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The Global SCALE Network allows faculty, researchers, students, and affiliated companies from all six centers around the world to pool their expertise and collaborate on projects that will create supply chain and logistics innovations with global applications.

This reprint is intended to communicate research results of innovative supply chain research completed by faculty, researchers, and students of the Global SCALE Network, thereby contributing to the greater public knowledge about supply chains.

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Research Report: M051-2014-18
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Introduction

An upstream Make-To-Order (MTO) packaging manufacturer who operates in a food and dairy chain wants to level its highly fluctuated demand from its dairy producer customers by supply chain collaboration. Contrastingly from the orders, the customer’s production is much more stable as shown in Figure 1, comparing the orders and production during year 2012 and 2013.

This upstream demand amplification or so called the bullwhip effect is named and explained by Lee (1997).
Measuring Current Performance

To begin the analysis, inventory replenishment process between the companies is mapped into the inventory order based control system (IBOCS) model shown in Figure 2. The figure shows that the customer replenishment decision is based on its sales forecast, moreover, a target inventory level is predefined to maintain at the end of a period.

Order replenishment lead-time is segmented into production lead-time and delivery lead-time. The lead-times associated is summarized in Figure 3.

In addition, historical inventory is analyzed as the base inventory level to further compare. As a result, historical production quantity and inventory level is evaluated against the order replenishment lead-time and lead-time variability to measure the current service level, using item fill-rate measurement.

Applying (S,R) Policy and Order Smoothing Rule

A two-stage supply chain spreadsheet model is constructed to simulate demand, lead-times, and delivery options in this chain. Item fill-rate, average on-hand inventory, and order coefficient of variance (COV) are used as the key measurements for different scenarios to compare the service level, cost, and order fluctuation rate. The (Order-Up-To S, Review Period R) inventory policy, known as a close-to-optimal but generates stable ordering pattern, is first applied to the simulation to conduct points of demand comparison analysis. The result suggests the company use the historical production data as the input of the (S,R) policy. It also presents 16% increase in service level by applying the (S,R) policy while maintaining the same inventory level, in addition, order fluctuation rate reduces from 83% to 43%.

Sensitivity analysis of service level and review period is also run to find proper predefined parameters for the company by considering the tradeoff between these parameters and the performance. It suggests the company maintain two-weeks inventory review period and sets the target item fill-rate at 96%.

Further improvements are explored by applying the order smoothing rule proposed by Balakrishnan, et al., (2004). It reduces order variability by setting the order quantity equal to a convex combination of previous demand realizations using the smoothing coefficient (α).

\[ q_t = \alpha_1 x_{t-1} + (1-\alpha_1)q_{t-1} \]

Figure 4 shows the system dynamic diagram of the order smoothing policy with the order smoothing formula as the inventory controller.

Table 1 summarizes the results from current scenario and the simulations of the (S,R) policy and the order
smoothing (S,R) policy. In addition, Figure 2 shows the orders generated by these 3 scenarios.

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Existing</th>
<th>(S,R)</th>
<th>Smoothing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item fill-rate</td>
<td>79.91%</td>
<td>93.52%</td>
<td>96.06%</td>
</tr>
<tr>
<td>Average on-hand inventory</td>
<td>19,337</td>
<td>23,831</td>
<td>23,571</td>
</tr>
<tr>
<td>Order fluctuation rate</td>
<td>82.98%</td>
<td>39.32%</td>
<td>29.27%</td>
</tr>
</tbody>
</table>

Table 1 Results Comparison

discussion

In this research, (S,R) and order smoothing (S,R) policy are successfully simulated to determine the optimal tactical inventory management policy for the upstream supply chain collaboration. The result shows that order smoothing rules generates the most stable order pattern to the company, and also achieves higher item fill-rate with the same inventory level because it set order quantity equal to a convex combination of previous demand realizations using the smoothing coefficient, which aligns with Balakrishnan’s assertion.

Conclusion

Key findings of the research are presented.

- A case study from an upstream Make-To-Order manufacturer who aims to dampen its demand while increase supply chain performance and reduce inventory level.
- A structural assessment framework to develop optimal tactical inventory management policy in a collaboration between companies: including demand and lead-times analysis, performance measurement, and simulation model.

Specific findings related to the case study:

- Points-of-demand analysis suggests the company use historical production data as the demand for the (S,R) and order smoothing policies.
- Based on the simulation model, the optimal inventory management policy, which is the order smoothing rule can be expect to improve the customer service level to 96.06% and reduce the order fluctuation rate from 83% to 29%. However, the trade-off between other inventory costs must be further analyzed.

Finally, the impact of applying the order smoothing policy on supplier production and raw materials, the strategic level on how many customers should a supplier collaborate with, and the multi-product scenarios in the synchronized supply chain are suggested for future research.

Cited Sources