Collaborative Supply Chain Forecasting: A Lean Framework

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Abstract

This paper proposes a conceptual framework to forecast supply chain demand in a collaborative manner and ultimately to coordinate and integrate various supply chain partner management activities including purchasing, production planning and inventory replenishment. This paper explains the collaborative forecasting concept and framework, identifies benefits that can be achieved using collaborative supply chain forecasting, and identifies potential obstacles to implementation.

Introduction

Marshall Fisher (1997) noted that a study of the U.S. food industry estimated that poor coordination among supply chain partners was wasting $30 billion annually. He further stated that supply chains in many other industries suffer from an excess of some products and a shortage of others owing to an inability to predict demand accurately and in a timely fashion. Many forces drive the need for the early exchange of reliable information and improved supply chain forecasting in order to eliminate waste. One of the most compelling reasons today is the more intense nature of global competition. A second force is the increasingly innovative nature of products, or the length of the life cycle and the duration of retail trends. In the apparel industry, for example, the life cycle of some garments is six months or less. Yet, manufacturers of these garments typically require up-front commitments from retailers that may exceed six months making long-term fashion forecasts risky. It is imperative to get products to market quickly; otherwise, lost revenues or markdown prices will be experienced. A third force is the longer, more complex supply chain given moves to offshore production. International sourcing for many items has lengthened the supply chain and cycle time. Long lead times necessitate supply chain planning visibility. A fourth force is the nature of the supply chain cost structure. Global markets and more competitors are likely to move the supply chain system towards universal participation by all supply chain members in an effort to cut costs (Raghunathan, 1999). These driving forces support the need to respond quickly and accurately to volatile demand and other market signals.

Collaborative Supply Chain Forecasting Benefits

The early exchange of information between trading partners provides for longer term future views of demand in the supply chain and an enhanced ability to synchronize planning and execution. Demand visibility provides the potential for numerous, substantial benefits. Benefits attributable to supply chain initiatives utilizing a strategy to synchronize inbound/outbound materials management activities with supply chain partners are well known and documented with several being listed in Table 1.

Actual results of several collaborative supply chain pilot initiatives highlight potential benefits of the proposed collaborative supply chain forecasting framework. The benefits for retailers include higher sales, higher service levels (in-stock levels), and lower inventories. Manufacturers have experienced similar benefits plus faster cycle times and reduced capacity requirements (Hill, 1999; Ireland and Bruce, 2000; Schachtman, 2000; Wolfe, 1998). A Nabisco/Wegman Foods collaborative planning, forecasting and replenishment (CPFR) pilot study produced a supply chain sales increase of 36-50% through a more efficient deployment of inventory (Lewis, 2000; Loudin, 1999; Schachtman, 2000). KPMG Consulting conducted a poll of both retailers and manufacturers in 1998 concerning the frequency and the benefits derived from information exchange. Manufacturers cited significant improvements in cycle time and inventory turns. Retailers indicated that order response times as short as 6 days for domestic durables and 14 days for non-durables were being achieved. Four out of 10cited at least at 10% improvement in both response times and inventory turns. Forty-five percent cited reductions of at least 10% in associated costs (Anonymous, 1998c). In supply chain collaboration pilot tests conducted with several vendors, Proctor and Gamble has experienced cycle time reductions of 12–20% (Schachtman, 2000). Proctor and Gamble estimates greater supply chain collaboration and integration will result in an annual savings by the year 2005 of $1.5 to $2 billion, largely reflecting the reduction in pipeline inventory (Anonymous, 1998c).

In 1996, approximately $700 billion of the $2.3 trillion retail supply chain was in safety stock (Lewis, 1999). Supply chain inventory may be as great as $800 billion of safety stock being held by second and third tier suppliers required to provide just-in-time delivery to their larger customers (Hill and Mathur, 1999). According to the U.S. Department of Commerce, there is $1 trillion worth of goods in the supply chain at any given time (Ulfelder, 1999). Even a small reduction in supply chain safety stocks is a sizeable dollar figure. In the KPMG survey, 42% of respondents indicated at least a 10% reduction in total inventory in the past 12 months (Anonymous, 1998c). According to published reports, some companies have achieved 20–30% reductions in inventory.

