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Countering the Bullwhip Effect by Absorbing It Downstream in the Supply Chain

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Abstract : The bullwhip effect, which refers to the amplification of demand variance as one moves up the supply chain, has been observed in various industries and extensively studied through analytic approaches. Existing methods to mitigate the bullwhip effect, such as decentralized demand information, vendor-managed inventory, and the Collaborative Planning, Forecasting, and Replenishment System, rely on the willingness and ability of supply chain participants to share their information. However, in practice, information sharing is often difficult to realize due to privacy concerns. The purpose of this study is to explore new ways to mitigate the bullwhip effect without the need for information sharing. This paper proposes a 'bullwhip absorption strategy' (BAS) to alleviate the bullwhip effect by absorbing it downstream in the supply chain. To achieve this, a two-stage supply chain system was employed, consisting of a single retailer and a single manufacturer. In each time period, the retailer receives an order generated according to an autoregressive process. Upon receiving the order, the retailer depletes the ordered amount, forecasts future demand based on past records, and places an order with the manufacturer using the order-up-to replenishment policy. The manufacturer follows a similar process. In essence, the mechanism of the model is similar to that of the beer game. The BAS is implemented at the retailer's level to counteract the bullwhip effect. This strategy requires the retailer to reduce the uncertainty in its orders, thereby absorbing the bullwhip effect downstream in the supply chain. The advantage of the BAS is that upstream participants can benefit from a reduced bullwhip effect. Although the retailer may incur additional costs, if the gain in the upstream segment can compensate for the retailer's loss, the entire supply chain will be better off. Two indicators, order variance and inventory variance, were used to quantify the bullwhip effect in relation to the strength of absorption. It was found that implementing the BAS at the retailer's level results in a reduction in both the retailer's and the manufacturer's order variances. However, when examining the impact on inventory variances, a trade-off relationship was observed. The manufacturer's inventory variance monotonically decreases with an increase in absorption strength, while the retailer's inventory variance does not always decrease as the absorption strength grows. This is especially true when the autoregression coefficient has a high value, causing the retailer's inventory variance to become a monotonically increasing function of the absorption strength. Finally, numerical simulations were conducted for verification, and the results were consistent with our theoretical analysis.

Keywords : bullwhip effect, supply chain management, inventory management, demand forecasting, order-to-up policy
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