Demand Level by Supply Chain Collaboration

By Nitipum Silawanna
Thesis Advisors: Dr.Ioannis N. Lagoudis and Dr. Asad Ata

Summary: Supply chain inefficiency and bullwhip effect cause high demand volatility for upstream suppliers. This research uses a Make-To-Order packaging manufacturer as a case study to explore opportunities to smoothen its demand from a dairy manufacturer by supply chain collaboration. The (S,R) inventory management approach and the order smoothing rule are applied to select an optimal inventory policy for a vendor-managed inventory program that does not only reduce the inventory related costs but also improves customer service level and smoothens demand.

Nitipum Silawanna holds a bachelor degree of business administration from Chulalongkorn University, Thailand. Prior to the MSCM program at MISI, he worked as Business Process Improvement Analyst at Siam Cement Group Paper (SCG Paper), in the SAP re-implementation project team. Upon graduation, he will work as a senior supply chain & operation associate for a large consulting firm.

KEY INSIGHTS

1. The structural assessment framework and key measurements examined in this case can be applied to other supply chain collaborative projects for Make-To-Order manufacturers, which aims at different objectives from Make-To-Stock followers.
2. Based on the simulation, the order smoothing rule does not only reduce the order variability from 80% (existing scenario) and 40% (S,R) policy to 29%, but also improves the customer service level from 93.5% (S,R) to 96% because the smoothing coefficient incorporates moving average forecasting methodology into the replenishment policy.

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). His study details four sources: demand signal processing, rationing gaming, order batching, and price variation; of the bullwhip effect. Disney and Towill (2003) show in a system dynamic simulation that VMI (or called in different names such as Continuous Replenishment Program (CRP), Rapid Replenishment (RR), etc.) offers significant opportunities to reduce the bullwhip effect in supply chain by eliminating the rationing gaming and order batching causes.

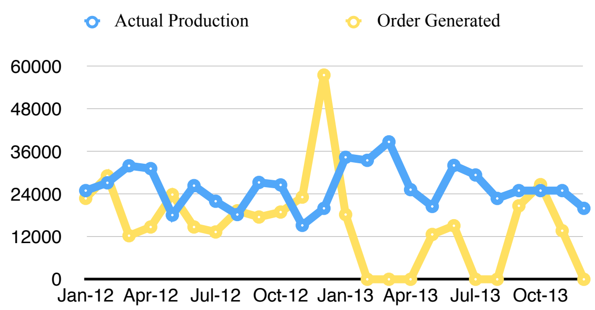

Figure 1 Production and Orders Comparison

Inspired by such complex problem, this research aims at finding an optimal tactical inventory management approach to improve the supply chain performance and dampens the orders, for a collaboration between a packaging manufacturer and its dairy manufacturer customer.

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.

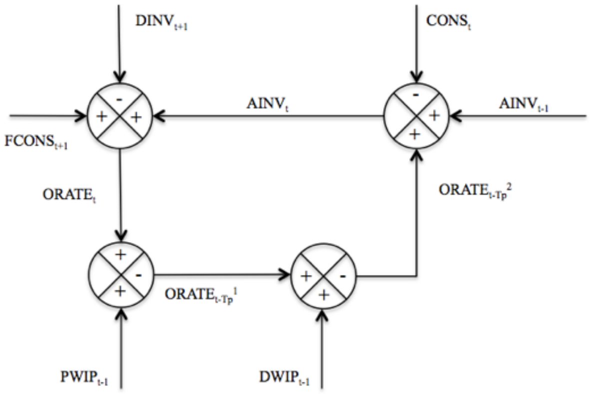

Figure 2 IBOCS Model of the Current Order Replenishment Process

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

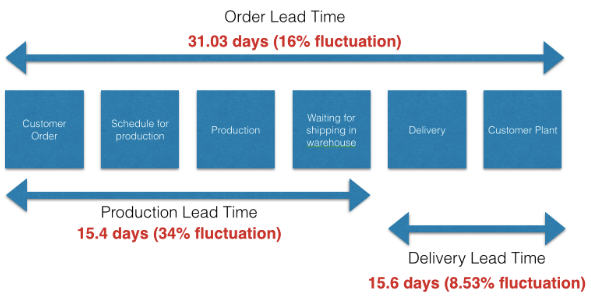

Figure 3 Order Replenishment Lead-times

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).

$$q_t = \alpha_1 x_{t\text{-}1} + (1\text{-}\alpha_1)q_{t\text{-}1}$$

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

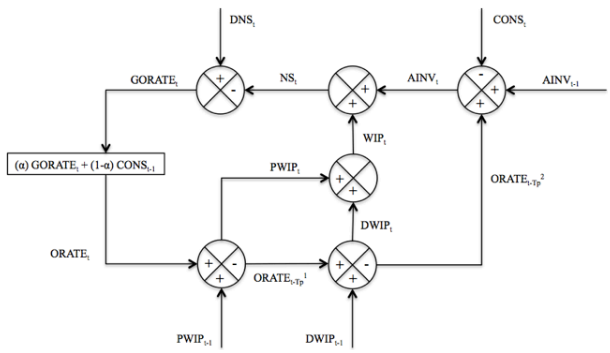

Figure 2 IBOCS Model of the Order Smoothing Rules

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.

Scenarios	Existing	(S,R)	Smoothing
Item fill-rate	79.91%	93.52%	96.06%
Average on-hand inventory	19,337	23,831	23,571
Order fluctuation rate	82.98%	39.32%	29.27%

Table 1 Results Comparison

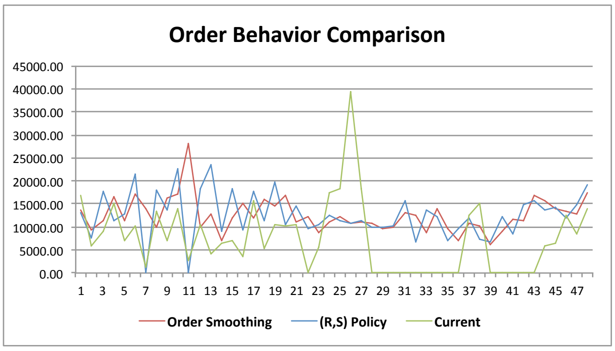

Figure 5 Order Behavior Comparison

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

- Disney, S. M., & Towill, D. R. (2003). *The effect of vendor managed inventory (VMI) dynamics on the Bullwhip Effect in supply chains.* International Journal of Production Economic.
- Lee, H.L., Padmanabhan, P., Whang, S., 1997a. *Information distortion in a supply chain: The Bullwhip Effect.* Management Science 43, 543–558.
- Ryzin, G. J. Van. (2001). *Analyzing Inventory Cost and Service in Supply Chains*, (April).
- Balakrishnan, A., Geunes, J., & Pangburn, M. S. (2004). *Coordinating Supply Chains by Controlling Up stream Variability Propagation*. Manufacturing & Service Operations Management, 6(2), 163–183.