Almost immediately after its initial efforts to collaborate on supply chain forecasts, Heineken's North American distribution operations experienced a 15% reduction in its forecast errors and cut order lead times in half (Hill and Mathur, 1999). As order lead times are lowered, order response time improves. Anecdotal evidence has noted 15–20% increases in fill rates and half the number of out-of-stock occurrences (Hill, 1999). Enhanced knowledge of future events (e.g., promotions and pricing actions), past events (e.g., weather related phenomena), internal events (e.g., point-of-sales data and warehouse withdrawals), and a larger skill set gained from collaboration may all contribute to enhance forecast accuracy (Lapide, 1999).

Table 1
Anecdotal Supply Chain Synchronization Benefits

Retailer (Customer) Benefits:
1. Increased sales
2. Higher service levels (in-stock levels)
3. Faster order response times
4. Lower product inventories, obsolescence, deterioration
Manufacturer (Vendor) Benefits:
1. Increased sales
2. Higher order fill rates
3. Lower product inventories
4. Faster cycle times
5. Reduced capacity requirements
Shared Supply Chain Benefits:
1. Direct material flows (reduced number of stocking points)
2. Improved forecast accuracy
3. Lower system expenses

Supply chain forecast collaboration efforts should also result in lower product obsolescence and deterioration. Riverwood International Corporation, a major producer of paperboard and packaging products, is working to establish collaborative forecasting relationships with customers in order to make production scheduling and inventory control less risky.

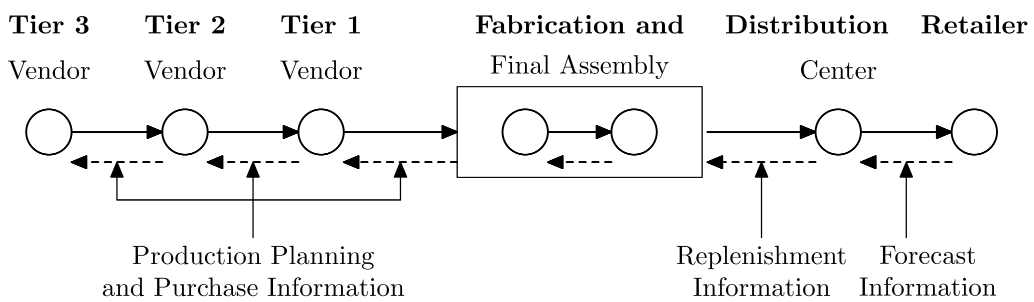
This company seeks to balance the need to stock up on inventory for sudden demand surges against the fact that paperboard starts to break down after 90 days (Stedman, 1998a). With a higher degree of collaboration and a timelier sharing of information between retailer and manufacturer, greater stability and accuracy in production schedules result in making inventory planning more accurate. Furthermore, as production schedules more accurately reflect the needs of the retailer to satisfy near term demand, reductions in manufacturer capacity requirements are possible. The benefits cited from these pilot programs as well the supply chain synchronization strategy benefits noted in Table 1 underscore the importance of the offered framework to forecast supply chain demand. The focus of the proposed supply chain forecast framework is to allow supply chain trading partners to operate in a leaner, more responsive and competitive manner.

Collaborative Supply Chain Forecasting Framework

During the past decade, there have been advancements in technology allowing for real time capture of retail level demand and the exchange of that demand information across a supply chain. If shared, this information offers the dual prospect of greatly reducing excess inventories and enabling supply chain partners to stock inventories of items which are needed to meet current demands. Web-based communication is faster and is available at a price more trading partners can afford. It is well known that older communication techniques such as mail, fax, or electronic data interchange are slower, typically require a more error-prone manual entering of identical data by both trading partners, may be unaffordable by some supply chain trading partners, and may be done in batch file transfer mode, which also delays the exchange of information.

Current technologies offer supply chain partners the ability to develop forecasts in a "pull" manner, namely beginning with the point where demand occurs, at the retail level and working back sharing information upstream through the supply chain. At the retail level, point-of-sale (POS) technology can capture demand as it occurs, data mining can detect the early onset of demand trends, and CPFR can be used to communicate demand information. These technologies can better enable supply chain partners to share and agree upon joint forecasts and to ultimately synchronize production planning, purchasing, and inventory allocation decisions across a supply chain. These technologies offer an enhanced ability for supply chain trading partners to operate in a lean manner.

Figure 1
Supply Chain with Retail Activities



Note: Solid arrows represent material flows; dashed arrows represent information flows

To date, the points of collaboration of many supply chains have focused upon the synchronization of production plans that commence with the original equipment manufacturer (OEM) and integrate production, purchase and shipping plans upstream. The exchange of planning information on the outbound side of distribution as shown in Figure 1, from the OEM to the retailer, has been largely overlooked. Evidence of this abounds in today's markets when financial analysts cite lack of future earnings visibility and excessive inventory accumulations.

