Information Visibility and Its Impact in a Supply Chain

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Competitor collaborations, often in the form of electronic marketplaces, increasingly have become an important part of our economy (Macleod et al. 2001). One such company is Nis-tevo, a web-based collaborative logistics network, which enables independent companies to pool their trucking requirements and thus generate routes that decrease overall costs. However, companies constantly examine whether information sharing is beneficial i.e., whether it is in their self interest to share information. For example, the CEO of Newbury Comics, a dominant music retailer in Boston area, realized that sales information he shared with his industry was putting his company at disadvantage (Singer 1999), by providing an advance read of future trends to other retailers. Thus, he decided to stop reporting sales information to SoundScan (www.soundscan.com), which collects sales data from point-of-sale cash registers weekly from over 14,000 retail, mass-merchant and non-traditional (on-line stores, venues, etc.) outlets and reports aggregate information to its subscribers. Another example is the decision by Wal-Mart to discontinue sharing its sales data with outside companies like Information Resources Inc. and ACNielsen (Hays 2004). In the past, these companies had paid Wal-Mart for the information and then sold it to other retailers.

There are many factors that influence a firm’s incentives to share information. These include (a) where the firm is located in a supply chain, (b) how this firm competes with others, (c) what type of information is going to be disclosed, etc. Without a specific framework, it is hard to predict the outcome of information sharing. In this paper, we focus on the effects of information sharing in an environment with a supplier learning curve.

In many industries, the wholesale price declines as industry production volumes increase. A key factor that drives such price decreases is known as the learning curve or the ”learning-by-doing” effect (Fudenberg and Tirole 1983). This means that a product’s unit cost decreases due to the accumulated experience in producing and selling the product.
empirical studies, e.g., Lieberman (1984) and Gruber (1992), show that wholesale price is a decreasing function of cumulative industry output. In a supply chain setting, the buyer’s expectation of supplier’s learning curve will affect his procurement strategy, which in turn impacts price reductions and his long-term cost.

In this paper, we focus on a supply chain consisting of independent retailers who share upstream supply. Retailers face one period of demand and can satisfy the demand by ordering in the first period or back-ordering some of the demand and satisfying it in the second period. The wholesale price in the second period is decreasing in the total order size, across the two retailers, in the first period. This decrease in wholesale price captures the market learning effect of aggregate orders that has been extensively documented in the empirical literature. It also induces “supply competition” rather than the traditional “demand competition” that has been examined in the economics literature.

Our goal is to examine the effect of information sharing, regarding the demand state, across the two retailers. In a centralized supply chain, it is apparent that information sharing will increase supply chain profits. However, such a result is not obtained in a decentralized environment. We show that there are situations in which one retailer may want to voluntarily provide information about his demand state to the other retailer in order to make himself better off while worsening the profits for the other retailer. We also show that there are situations where partial information sharing may make both retailers better off relative to complete information sharing.

While these results provide interesting methodological insights, they also suggest some interesting applied suggestions. There are several instances whereby antitrust considerations limit the extent of information sharing across competitors. As an example, it is only recently that trucking firms have been able to share average cost information across routes. Similarly, in a ruling regarding downstream firms that share upstream capacity, the courts ruled that no information could be shared about shipment volumes, costs etc. (Macleod et al. 2001). Our model suggests that such limitations in information sharing may increase individual retailer profits over full information sharing. Thus, we suggest a possibly interesting insight that societal limitations on information sharing may prevent prisoners dilemma outcomes and in fact improve profits in decentralized supply chains.

From a supply chain perspective, the model provides a note of caution to information sharing under supply competition in a decentralized environment. Intuitively, information sharing increases the space of gaming behavior and thus negates the averaging effect of
lack of information. This increase in gaming behavior, also termed the leakage effect, may dominate the beneficial effect of information sharing, called the direct effect. Thus, the resulting supply chain may be worse off under increased information sharing.

Intuitively, a firm’s expected profit should increase, or at least not decrease with an increase in information visibility to the system. Indeed, this is supported by many practices and papers in supply chain management. For example, the emerging implementation of collaborative planning, forecasting and replenishment (CPFR) and vendor managed inventory (VMI) system in practice needs partners in a supply chain to share their information on demand, inventory, cost, etc. Many recent papers in operations management focus on the value of vertical information sharing in a supply chain. In general, this line of research takes the perspective of a virtual or real central planner, who makes decisions that optimize the performance of the system. It is shown that improved information visibility increases the performance of the system compared to the case when the central planner has only local information. They show that the benefits of information sharing come from improved demand forecasting (e.g., Aviv 2001) and/or mitigation of information distortions along the vertical chain (e.g., Lee et al. 1997), which result in better inventory allocation, lower safety stock and shortage costs, faster and cheaper order processing, etc.

While the benefits of vertical information sharing are obvious and intuitive, the effects of information sharing among horizontal competitors are not so clear. Interestingly, most papers related to this issue can be found in the economics literature. Theoretical research on information sharing in an oligopoly was pioneered by Novshek and Sonnenschein (1982), then followed by Clarke (1983), Gal-Or(1985, 1986), Li(1985) etc. These models have assumed that market uncertainty is due to either unknown constant marginal cost for the firms or unknown market demand, which could be a common or firm-specific parameter. In general, the results of these models depend on the assumption of competition type-Cournot or Bertrand, and the product type-substitute or complement. Vives (1999) summarizes these results and suggests that firms in a Cournot game with homogeneous(substitutable) products have incentives to unilaterally reveal information about private values. Our model produces a contrary result although we also consider quantity competition and sharing of private values. in addition, we extend the analysis to the case when the quantity equilibrium is on the boundary.

Li (2002) is the first paper to consider the incentives of vertical information sharing with horizontal competition in a supply chain environment with an upstream manufacturer
and many downstream retailers. In his paper, he states that: *In a general situation of strategic conflicts, obtaining additional information does not necessarily make the informed player better off and giving away private information to other players does not necessarily make the original information holder worse off*. If this is true, then a further question is: whether a player could be worse off if he unilaterally obtains more information from his competitor while making the competitor better off, and under what conditions this can be true. Unfortunately, the current literature does not give clear answers to this question. We are thus interested in answers to following questions:

1. Can one player who unilaterally obtains more information make himself worse off while making the other player better off?
2. For a symmetric game, can partial information sharing be a dominant strategy?
3. Do competitors in a quantity competition game with homogeneous products always have incentives to share information about their private values?

Our model structure enables us to provide some interesting results on these questions. Specially, our research makes following contribution:

Firstly, we show that the two retailers have no incentives to share information about their private values when equilibrium order quantities are interior i.e., the order size is between zero and the demand. This result is contrary to the result in oligopoly models on information sharing. In addition, the incentives for information sharing are not simply determined by the competition structure, e.g., competition type and product type. The incentive for information sharing may be reversed by market conditions (e.g., price and demand) under a fixed competition structure. This may occur when the quantity equilibrium is on the boundary.

Secondly, we show that one retailer who unilaterally discloses more information to his competitor may make himself better off while making his competitor worse off, if some order quantities are on the boundary. To the best of our knowledge, this is the first to show this kind of counterintuitive result.

Thirdly, we consider a symmetric game, in which two retailers must agree to share the same level of their private information. In this case, we show that partial information sharing may be the equilibrium strategy for retailers. This indicates that equilibrium behavior of information sharing is not necessarily a bang-bang choice, which is suggested by previous literature of oligopoly. This finding also suggests that limiting information sharing between parties in a decentralized supply chain may benefit them.
References


