Learn and Screen- A Strategic Approach to Collaborative Inventory Management

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We consider the interaction between a supplier and a retailer who operate within a collaborative partnership agreement, such as Vendor Managed Inventory (VMI). Under this agreement, the supplier (she) takes the sole responsibility, including financial and operational control, of inventory in the supply chain. The retailer (he) takes the responsibility of store level execution to satisfy end customer demand as much as possible, given on hand inventory. The retailer shares customer sales information (POS data) and inventory levels with the supplier at the end of each selling period via electronic data interchange. The POS data helps the supplier to improve her demand forecasts for the future periods, thereby improving her inventory replenishment process over time.

Practitioners and scholars have shown that centralized inventory control together with information sharing (e.g., VMI) allows supply chains to be more effcient and responsive to customer needs. However, recent empirical and anecdotal evidence also suggests that VMI type agreements have proven to be difficult to maintain over multiple planning horizons. One often cited reason for such failed relationships has been incentive misalignment and declining trust among firms implementing VMI. For example, the retailer, owing to his proximity to customers, often possesses demand information over and beyond POS data. The supplier could improve her forecasts (and hence, her inventory decisions) by learning about the retailer's private demand information. However, the retailer has a conflict of interest in credibly revealing this information even in long-term/multi-period relationships. In such collaborative partnerships, leftover inventory is the supplier's (and not the retailer's) liability (Simchi-Levi et al., 2008). Hence, the retailer is always better off depicting a positive outlook of demand, to ensure sufficient inventory during all selling periods and always demands for more supply. The supplier, therefore, disregards this information and bases her replenishment decision on POS data. Such lack of coordination often leads to unnecessary lost sales.

Recently, *Forbes (2014)* reported that Wal-Mart, a pioneer in VMI, has lost around $3 billion to out-of-stock items. Similarly, Target had to end its operations in Canada. Poorly stocked shelves, leading to lost sales, was cited as an important contributor to their failure (Dahlhoff, 2015).

We explore the following questions in this paper: How should the supplier dynamically manage centralized inventory in a lean fashion when lost sales are unobserved and the retailer has private demand information, over multiple selling periods? Can the supplier use her inventory decisions to gain long-term strategic leverage in her partnership with the retailer? Is there a mechanism that the supplier could use to credibly elicit demand information from the retailer while effectively managing inventory over a long-term planning horizon?

To address these questions, we propose a learn and screen approach for the supplier that combines inventory control with mechanism design. At the beginning of each period, the supplier assesses her inventory levels and demand forecast. Given this information she either decides to improve her demand forecast by obtaining another period of POS data or offers a long-term screening contract to the retailer to credibly elicit his demand information. If the supplier chooses the former, she makes an inventory decision and improves her demand forecast for the next period using Bayesian updating (after observing the POS data in the current period). If the supplier decides to screen the retailer, she offers a menu of long-term contracts that prescribe two things: the base-stock level the supplier would maintain in each period henceforth, and the corresponding payment from the retailer.

Information sharing and inventory control play a crucial role in determining the success of collaborative practices such as VMI. The centralized inventory control alleviates Bullwhip effect, but ensuring credibility of the retailer's demand forecast report remains a challenge. The learn and screen approach implemented within this framework provides a channel for credible communication of demand information. Therefore, the supplier with superior demand information can better leverage and share benefits that accrue from centralized inventory control.

The supplier's inventory decisions determine per period profits for the entire supply chain and the quality of information gathered in a selling period. We show that the option to screen the retailer in a later period could motivate the supplier to invest more in her learning process. By improving her knowledge of market demand at the time of screening the retailer, the supplier can reduce the informational advantage the retailer possesses. The mechanism therefore reinforces the supplier's faith in her learning process. As a consequence, the retailer enjoys higher profits resulting from better-stocked shelves.

The quality of supplier's demand forecast plays an important role in determining the timing of contracts as well as the information rent she leaves to the retailer. If the supplier had access to the retailer's demand knowledge, i.e., their demand forecasts were identical; the supplier would have offered contracts without further postponement. These contracts also maximize the total supply chain efficiency. Owing to the zero informational advantage of the retailer, the supplier is able to extract all the rent through the contracts. We show that the timing of when to offer a menu of contracts depends on a few key trade-offs. By delaying the time to offer contracts, the supplier could improve her forecasts (contingent on her inventory decisions). However, this delay results in loss of efficiency due to supply/demand mismatch in the preceding selling periods.

We also provide a complete characterization of the optimal contracts that are offered to the retailer. The optimal payments take the form of quantity-discount scheme, where in the retailer is incentivized to credibly reveal her forecast if the underlying market demand is high. We also investigate, evolution of the structure of these contracts and their dependence on the dynamic inventory control used by the supplier.

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Simchi-Levi, D., Kaminsky, P., and Simchi-Levi, E. (2008). *Designing & Managing the Supply Chain*. McGraw-Hill/Irwin, New York, NY, 3rd edition.