This information exchange should emanate from the point at which demand actually originates. This is the furthest downstream point in the supply chain, where consumer demand actually occurs. It can be argued that all other points where demand occurs simply represent purchase orders for inventory replenishment. This suggests, in most instances, supply chain forecasts should originate at the retail level, as depicted in Figure 1.

Ideally, since forecasts form the basis for all planning activities, then in a highly coordinated, tightly integrated lean supply chain, collaborative forecasts should drive all partner planning activities. The importance of timely, accurate forecasts cannot be overemphasized for products with long supplier capacity reservation standards such as clothing, trendy items with short life cycles such as toys, low margin items such as foodstuffs, or long lead time items produced overseas. For all of these items, time to market is critical.

Therefore, timely and accurate forecasts are key to competitive success. Collaborative forecasts are capable of providing the benefits found in Table 1. Ideally, the collaborative supply chain forecast would accomplish several objectives. It is imperative the approach have characteristics of affordability, accuracy, timeliness, flexibility, and simplicity. First, it should integrate all members of the supply chain, including distribution and retail activities. The sharing of selected internal information on a secure shared web server between trading partners can lower implementation costs and increase accessibility. Second, as depicted in the simplified supply chain of Figure 1, the origination point of collaboration should be the retail level demand forecast.

This can then be used to synchronize order replenishment, production scheduling, purchase plans, and inventory positioning in a sequential fashion upstream for the entire supply chain. This will promote greater accuracy. Third, a web-based exchange of information can increase speed relative to older existing means of communication. Fourth, flexibility can be enhanced if it is able to incorporate a variety of supply chain structures and forecast procedures. In order to accomplish the noted objectives, a five-step framework is proposed and detailed below.

Step One: Creation of a front-end partnership agreement.

This agreement specifies: (1) objectives (e.g., inventory reductions, lost sale elimination, lower product obsolescence) to be gained through collaboration, (2) resource requirements (e.g., hardware, software, performance metrics) necessary for the collaboration, and (3) expectations of confidentiality concerning the prerequisite trust necessary to share sensitive company information, which represents a major implementation obstacle.

Step Two: Joint business planning.

Typically partners identify and coalesce individual corporate strategies to create partnership strategies, design a joint calendar identifying the sequence of planning activities to follow which affect product flows, and specify exception criteria for handling planning variances between the trading partners' demand forecasts. Among other things, this calendar must specify the frequency and interval of forecast collaboration. A 1998 pilot study conducted between Wegman Foods and Nabisco to develop weekly collaborative forecasts for 22 Planters Peanut products took approximately five months to complete steps one and two (Stedman, 1998b).

Step Three: Development of demand forecasts.

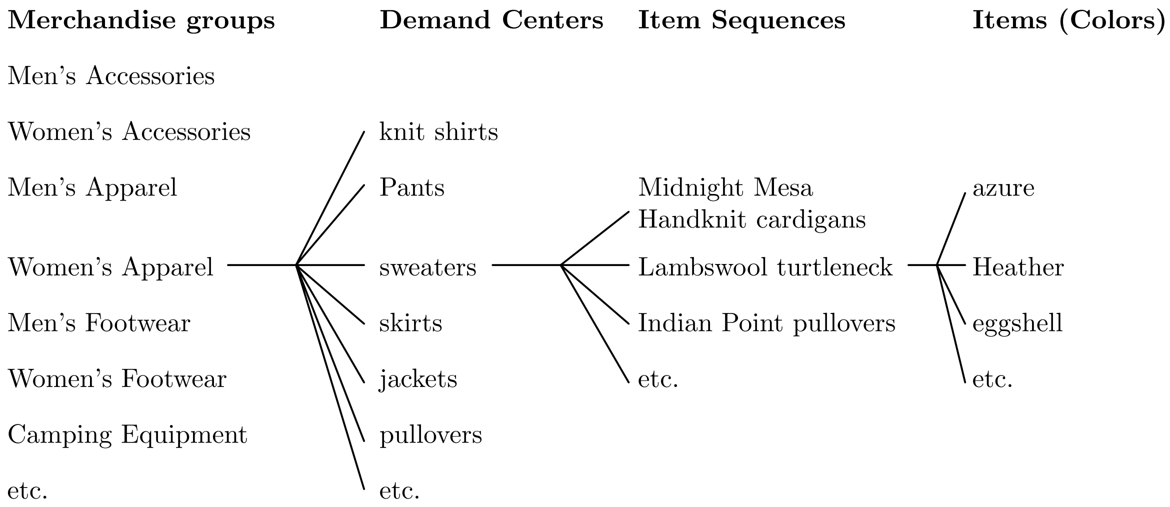
Forecast development should allow for unique company procedures to be followed affording flexibility.

