



Innovative Applications of O.R.

Effects of knowledge spillover on inter-organizational resource sharing decision in collaborative knowledge creation

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ARTICLE INFO

Article history:

Received 29 May 2008

Accepted 17 April 2009

Available online 24 April 2009

Keywords:

Cost benefit analysis

Knowledge spillover

Investment analysis

OR in research and development

Resource sharing

ABSTRACT

Collaborative knowledge creation is important for firms to gain new competitive advantages, but knowledge outgoing spillover harms their existing competitive advantages, which puts them into a dilemma when investing R&D resources. This study formalizes and investigates this dilemma using the Stackelberg leader–follower framework. Through our analyses, we find that, (1) current knowledge creation efforts and prior knowledge are substitutable in collaborative knowledge creation, and through controlling the ratio of current knowledge creation efforts to prior knowledge invested, the leader and the follower can gain benefits from collaboration and restrict knowledge outgoing spillover simultaneously; (2) because the leader invests resources first and faces moral hazards, it has the incentives to participate in collaborative knowledge creation only when its benefits from collaborative knowledge creation fruits and knowledge incoming spillover are bigger than those of the follower, and the more moral hazards it confronts, the more it demands; (3) the leader and the follower invest resources at ratios consistent with the benefits and costs the resources bring to them if they can determine the amount, or the collaboration is unstable.

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1. Introduction

Knowledge has become the most strategically important resource of firms to gain competitive advantages (Grant, 1996), and forming alliances to leverage each other's knowledge becomes an important strategy for firms to survive and prosper (Hamel, 1991; Khanna et al., 1998; Prahalad and Hamel, 1990). In this process, firms share knowledge and invest knowledge creation efforts to accomplish goals that they can not obtain efficiently. Adequate resource sharing has a statistically significant effect on the outcome of collaborative knowledge creation (Boddy et al., 1998).

However, firms confront knowledge outgoing spillover when they invest knowledge resources in collaborative knowledge creation. Dussauge et al. (2000) argue two forms of knowledge transfer exist in learning alliances. One is firms' objective and the other is out of firms' control. Das and Teng (1998) also point out unauthorized learning leads to firms' knowledge unwanted transfer and imitation. Furthermore, firms' knowledge may spill to others in addition to alliance partners. As a result, desire for collaborative knowledge creation fruits and fear of knowledge outgoing spillover put firms into a dilemma when investing prior knowledge in collaboration, which is put forward by many scholars but has not been settled effectively (Kale et al., 2000; von Hippel and von Krogh, 2006). Then, what measures can firms take to deal with the dilemma when sharing knowledge? How do firms decide the amount of prior knowledge invested in collaboration? If firms reduce prior knowledge investment amount, will the performance of collaborative knowledge creation be affected? This paper tries to investigate and solve these problems.

This research is part of endeavors to construct formal foundations of resource-based view and knowledge-based view (eg., Makadok and Barney, 2001; Makadok, 2001; Adner and Zemsky, 2006). It is related to the work of Pacheco-de-Almeida and Zemsky (2007), which develops a formal model of the timing of resource development by competing firms. While their work considers knowledge outgoing spillover between firms which create knowledge independently, our focus is on knowledge spillover between alliance partners as stressed by Kale et al. (2000). The closest contributions are made by Samaddar and Kadiyala (2006), who explore the requirements for collaborative knowledge creation to be formed and continue, but our study is different from their work significantly.

First, their research overlooks the effects of knowledge outgoing spillover, although scholars have observed the phenomenon of knowledge outgoing spillover in collaboration and warned firms to pay attention to it for a long time (Kale et al., 2000; von Hippel and von Krogh,

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2006), and this study makes knowledge spillover an explicit part of firms' resource investment strategy. Resource investment is indispensable for the success of collaborative knowledge creation, but knowledge outgoing spillover caused by prior knowledge investment undermines firms' existing competitive advantages. For example, when Apple collaborated with Microsoft between 1980 and 1984, it did not pay enough attention to knowledge outgoing spillover and lost its distinctive knowledge and competitive advantages (Norman, 2001). Therefore, it is valuable to investigate how knowledge outgoing spillover influences firms' resource investment. The research results suggest that a firm's knowledge outgoing spillover is positively related with the current knowledge creation efforts invested by the firm and its partner and the prior knowledge invested by the partner, while negatively related with the prior knowledge invested by the firm, if they can determine the amount invested.

