Special Feature: Forecasting for the Supply Chain

Defining “Demand” for Demand Forecasting
Choosing Levels of Aggregation for Supply Chain Forecasts
The Value of Forecast Information Sharing in the Supply Chain

Worst-Case Scenarios in Forecasting: How Bad Can Things Get?
The Keys to the White House: Forecast for 2012
Looking Under the Hood of That Trend
BECOMING MORE “CONSUMERCENTRIC”
Changes in the economic environment have led organizations to reevaluate their business models. There is now a greater focus on finding better ways of providing products and services to customers across complex networks of suppliers. Coordination of decisions across the supply chain has been recognized as an effective way of getting closer to the customer. Cross-industry collaboration initiatives for formal coordination of decisions, such as Collaborative Planning, Forecasting, and Replenishment (CPFR) and Vendor-managed Inventory (VMI), have been successful in terms of service-level improvements and inventory reductions.

Sharing information is a major enabler of collaboration strategies and is a move away from being “customer-centric” to “consumer-centric.” Instead of focusing on satisfying demand from the immediate customer, such as a wholesaler, information sharing allows better satisfaction of demand from the consumer, who is the end-customer in the supply chain.

POTENTIAL INVENTORY BENEFITS
Case studies of collaborative supply chains show improved forecasting accuracy, resulting in lower inventory costs. Empirical studies investigating benefits of sharing information have reported reductions in inventory levels up to 50% (Disney and Towill, 2002), reductions in inventory costs up to 40% (Ireland and Crum, 2006), and reductions in supply-chain costs by up to 40% (Boone and Ganesan, 2008).

The empirical studies have shown how much companies may benefit by sharing information; however, the realization of benefits depends on various factors, which we shall discuss here.

To assess the benefits of information sharing, we conducted a simulation experiment using sales data from two companies: a major European supermarket and a U.S. computer-hardware manufacturer. In the simulation study, we generate two sets of forecasts: with and without sharing forecast information. We calculate the value of information sharing based on the savings in inventory cost and reductions in the bullwhip effect.

THE BULLWHIP EFFECT
The bullwhip effect is the occurrence in supply chains of increased order variability (uncertainty) as demand moves upstream away from the final customer.

In supply chains, there is a physical flow of products downstream toward the ultimate consumer, but also a flow of information from downstream to upstream members through placement of orders. When each member in the supply chain adjusts its orders according to its own forecasting methods and inventory policies, the demand seen...
by upstream members is not the consumer demand for product but the demand of the nearest downstream customer.

In many supply chains, orders placed in this fashion have a tendency to become more variable as they move upstream, farther away from the consumer. Consequently, the orders seen by the upstream stages of a supply chain have more variability than the orders seen by the downstream stages. Such increased variability makes ultimate consumer demand more difficult to forecast by upstream suppliers.

The bullwhip effect has been identified as one of the most important research areas in the field of operational research (Fildes and colleagues, 2008).

Bullwhip effects can result in huge operating costs for upstream suppliers. Higher order variability leads to inefficiencies, high inventory costs, and loss of customer responsiveness.

One report (Lee and colleagues, 1997) estimated an increase of 12–25% in operating costs and included the finding that the U.S. grocery industry would have saved $30 billion per year by reducing the bullwhip effects on demand. Another study (Ireland and Crum, 2006) reported that the retail industry in the U.S. lost between $7 and $12 billion in annual sales because of out-of-stock situations brought on by the bullwhip effect. A third (Sterman, 2006) commented that the bullwhip effect was the most significant factor in Cisco Systems’ write-off of $2.25 billion of obsolete inventory.

FORECAST INFORMATION SHARING
Sharing Point of Sale (POS) data enables an upstream supply-chain member, such as a manufacturer, to have access to sales data of a downstream member, such as a retailer. The upstream member can then utilize these data in making forecasting decisions.

In this situation, the retailer and the manufacturer are both making their forecasts based on the POS data at the retailer. If the objective of sharing POS data is the creation of forecasts, it would make more sense if the retailer shares its forecasts rather than the POS data, so that the retailer and the manufacturer use the same forecast to place orders.

We call this the forecast information sharing (FIS) approach. Operationally, it is a better collaboration approach.

**Key Points**

- The sharing of information in supply chains should become more “consumer-centric,” instead of focusing on satisfying demand from the immediate customer, such as a wholesaler.
- Doing so would reduce the bullwhip effect – the increased order variability (uncertainty) as demand moves upstream away from the final customer – with resulting inventory benefits.
- The magnitude of the inventory benefits depends on various factors, including the forecast horizon (lead time) and forecast methodology. But for longer lead times, a reduction in the bullwhip effect will lead to greater inventory cost saving.
- Companies using shorter order histories in their forecast process will gain more benefits from the sharing of forecast information.
strategy since it results in one forecast rather than two distinct forecasts. The forecasting can be done by the manufacturer, the retailer, or collaboratively, as suggested by Boone and Ganeshan (2008), in which case both parties bring their forecasting expertise to make a single forecast based on the shared data. The benefits of FIS will be assessed in our simulation experiment.

**EXPERIMENTATION ON REAL DATA SERIES**

The simulation was designed to estimate the benefits from forecast information sharing. The data came from two companies: a major European supermarket in Germany and a computer-hardware manufacturer based in the United States. For confidentiality reasons, the companies and their customers remain anonymous. We assume that the forecasting was done by the retailer and shared with the manufacturer.

