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Supplier selection of a critical component when the production process can be improved

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ABSTRACT

In this paper, we consider the scenario where an original equipment manufacturer (OEM) has decided to outsource the production of a critical component. There are two potential suppliers: one of them is an independent supplier, while the other is a manufacturer that sells a competing product. The customers are heterogeneous in taste preferences, and the firms have products that are horizontally differentiated. Firms can perform R&D activity to improve the production process of this critical component, resulting in a larger customer value. The OEM needs to decide (1) whether to outsource the production of the component to the independent supplier or to the competitor, and (2) whether the OEM or the supplier should invest in the improvement of the production process of the component. We find that it may be optimal to outsource to the competitor and let the competitor be responsible for improving the production process, even though the competitor has the *highest* cost. We also find that when it is optimal to outsource the production to the independent supplier, the competitor is worse off if the OEM uses the more costly firm to improve the process.

1. Introduction

Apple outsources the production of Ax chips for its iPhone and iPad, and one of the main suppliers is Samsung Electronics Company Ltd., manufacturer of the competing Galaxy smartphone and tablet. One possible explanation for this co-opetition relationship is that Apple can take advantage of Samsung Electronics's economies of scale (BBC News, 2011; The Economist, 2011). However, Apple is considering switching chip suppliers to minimize its reliance on Samsung Electronics, and one of the alternatives is the Taiwan Semiconductor Manufacturing Company (TSMC), a large contract chip maker that does not have any competing products (Jim and Chang, 2011; Mick, 2011; Samuel, 2012).

In the high-tech industry, many companies outsource the production of components to their competitors. For example, Apple outsources the production of the iPhone's display to the Korean consumer electronics manufacturer LG Electronic Corp., which has its own smartphone, Optimus One. The Taiwanese smartphone and tablet manufacturer HTC buys components such as RAM, flash and display panels from its competitor, Samsung Electronics Company Ltd. Sony is the supplier of the Trinitron-based monitor to Toshiba, and it also sells Trinitron-based monitors of its own brand. Palm sells handheld devices and supplies its proprietary operating system to HP and Dell's handheld devices.

A component can have an important impact on how customers view the product. To illustrate, the main difference between iPhone 4 and iPhone 4S is the type of Ax chip, and thus the Ax chip is critical to the success of iPhone. When outsourcing the production of this critical component, it is important for the OEM to guarantee the quality of the production process. According to the Georgia Center of Innovation for Manufacturing, firms participate in various R&D activities, "[ranging] from addressing production issues to inventing new equipment and processes for cutting-edge technologies, to improving understood technologies and processes in order to speed up production and realize more efficiencies" (Atlanta Business Chronicle, 2012). A key consideration for the OEM is to decide who should invest in improving the production process. In some cases, the suppliers are solely responsible for improving their own process. However, cases do exist where the manufacturer invests substantially to improve the suppliers' production processes. For example, Intel has agreed to invest $4.1 billion in the Dutch semiconductor machinery maker ASML to reduce the time required for deploying the lithography equipment that supports these technologies. Moreover, Toyota and Honda send engineers to the suppliers' facilities for several months to help improve the production processes (Arrunada and Vazquez, 2006; Intel, 2012). One advantage of the OEM accepting responsibility for deciding on the size of the investment in process improvement is that it avoids the

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inefficiencies that result from decentralized decision-making (double marginalization).

When outsourcing to competitors, one more layer of incentive must be addressed when deciding who should invest in improving the production process. If the competitor is responsible for the process improvement, the competitor might transfer the process improvements of the OEM's component to the production of its own component. For example, Hamel et al. (1989) state that when a Western firm outsources to an Asian firm, the objective of the Western firm is often to avoid process-improvement investments, while the objective of the Asian firm is usually to transfer the technology to its own products. As an illustration, during the mid-1970s, British automaker Rover outsourced its technology and product-development to its competitor, Honda, to avoid investments in the design and building of new cars. After perfecting these techniques, Honda applied its newly acquired skills to the production of its own products. Thus, in order to prevent the competitor from taking advantage of the process improvement, the OEM might be better off being responsible for improving the production process of its own product so it can own the intellectual property of the process improvement. For example, Apple has patents on new ways for testing sensors, for producing magnetic attachment system and for checking the acoustic test fixture of its product components (PatentlyApple, 2012). In this scenario, Apple's (i.e., the OEM) competitors cannot take advantage of its process improvement effort.