All supply chain participants should generate independent forecasts allowing for explicit recognition and inclusion of expert knowledge concerning internal operations and external factors. Given the frequency of forecast generation and the potential for vast numbers of items requiring forecast preparation, simple forecast techniques easily used in conjunction with expert knowledge of promotional or pricing events or other factors to modify forecast values accordingly could be used. Retailers must play a critical role as shared POS data permits the development of accurate and timely expectations (compared with forecasts based upon extrapolated warehouse withdrawals or aggregate OEM orders) for both retailers and vendors (Lewis, 1999).

Hierarchical forecasting (HF) provides the structure of the proposed framework for including all supply chain partners in the collaborative pull forecast process. HF has been shown to have the ability to improve forecast accuracy and support improved decision-making within one firm (Fliedner, 1989). To date, several studies have offered practical guidelines concerning system parameters and strategic choices, which allow for custom configurations of HF systems within a single firm (Fliedner, 2001, 1999; Fliedner and Lawrence, 1995; Fliedner and Mabert, 1992). HF is able to provide decision support information to many users within a single firm, each representing different management levels and organizational functions (Fliedner and Mabert, 1992). Consequently, HF is increasingly being commercially offered as an integral framework of the enterprise resource planning (ERP) systems.

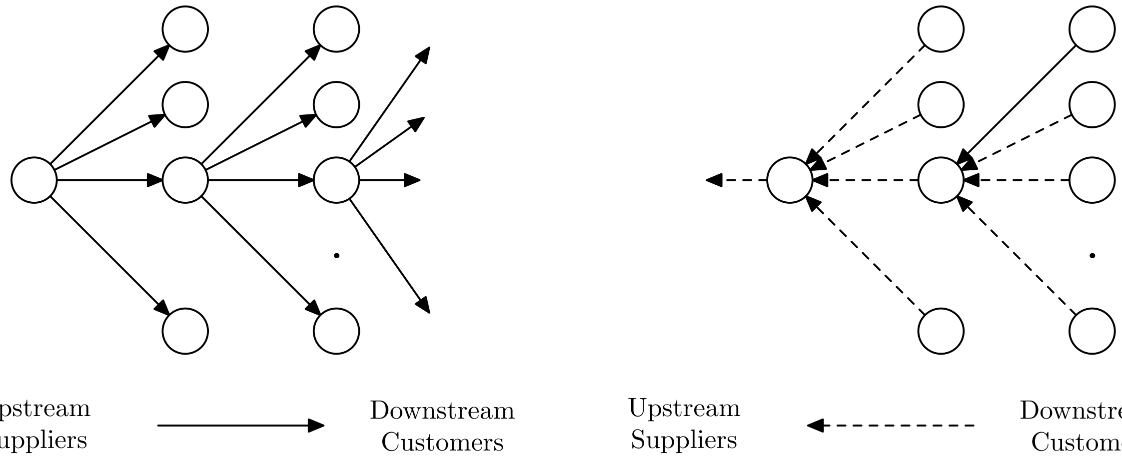
Initial applications of the HF approach have been used to provide forecast information based upon a strategy of grouping items into product families, similar to the example depicted in Figure 2. The typical firm's product line possesses a similar arborescent structure shown in this figure. As depicted in Figure 3, the typical supply chain also possesses a similar arborescent structure with upstream nodes typically supplying inventory to multiple downstream nodes. Therefore, extending HF to an arborescent supply chain structure in order to provide the pull forecast framework is readily done. Consequently, improved forecast accuracy and greater support for improved decision-making across many firms should be attainable.