The European supermarket provided two years of weekly sales data for 1,773 fast-moving products. The data from the U.S. computer-hardware manufacturer contains two years of monthly sales data for 25 fast-moving products. Further research is underway to consider the effects of Forecast Information Sharing on slow-moving products.

The simulation generates two sets of forecasts: without and with information sharing. In the first, forecast information sharing does not take place among the supply-chain members. The retailer produces a lead-time forecast based on the sales history and places an order with the manufacturer. Because the POS or forecast data is not being shared, the manufacturer has no visibility of the sales by the retailer. Based on the orders received from the retailer, the manufacturer makes its forecast and places an order to its supplier, based on the orders received from the retailer.

The second set of forecasts is based on FIS and assumes that the manufacturer makes ordering decisions based on the retailer’s demand forecast.

We compare the two sets of forecasts on the basis of (a) bullwhip ratios and (b) inventory costs. The bullwhip ratio is the ratio of the variance (square of standard deviation) of orders to the variance of the demand at the manufacturer.

For inventory-cost calculations, we assumed that holding cost is $1 per item and the penalty cost for back orders when out of stock is $25 per item. We assume that the companies use the common order-up-to (OUT) inventory policy, which checks inventory levels at every review period and, if below the desired order-up-to level, orders enough stock to reach this level.

**OUT Level = Lead-time Forecast + Safety Level**

To compare the benefits of FIS for short vs. long forecast horizons, the simulation considers forecasts for lead times from 1 to 12 periods (weeks or months).

The simulation also considers the choice of the forecasting methods. Various surveys have found that Moving Averages and Exponential Smoothing are the two most widely used operational forecasting methods (Mentzer and Kahn, 1995), so we used both of these in the study.

In a recent meeting of forecasting practitioners, the audience was quite interested in exploring how the benefits of information sharing are affected by the length of the data history of demand, so we considered this factor as well.

**THE RESULTS**

Our simulations reveal that, in comparison to the base case where information is not shared, FIS reduces the bullwhip ratio and lowers inventory costs. This result holds for both forecasting methods and for both companies.

Most striking is how similar the results are for the two companies. It is also clear that substantial savings are achievable through FIS.
Effects of Lead Time

Figures 2a and 2b show the benefits of FIS for lead-time forecasts of 1, 6, and 12 periods. Because the sales histories from the U.S. hardware manufacturer were only 12 months long, we based the lead-time comparison only upon the sales data from the European supermarket.

FIS provides relatively low savings when the lead time is small but relatively high savings when it is large. This is a logical result, as the forecasts for shorter lead times would be less variable than those for longer lead times, making sharing of forecasts less beneficial.

Effect of Length of Data History

We found that the benefit of FIS is higher (in terms of percentage reduction in inventory cost) the shorter the length of the data history on orders. This makes intuitive sense: the manufacturer’s order history contains information about the POS data at the retailer. When the manufacturer forecasts with more order history, it is already utilizing more POS data at the retailer. Therefore, the benefit of sharing forecast information decreases as more order history is used, although it remains substantial even for long histories.

Technically, we simulated different order histories by varying the length of the SMA and the smoothing constant in SES. Once again, we used only the European supermarket due to the lack of sufficient data for the U.S. hardware manufacturer.

MANAGERIAL IMPLICATIONS

In recent years, companies have been working to achieve better visibility in supply chains. In many cases, more-visible supply chains have helped organizations create a competitive advantage, e.g. Wal-Mart. Many empirical studies have reported that benefits of supply-chain collaborations have been high when information has been shared.

Our study explored the effects of several key factors on these benefits. We simulated the sales data of two companies under conditions of no sharing vs. forecast-information sharing and found that the benefits of FIS

- are substantial, both in reducing the consequences of the bullwhip effect and in

Table 1. Benefits of FIS Approach

<table>
<thead>
<tr>
<th></th>
<th>Percentage Reduction in the Bullwhip Ratio</th>
<th>Percentage Savings in Inventory Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>European Supermarket</td>
<td>82.3 (84.2)</td>
<td>41.0 (49.4)</td>
</tr>
<tr>
<td>U.S. Hardware Manufacturer</td>
<td>83.6 (84.4)</td>
<td>37.1 (46.0)</td>
</tr>
</tbody>
</table>
reducing inventory costs overall;
• hold for very different companies;
• hold for both of the two main forecasting methods – SMA and SES; and
• are greater for longer lead times and shorter order histories.

A company wishing to investigate the level of savings to expect from sharing POS/forecast information can implement a similar simulation of its sales forecast and inventories. In doing so, it will learn what potential savings in cost or improvements in service levels could result; this in turn will help guide decisions on investment in the information technology required for such collaborations.

We should recognize potential stumbling blocks in the sharing of information in a supply chain, including data confidentiality and the lack of trust between supply-chain partners. Trust between partners may take years to develop, and experts recommend forced compliance of data sharing by contractual obligations.

Supply-chain collaborations can improve the performance of supply chains. In an era of global trade and competition, competition is increasingly between supply chains rather than individual organizations. This has made collaboration activities an essential function of any supply chain. Visibility of information is an integral part of most collaboration activities, and visible supply chains require formal information systems to support the sharing of information. Exponential developments in the field of information technology have resulted in decreased cost of information-systems requirements for such collaborations. The high savings in supply-chain costs due to such collaboration activities justifies the implementation of systems and structures to support sharing of information.

REFERENCES