In this paper, we examine the case where an OEM (e.g., Apple) has decided to outsource the production of a critical component (e.g., Ax chip). There are two potential suppliers: one of them is an independent supplier (e.g., TSMC), while the other (e.g., Samsung Electronics) is both a supplier and a manufacturer that sells a competing product. Customers often have brand preferences (Sriram et al., 2006), either due to a familiarity with the brand-specific technology (e.g., features) or to a preference for the brand itself (Apple versus Samsung). Therefore, we consider the case where the customers are heterogeneous in taste preferences. Furthermore, even though customers have preferences for one firm's product over another, these preferences are not due to product quality. For instance, among the firms that motivate our study, none of the products have quality that is uniformly better than the others. Consequently, we assume that firms have products that are horizontally differentiated. We assume that this component is critical to the end product. Therefore, when the production process of this component is improved, the end-product becomes more valuable to the customers.

The OEM first decides which supplier to outsource to, and whether the OEM itself or the supplier will invest in improving the production process. Then, the contract parameters, process improvement efforts and retail prices are decided sequentially. The research questions of this paper are as follows:

1. Should the OEM outsource the production of a critical component to the independent supplier or to the competitor?
2. Should the OEM or the supplier invest in improving the production process?

We intend to illustrate the following key drivers. First, different firms have different process improvement costs, and therefore one might expect that the OEM should outsource to the firm with the lowest cost. Second, when the OEM is responsible for making the process-improvement decision, it eliminates the problem of sequential optimization at the individual supply chain stages that results in suboptimal system performance (double marginalization). Lastly, when the competitor is responsible for the process improvement of the OEM's component, it would transfer the improvements to the OEM's component into the production of its own component. However, anticipating this behavior, the OEM can design a contract that captures the benefit of the economies of scales.

Much of the extant popular press seems to focus on the cost aspect of outsourcing decisions (e.g., King, 2008), and this subject has also been a focus of some academic research (e.g., Kim, 2003; McCarthy and Anagnostou, 2004). Therefore, one might expect that (1) the OEM would be worse off from the higher cost firm improving the process, and (2) since the competitor has opposite interests, the competitor would be better off if the OEM uses the higher cost firm to perform the task. Interestingly, we find that cases do exist where the OEM can be better off outsourcing the production of the component to the competitor, even though this competitor has the highest process-improvement cost. There are also cases where the competitor is worse off if the OEM is responsible for the process-improvement task when outsourcing the production to the independent supplier, even when the OEM is more costly. Our results illustrate that when making an outsourcing decision, managers should not only look at the cost aspect but also at the coopetition relationship with the competitor and at the inefficiencies of double marginalization. As a result, the OEM can benefit from the economies of scale in process improvement, and the competitor can be worse off.

This paper is structured as follows: First, we review the related literature, followed by the mathematical model and the analytical results in Sections 3 and 4, respectively. We then provide an extension to the main model in Section 5, and finally conclude the paper in Section 6. The details of the derivation of the equilibriums and the proof of results are provided in Appendices A and B, respectively.

2. Literature review

There are three streams of literature related to our study. Our paper is closely related to the topic of channel conflict, where the retailer sells a private-label product that competes with the national-brand product (e.g., Sayman et al., 2002; Groznik and Heese, 2010; Heese, 2010). The retailer may not price its product (private label) aggressively because it shares the profit from the competing product (national brand). However, these papers assume that the retailer is *selling* both competing products, and hence the retail prices of both products are controlled by one firm. In our model, the competitor is *supplying* for both competing products, and the retail prices of both products are controlled by different firms, and therefore the structural impact of the competition between both firms also differs.

The second stream of literature involves the topic of supplier selection, where different suppliers have different characteristics. Aissaoui et al. (2007) provide a comprehensive review, and we highlight a few papers below. Choi et al. (2004) consider a retailer's ordering policy, where the delivery cost decreases in lead time, and demand is uncertain but demand information can be updated. They consider the tradeoff that the cost of delivery is low when the retailer orders early, and the demand is more accurate when the retailer orders at a later stage. They find that it is most beneficial to deploy the optimal ordering policy when the profit margin is low, when the demand of the prior has a large variance and when the variance of the inherent demand is small. Gheidar et al. (2009) consider the channel coordination issue between one buyer and several potential suppliers with the purpose of minimizing the supplier's cost function. Mendoza and Ventura (2010) investigate the inventory policy that optimizes the replenishment cost, capacity, and quality that coordinate the transfer of items between stages.