Figure 2
L.L. Bean's Product Line Hierarchical Structure*



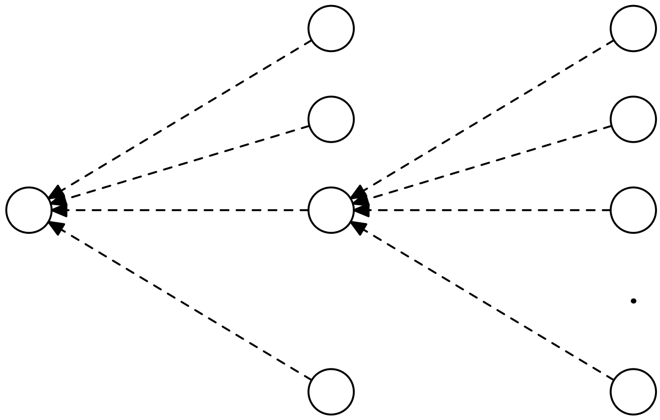
*Source: Schliefer, Jr., A. (1992). "L. L. Bean, Inc.: Item Forecasting and Inventory Management," Harvard Business School Case (9-893-003).

Figure 3
Example Supply Chain Arborescent Structure



Note: Solid arrows represent material flows; dashed arrows represent demand and forecast information flows; all nodes and links not depicted

Figure 4
Example Multiechelon Supply Chain Structure



Note: dashed arrows represent demand and forecast informationflows.

As demand information is shared upstream in the supply chain, HF provides a convenient structure for aggregating downstream demands and subsequently assisting the development of collaborative supply chain forecasts. The process may be best explained by a simplified illustrative example using a multiechelon supply chain structure comprised of a single original equipment manufacturer (OEM), m distributors, and n retailers, as depicted in Figure 4. A simplified numerical example of process steps three and four is provided in the Appendix.

As with HF, the proposed process begins with "bottom-up" demand aggregation. Beginning at the furthest downstream (retail) point, captured demand for customers across echelon three is aggregated up to the distributor. This process is successively repeated for each echelon comprising the multiechelon structure. Web-based technology enables real-time posting of supply chain exchange partners' demand values on a secure, shared web server to accomplish the demand aggregation process. For each of n retailers comprising echelon 3, identify item i demand supplied by distributor j and inventoried by retailer k in period t is simply identified as:

$$D_{i,j,k,t}, \qquad k = 1 \text{ to } n. \tag{2}$$

Then, in succession, for each distributor j comprising echelon 2, define item i's semi-aggregated period t demand, $D_{i,j,t}$, as the contemporaneous sum of n retailer time series as:

$$D_{i,j,t} = \Sigma_k D_{i,j,k,t}, \qquad k = 1 \text{ to } n. \tag{3}$$

In likewise fashion, for the OEM of echelon 1, define item i's aggregated period t demand, $D_{i,t}$, as the contemporaneous sum of m distributors' time series as:

$$D_{i,t} = \Sigma_j D_{i,j,t}, \qquad j = 1 \text{ to } m. \tag{4}$$

After demand aggregation is performed, a second step, forecast generation, takes place. A forecast for each item i for any participant in echelon e is determined for any future period p, $F_{i,e,t+p}$. This is done by each firm for all items comprising its product line. These forecasts are referred to as "direct" forecasts as the respective demand time series for each item may be used to directly determine it. Within commercial HF systems, simple averaging techniques are often used to determine these direct forecasts due to the large number of items and the frequency of forecast generation. Through manual intervention, these direct forecasts may reflect expert knowledge concerning internal operations and external factors.

The typical supply chain consists of many echelons. Therefore, this two-step process of aggregation and forecast generation is repeated for each echelon in sequential fashion upstream through the supply chain until a direct forecast of company-wide demand is determined for all participants in any multiechelon supply chain structure.

Step Four: Sharing forecasts.

The downstream customer (order forecasts) and upstream vendor (sales forecasts) then electronically post their respective independently-generated forecasts for a list of products on a dedicated server. At this point, consensus forecasts between trading partners are not likely to exist given the independent forecast development of the bottom-up process. Therefore, through collaboration the direct forecasts are subsequently used within a "top-down" process in order to derive consensus forecasts between supply chain partners and throughout the supply chain. In the "top-down" process, with the exception of the top-most level, an operational forecast for any item is determined by prorating the forecast determined at the immediate upstream (parent) echelon. These forecasts are referred to as "derived" forecasts as immediate downstream (child) echelon forecasts are ultimately derived from parent forecasts. The process begins with the direct forecast of the aggregate OEM demand (echelon 1, Figure 4) determined as the last step in the bottom-up process. It is used to determine derived child forecasts (echelon 2, Figure 4) with a proration procedure.

