Decision Support

Vertical integration with endogenous contract leadership: Stability and fair profit allocation

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A B S T R A C T

This paper studies vertical integration in serial supply chains with a wholesale price contract. We consider a business environment where the contracting leader may be endogenously changed before and after forming the integration. A cooperative game is formulated to normatively analyze the stable and fair profit allocations under the grand coalition in such an environment. Our main result demonstrates that vertical integration is stable when all members are pessimistic in the sense that they are sure that they will not become the contracting leader if they deviate from the grand coalition. We find that in this case, the grand coalition's profit must be allocated more to the retailer and the members with higher costs. Nevertheless, we also show the conditions under which the upstream manufacturer can have strong power as in traditional supply chains.

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1. Introduction

Modern supply chains in many industries—such as the well-known examples in the automobile, electronics, and apparel industries—involve world-wide networks with many tiers, which are filled by many companies playing various roles (Netessine, 2009). In addition, in many cases, the power balance among the members in a chain has drastically changed in the last two decades. Specifically, we can increasingly find examples of retailers or other downstream companies who have now become contract leaders in supply chains, although formerly, manufacturers had the most power and held contract leadership. In particular, the power of retailers, including Wal-Mart, Tesco Plc, and UNIQLO, has been increasing drastically. As a result, in consumer goods markets, private labels by some major retailers have recently emerged wherein the retailers design their labels and offer their manufacturers contracts to produce them. This is in contrast with traditional national brands where manufacturers design and produce products, and then sell them widely through retailers. In fact, the share of private labels has become about twenty percent in Wal-Mart, while in Tesco Plc, which is the third biggest retailer in the world, it actually exceeds forty percent.

As another example, UNIQLO has established a "Specialty store retailer of Private label Apparel" (SPA) model encompassing all stages of a label's business from design to production to sales, although the manufacturing is outsourced. Further, at each stage, UNIQLO plays a leading role, for example, by conducting stringent quality control checks in outsourcing at the production stage. Furthermore, Reebok, in the apparel industry, and Google, in the smartphone industry, are examples of contract leaders in supply chains who are neither retailers nor manufacturers. Reebok outsources its entire manufacturing to manufacturers it contracts to, which are located in Southeast Asia and so on, and sells the product through many retailers (van Dusen, 1998). Google, too, outsources the manufacturing of its Nexus series of phones to leading manufacturers (preferring one manufacturer for each generation of product: HTC for the first, Samsung for the next two, and LG for the fourth and current), and sells them through cell phone carriers or retail stores (Arrington, 2010). As seen from such examples, with increasing tendency, many companies in mid-tier positions in supply chains are taking contract leaderships by utilizing their brand power. Therefore, they focus on their brand development and management, rather than engaging in each stage of the chain, that is, producing, retailing, and so on. All these examples show that recently in supply chains, an entity in any position can attain contract leadership and the sequential orders of contracts can vary accordingly.

However, we should note that for any decentralized supply chain, the problem of double marginalization exists, where each firm sets a higher price in order to gain a higher profit margin. This

then leads to a higher retail price, lower demand, and (thus) lower profit (Spengler, 1950, Tirol 1988, and so on). Further, it is well known that one of the solutions to this problem is vertical integration among firms. In fact, in the real world, one well known example of vertical integration is that of Toyota, the Japanese automobile manufacturer, that formed the so-called "keiretsu," a business group linked in a supply relationship. In contrast, the SPA model and the development of private labels mentioned above can be seen as examples where having a strong retailer leads to vertical integration of each process in a supply chain (design, production, wholesale, retail, and so on) into a centralized system. In addition, as is well known, DELL established the "direct model" in the 1990s, where one leader firm coordinates all stages of the supply chain and ensures virtual integration into a centralized system (Magretta, 1998).