Second, their study takes prior knowledge investment exogenous and firms can only determine the amount of current knowledge creation efforts, while this study considers the condition that firms can control the amount of prior knowledge invested, because it has been suggested limitations on the amount of knowledge shared can protect firms against losses of competitively important knowledge (Kumar and Seth, 1998; Mohr et al., 1994). Then, does this have some effects on conditions motivating firms to collaborate if firms can decide the amount of prior knowledge invested? Through cross analysis, we find that if firms can determine the amount of prior knowledge invested, the leader faces more moral hazards, and it demands a larger share of the benefits from collaboration, which makes the collaboration more difficult to be formed. Moreover, the leader and the follower should not only invest current knowledge creation efforts at an optimal ratio but also invest prior knowledge at an optimal ratio.

Third, the central contribution of this paper is that it formalizes and settles firms' dilemma of knowledge sharing in collaborative knowledge creation, and we can gain more insights into the tension between knowledge sharing and knowledge protection. Firms benefit from collaborative knowledge creation while suffer competitive advantage harms due to knowledge outgoing spillover caused by prior knowledge investment. This research formalizes this dilemma and finds current knowledge creation efforts and prior knowledge are substitutable in collaborative knowledge creation. Through controlling the ratio of current knowledge creation efforts to prior knowledge invested, firms can gain benefits from collaboration and restrict knowledge outgoing spillover simultaneously.

The dilemma of inter-firm information or knowledge sharing and protection has also been studied in supply chain management and industrial organization. Information sharing in supply chain can bring in many benefits, including improved ordering function (Chen, 1998), better inventory allocation (Bourland et al., 1996; Lee et al., 2000), etc. Such benefits are derived in part from the fact that information sharing mitigates the information distortions along the vertical linkages and results in lower inventory and/or shortage costs (Lee et al., 1997). However, information sharing makes firms exposed to others, which may drive them into disadvantages. Li (2002) argues that vertical information sharing has two effects, namely "direct effect" due to the changes in strategy by the parties involved in sharing the information and "leakage effect" due to the changes in strategy by other competing firms. Chu and Leon (2008) and Li and Zhang (2008) investigate conditions in which firms have incentives to engage in information sharing. While literature in supply chain management focuses on vertical information or knowledge sharing, researches in industrial organization mainly study horizontal information or knowledge sharing. Li and Zhang (2008) give a brief and excellent literature review on this topic. Each individual firm privately observes a noisy signal of the demand before deciding its selling price or output quantity. After deciding whether to expose its own signal to an information club, firms compete in a Bayesian fashion with incomplete information. The research results suggest that all firms will reveal their private demand information if the competition is in price but none will do so if the competition is in quantity.

This study is also significantly different from the researches in supply chain management and industrial organization. First, these researches study the effect of knowledge or information sharing on cost reduction, while our study investigates the value-added process and analyzes how firms' resource investment decision including prior knowledge sharing affects the performance of collaborative knowledge creation. Second, damage from information sharing in supply chain management and industrial organization is caused by competing firms' strategic reactions for they know firms' intents, while in our model the damage from knowledge leakage is the result that knowledge rarity and inimitability are undermined.

This research uses the Stackelberg leader–follower framework to analyze the effects of knowledge spillover on firms' resource investment decision and explore the relationship between collaborating organizations. Stackelberg leader–follower game is helpful to understand the dynamics of the decision-making process in dyadic relationships (Scherer, 1996), and the equilibrium values of the game provide guidance to an organization's decision-making behavior. In Stackelberg leader–follower game, firms have incentives to maximize the benefits of the system, but they also must compete to maximize their shares of the system benefits. This is similar to the situation of collaborative knowledge creation, in which firms share prior knowledge and invest knowledge creation efforts to pursue knowledge creation fruits while they also should consider the shares they obtain from the collaboration and restrict knowledge outgoing spillover. The goal of each firm is to maximize its economic benefits. Moreover, firms' positions are usually unequal in the collaborative knowledge creation, and the leader is the firm that has more decision-making power or experience in the specific area of knowledge creation (Samaddar and Kadiyala, 2006). For example, during the collaboration between Apple and Microsoft in 1980s, Apple had more decision power and was the leader (Norman, 2001). Therefore, it is proper to analyze the effects of knowledge spillover on firms' resource investment decision and explore the relationship between collaborating organizations using the Stackelberg leader–follower framework.

The rest of the article is organized as follows. In Section 2, we present the background on firms' dilemma of prior knowledge investment and knowledge protection, and the model is constructed in Section 3. An analysis when firms can only determine current knowledge creation efforts is in Section 4, and in Section 5 we extend the model to allow firms to determine the amount of prior knowledge invested, followed by a cross analysis in Section 6. Some empirical evidence and managerial implications are provided in Section 7, and we conclude with Section 8.

2. Knowledge sharing dilemma in collaborative knowledge creation

2.1. Knowledge sharing to obtain new knowledge

During the collaborative knowledge creation process, firms first pool their resources needed for the collaboration. While firms become more and more focused to develop their core competences (Prahalad and Hamel, 1990), knowledge is updating more and more quickly and

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