Muir (1979) identifies the rationale supporting the use of the top-down step of HF to derive operational forecasts for each supply chain member within the proposed framework. Muir argues that there is a stabilizing effect from combining demand data of two or more homogenous items. This rationale may best be explained by a simple numerical example. Assume four items each have an identical sales pattern of 100 units of average monthly demand with a standard deviation of 10. Let these four items comprise a family. Assuming normal and independent demand distributions, the statistical values for the family may be calculated, as shown in Table 2. As shown, the standard deviation of monthly or annual demand is proportionately smaller for a family of four items than for the individual item. Fliedner (1989) concluded that HF does provide for improved forecast accuracy within a single firm due to this stabilizing effect. However, attainment of improved supply chain forecasts will be situation dependent.

Table 2
Item versus Family Demand Patterns

Demand statistic	Item	Family
Monthly Demand	100 units	$4(100) = 400.00$ units
Monthly Demand Standard Deviation	10 units	$\sqrt{4(10^2)} = 20.00$ units
Annual Demand	$12(100) = 1.200$ units	$12(100)4 = 4.800$ units
Annual Demand Standard Deviation	$\sqrt{12(10^2)} = 34.64$ units	$\sqrt{12(10^2)4} = 69.28$ units

Gross and Sohl (1990) demonstrate several proration procedures. These authors examined 21 different disaggregation (proration) techniques within a two-level HF system structure. One common approach cited multiplies the parent echelon forecast by the ratio of respective subaggregate child demand over aggregated parent item demand. For example, within echelon 2, distributor j's operational demand forecast for item i may be derived from its vendor's (OEM) demand forecast as:

$$F_{i,2,t+p} = F_{i,1,t+p}(D_{i,j,t}/D_{i,t}). \qquad (5)$$

This procedure yields a "derived" consensus of expectations between the OEM and its distributors in the sense that the sum of all distributors' forecasts for echelon 2 would equal the echelon 1 forecast. However, it neglects explicit recognition and inclusion of expert knowledge concerning internal operations and external factors of the distributor. At this point, the distributor would compare its corresponding direct forecast with its derived forecast for variance. An exception notice would be issued for any forecast pair where the difference exceeds a pre-established safety margin (e.g., 5%). If the safety margin is exceeded, planners from both firms may collaborate electronically to derive a consensus forecast used ultimately for customer planning and for further downstream collaboration thereby affording the ability to recognize each trading partner's individual expert knowledge.

This process is then repeated downstream through the hierarchical multiechelon structure for the number of echelons that define the supply chain structure. Namely, an echelon 3 member's forecast for item i may be derived from its vendor's demand forecast as:

$$F_{i,3,t+p} = F_{i,2,t+p}(D_{i,j,k,t}/D_{i,j,t}). \qquad (6)$$

One consequence of the top-down proration process is that the resultant sum of r subaggregate forecasts equal the aggregate forecast between any two adjacent supply chain echelons. For any echelon e, this may be defined as:

$$F_{i,e,t+p} = \Sigma_j F_{i,e+1,t+p} \quad \text{for} \quad j = 1, \ldots, r, \qquad (7)$$

where r is the total number of immediate downstream children.

Resultant forecasts of this HF process are consistent with forecasts at either a higher or lower echelon levels, as shown in equation (6). It is these derived forecasts determined in the top-down process that are used for planning and execution. Given the number of individual product forecasts, a rules-based system response system will ultimately be needed in order to accommodate the large number of potential exception messages (Verity, 1997).

Step Five: Inventory replenishment.

Once the corresponding forecasts are in agreement, the order forecast becomes an actual order, which commences the replenishment process. Each of these steps is then repeated iteratively in a continuous cycle, at varying times, by individual products and the calendar of events established between trading partners.

It has been suggested that partners review the front-end partnership agreement annually, evaluate the joint business plans quarterly, develop forecasts weekly to monthly, and replenish daily (Schenck, 1998a).

Obstacles to Collaborative Supply Chain Forecasting Implementation

No discussion of a proposed new framework would be complete without recognition of anticipated barriers to implementation. As with most new corporate initiatives, there is skepticism and resistance to change. Several of the anticipated obstacles to implementation are noted in Table 3 and discussed below.

