice? Each supply chain member has a different profit function with regard to the quality, which could yield different optimal quality levels and in turn affect quality investment expenses and profits. Thus, the power configuration of the quality decision plays an important role in our model. Enlightened by the famous “Manufacturer Stackelberg” and “Retailer Stackelberg” models proposed by Choi (1991), we consider two types of channel power structures: The CM has complete control on the quality decision vs. the OEMs have complete control on the quality decision. In addition, observing the downstream firms in a supply chain, such as retailers cooperating on product differentiation to relax price competition (Banker et al., 1998; Tsay and Agrawal, 2000; Xiao et al., 2014), we investigate the OEMs cooperating and not cooperating on quality decisions separately in the latter case. We find that if the CM is willing to share a sufficiently large investment fraction, then the CQI strategy will be beneficial to quality enhancement regardless of who sets the product quality level. With the respect to the equilibrium payoffs (profits), this study shows that the CM always prefers to have complete control over the quality choice with the implementation of the CQI strategy, while the OEMs are always hurt by vertical quality cooperation except that they cooperate on the quality decision when there is a rather large CM share. In addition, the whole supply chain profit can be improved by practicing the CQI strategy. Furthermore, we explicitly propose the conditions for realizing this improvement. In other words, we show that implementing the CQI strategy could be valuable for the supply chain.

The reminder of this paper is organized as follows. Section 2 briefly reviews the related literature, and Section 3 details our key assumptions and notations. In Sections 4 and 5, we investigate three decision models of the quality choice: the CM optimally sets the product quality and the OEMs cooperate or do not cooperate on the quality decision. Section 6 discusses the effects of the CQI strategy on quality improvement and equilibrium profits as well as supply chain performance. Concluding remarks and future directions are presented in Section 7. All of the proofs are deferred to the appendix for clarity of exposition.

2. Related literature

Non-price competition is observed in many industries and is well-studied in the economics and marketing literature. As an important non-price competitive feature in the majority of industries, product (service) quality has received intensive attention. Some pioneering studies have investigated the market equilibrium and social optimum value for the product quality of a monopolist (Spence, 1975; Sheshinski, 1976; Mussa and Rosen, 1978). These basic models were extended to discuss oligopolists competing on quality with a constant or zero quality cost and a single product in studies by Dixit (1979) and Gal-Or (1983). Moorthy (1988) later employed a quadratic function to describe the quality cost and studied a noncooperative game model between two identical oligopolists whose consumers preferred a higher quality product to a lower quality product. With a similar quadratic quality cost function for a single product, Banker et al. (1998) studied the noncooperative game model between two competing manufacturers who faced a linear demand pattern and how the quality was influenced by having a competitive intensity. Other related literature on this topic includes Rhee (1996), Villas-Boas (1998), Desai (2001), and others. More recently, Yayla-Küllü et al. (2013) studied multiproduct quality competition with consideration of having a limited capacity. As a strategic issue, quality in these studies refers to both the design and conformance quality characteristics that are of interest to the customer when evaluating the product offered by the firm (see Garvin (1984) for an excellent summary of the quality definition). However, these studies did not investigate the strategic interaction among the players in the environment of a supply chain channel.

Researchers in marketing and operations have pushed quality choice into the framework of a supply chain. We refer to the seminal work of Reyniers and Tapiero (1995), which highlighted the importance of strategic quality choice in a supplier–producer supply chain. Chambers et al. (2006) analyzed the impact of variable production costs on competitive behavior in a duopoly in which manufacturers