The theoretical analysis on vertical integration in the framework of game theory has been well documented. In addition, there exist many researches on coordination schemes for attaining the centralized solution under decentralization. However, most of these papers analyze supply chains with only two tiers of suppliers and retailers, and thus multi-tier supply chains, including those with a middle man have received very little attention. In contrast, with regard to the sequential orders of contracts under pre-cooperation, most papers assume that a manufacturer is the contract leader and contracts are sequentially taken from upstream to downstream members. Thus, there are remarkably few studies that assume a downstream firm's potential to play a leadership role in multi-tier supply chains. As an exception, Majumder and Srinivasan (2006) consider the possibility of varying sequential orders of contracts. However, with regard to vertical integration, they focus on the formation process of the integration and do not pay attention to the stability of the vertical integration formed or the rational allocation of profit among the members. However, we should note that the feasibility of forming the integration (grand coalition) and the stability of the formed coalition are quite different issues. It is very important to make the distinction between these two issues, as we can find this to be one of the main areas of consideration in game theory, especially cooperative game theory. In fact, the following recent example of the e-book market in the US shows the importance of considering the allocation of the centralized system's profit to each of its members in order to sustain the system. Specifically speaking, Amazon, which monopolizes the downstream platform in the e-book market, has set the price of its e-books at 9.99 dollars, but one of the major publishers, Macmillan, is not satisfied with this price. Consequently, in January 2009, in negotiations with Amazon, Macmillan introduced a requirement that they could set their own e-book prices from 12.99 dollars to 14.99 dollars. In addition, in the revenue-sharing contract between them, Macmillan asked Amazon to increase the rate of revenue sharing Macmillan receives from 35% to 70%. However, these negotiations broke down, and as a result, Amazon stopped selling Macmillan's products. Two days later, Amazon finally decided to accept Macmillan's requirements. According to some press reports, this is because Amazon recognized that Macmillan actually enjoys monopoly in major e-book markets, including school textbooks and so on (Rao, 2010; The New York Times, 2010).

We can interpret this fact as the break-down of the coalition because careful consideration was not paid to the possibility of an ex-post change of position in the contracting leader, although the parties previously succeeded in forming the grand coalition. As recently in the e-book market, the power balance between players in supply chains can drastically change in the early days of an industry. This implies that the leader position in supply chains may endogenously change before and after vertical integration. Therefore, under such environments, managers might be concerned about how they can maintain their vertical integration. Based on this motivation, by using a cooperative game theory, we explore stable and fair profit allocation under vertical integration in light of an ex-post change in the leadership position. We specifically address the following research questions.

- In serial supply chains with n tiers, provided that the leader can change (or all members believe that the leadership can change), after forming the grand coalition (centralized system),

  – When is the grand coalition stable?
  – How should the grand coalition's profit be allocated to each firm?

- With such circumstances as described above, under which conditions can the upstream manufacturer have the most power as in traditional supply chains?

In order to answer these questions, we use cooperative game theory that normatively discusses fair profit allocations under the grand coalition. We formulate our problem as a coalitional form game, the most standard model of a cooperative game. However, we should note that formulation is a troublesome issue. In order to formulate a coalitional form game, we must set the value (characteristic function) of a coalition as the maximum value it can individually earn (Myerson, 1996, and so on). This value is well-defined for standard cases in the absence of any externality, where any formation of a coalition does not affect the payoffs of players outside the coalition. Unfortunately, however, an externality exists under our setting, which implies that we must assume how the outsiders respond to the formation of a deviating coalition. Hence, here, we apply the theory of coalition formation, noting that there have been remarkable recent developments relating to game theory in this area. Specifically, we assume that even if some members deviate from the grand coalition, the remaining members continue with cooperation, such that the value of a coalition is defined as the equilibrium profit of the two-person game between deviating members and the remaining coalition. The formulation in this manner is one of the key points of this study and plays an important role in the discussions on our results mentioned later.

We now present an overview of the results obtained in this paper. First, we show that in terms of the existence of core allocation, the grand coalition is stable only if all members are pessimistic in the sense that they are sure they will not become the contract leader after any of their coalitional deviations from the grand coalition. This result suggests that although the whole of the supply chain benefits from vertical integration (which effectively eliminates double marginalization), integration is not stable if all or some members expect contract leadership. We next analyze the Shapley value and the nucleolus of our model, which indicates fair allocations under vertical integrations. As a result, we show that the grand coalition's profit must be allocated more to the retailer and the members who have higher costs. In other words, these specific members have relatively strong powers for vertical integration to be stably sustained. Therefore, this result suggests that under situations facing a variable leadership and rapid cost improvements due to technological advances, the retailer is likely to be in a much more beneficial situation under vertical integration, while the upstream manufacturer is not. However, we show that even under such conditions, the upstream manufacturer can have a relatively strong power if it can vertically integrate with multiple monopolistic retailers.

The rest of this paper is organized as follows. Section 2 reviews the relevant literature in vertical integration including that focusing on coordination and cooperation in supply chains, and clarifies the position of this paper. In Section 3, we formulate our problem