Table 3
Expected Barriers to Supply Chain Forecasting Implementation

1. Lack of trust and loss of control in sharing sensitive information
2. Lack of internal and external forecast collaboration interest
3. Availability and cost of technology/expertise
4. Fragmented information sharing standards
5. Aggregation concerns (number of forecasts adn frequency of generation)
6. Fear of collusion
7. Inexperience/Lack of skills at retail level

One of the largest hurdles hindering collaboration is the lack of trust over complete information sharing between supply chain partners (Hamilton, 1994; Stedman, 1998a; Stein, 1998). The conflicting objective between the profit maximizing vendor and cost minimizing customer gives rise to the adversarial supply chain relationship. Sharing sensitive operating data may enable one trading partner to take advantage of the other. Similarly, there is the potential loss of control as a barrier to implementation. Some companies are rightfully concerned about the idea of placing strategic data such as demand forecasts, financial reports, manufacturing schedules or inventory values online. Companies open themselves to security breaches (Stein, 1998). However, in a survey of 257 U.S. manufacturing and service companies, AMR Research found only 16 percent of respondents that are established participants in a business-to-business trading exchange cite security and trust problems (D'Amico, 2000). Furthermore, a 1998 study conducted by KPMG Consulting found 96% of retailers already sharing information regularly with their suppliers with almost half sharing information with manufacturing partners on a daily basis (Anonymous, 1998c). The front-end partnership agreements, nondisclosure agreements, and limited information access may help overcome these fears. The cost savings with a lean supply chain will clearly help too.

A second hurdle hindering collaboration is a cultural stumbling block. An unprecedented level of internal and external cooperation is required in order to attain the benefits offered by collaboration. Given that demand may be forecast many ways (e.g., by stock-keeping unit, product class, vendor, customer location, etc.), the various functional disciplines such as marketing, operations and finance of many firms have traditionally maintained separate demand forecasts and financial figures (Schachtman, 2000). As a result, internal forecasts are frequently conflicting (Tosh, 1998). The plans derived from these forecasts are typically not synchronized internally and this inconsistency leads to planning decisions reflecting different expectations of the same business activity. The magnitude of the problem of inconsistent forecasts is exacerbated when analyzing trading partner forecast consistency. There is the potential for a large number of pairs of inconsistent trading partner forecasts, which leads users to carry large buffer stocks given the demand uncertainties. Internal cooperation among the various functional disciplines needing forecast information for planning purposes is required. This represents a common cultural obstacle. A BusinessWeek/Boston Consulting Group survey of senior managers identified the second biggest barrier to innovation is a lack of coordination (McGregor, 2006). However, if departments are not collaborating for a single-number demand forecast, there is no sense in trying to collaborate with trading partners (Hill, 1999). Specifically, internal operations need to be synchronized first. Then, collaboration among trading partners may be pursued. Without internal collaboration, the entire forecast process is undermined.

Similarly, there must be external cooperation and a certain degree of compatibility in the abilities between supply chain trading partners (Abend, 1998). The availability and cost of technology, the lack of technical expertise, and the lack of integration capabilities of current technology across the supply chain present barriers to implementation (Schenck, 1998b). The demand forecasting process design must integrate quantitative skills and methods with qualitative assessment by using a collaborative process that cuts across business functions, distribution channels, key customers, and geographic locations (Chase, 1998). Collaboration ensures all supply chain planners are utilizing the same internally and externally consistent forecast.

The necessary "bandwidth" and the associated reliability of technology is also a potential barrier, as some companies may not have the network infrastructure to support the large number of potential new users. However, if the necessary trust in the relationship can be developed, synchronizing trading partner business processes with consumer demand need not be overly time consuming nor costly (Sherman, H. D. and Gold, F, 1985). In order for this to be possible, emerging standards need widespread adoption as opposed to numerous, fragmented standards Verity (1997).

Widespread sharing and leveraging of existing information across functions within an organization and between enterprises comprising the supply chain may be possible. Common emerging standards will be necessary to promote collaborative supply chain forecasting. Attaining a "critical mass" of companies willing to adopt these standards will be important in determining the ultimate success of collaborative practices. The cost of establishing and maintaining collaborative processes without common interfaces limits the number of trading partner relationships each participant is willing to invest in (Sherman, H. D. and Gold, F, 1985). However, as the ability to collaborate is made easier, the number of supply chain trading partners wanting to collaborate will increase.

An additional obstacle to adoption and implementation concerns two aspects of data aggregation: the number of forecasts and the frequency of forecast generation (Abend, 1998; Stedman, 1998b). Bar code scanning provides retailers the technology to forecast POS data by store whereas suppliers typically forecast orders at point of shipment such as the warehouse. The POS store data is more detailed as it represents daily shelf-level demands for individual stores. Point of shipment data represents the aggregate of all stores served by one warehouse, typically measured over a longer interval of time, such as a week. In the Wegman Foods/Nabisco pilot study, 22 weekly forecasts for individual products were developed collaboratively. In a full-blown collaboration for store-level planning, the number of daily collaborative forecasts would increase to 1,250 for Planters Peanuts alone (Stedman, 1998b). It is not uncommon for large retail stores to stock 75,000 or more items, supplied by 2,000 to 3,000 trading partners (Hickey, 1999). This obstacle must be coupled with the vast potential exception reporting given the large number of items to exchange information, which exacerbates this implementation obstacle. A variety of scenarios may be offered leading to exception reports (Katz and Hannah, 2000). Given the frequency of forecast variance review and the large number of potential exceptions that may occur, a rules-based approach to automatically resolve trading partner forecast variances will be required. In the development of collaborative forecasts, these aggregation concerns will need to be resolved. One means to synchronize business processes and overcome these obstacles is reliance upon the HF approach Fliedner (2001).

An additional obstacle to implementation focuses on the fear of collusion leading to higher prices (Verity, 1996). It is possible that two or more suppliers or two or more retailers may conspire and share information harmful to the trading partner. Frequently this fear arises when the item being purchased is custom made or possessing a proprietary nature, making it less readily available. Long-term supplier partnerships between mutually trustworthy partners reduce the potential for collusive activities.

A final potential obstacle to implementation recognizes the important role retailers must play in the process. However, in many industries, the employee turnover rate at the retail level coupled with its consequential impact on the experience and skill sets of retail employees may result in an important barrier to implementation efforts. However, with all of the barriers to implementation, success encourages adoption. Anecdotal evidence of the tremendous potential benefits cited in Table 1 attributable to collaborative supply chain forecasting will overcome these adoption barriers.

The Future of Collaborative Supply Chain Forecasting

Many companies are beginning to use their intranet to enhance collaboration of internal processes (Dalton, 1998) with *Enterprise Resource Planning* (ERP) systems. ERP systems are increasingly being used to provide the interconnected transaction foundation among the various planning systems comprising a company's intranet (Joachim, 1998). ERP permits an automatic transference of customer demand forecasts into a variety of corporate intranet planning modules. These advanced decision-support and enterprise execution systems largely focus on integrating and optimizing cross-functional, intra-organizational planning activities and transactions.

While ERP is being used successfully to standardize the **internal** financial and transactional processing needs of an organization, the next step is engaging distributors in partnerships using Internet technologies to standardize **external** financial and transactional processing needs. Although, ERP does not presently address interenterprise collaborative efforts, the proposed collaborative supply chain forecasting framework does.

Several approaches are being investigated to enhance collaborative relationships by way of extranets among supply chain partners (Joachim, 1998). Many of these efforts are based upon "middleware" software, which is used to bridge the gap and facilitate interenterprise collaboration and synchronize trading partner business processes (Schachtman, 2000). Presently, there are numerous ERP vendors, several of which offer software capable, to varying degrees, of integrating a customer demand forecast into a production planning module (Harrington, 2000). Some of these vendors are also emerging with an applications hosting business, whereby collaborative forecasting and planning setups for groups of users are offered. These new services are aimed at retailers and manufacturers that want to begin to use the Internet to exchange business data for collaborative purposes (Stedman, 1999).

Collaborative supply chain forecasting in conjunction with ERP may be used to provide the interconnected transaction foundation among the various planning systems via the Internet. In a research survey conducted by *InformationWeek* of 200 Information Technology executives currently using or deploying ERP, 52 percent of the respondents indicated current involvement or future plans to create a business supply chain using ERP software (Stein, 1998). This system would enable suppliers, partners, distributors, and even consumer's real-time access to the ERP system via an extranet. Specifically, supply chain participants utilizing the proposed forecasting framework would be able to connect ERP planning systems via the worldwide web.

The future evolution of the proposed idealistic framework will permit an automatic transference of supply-chain partner demand forecasts into vendor production schedules, accounting (accounts receivable and payable), human resource requirements, and supply-chain planning applications such as the warehousing and inventory control applications of ERP systems. The next logical step in the development of the proposed framework is the interenterprise integration of various ERP system planning activities. Benefits to be realized for all participants will include the mitigation of the supply chain bull-whip effect through better collaboration, increased sales, lower operational costs, higher customer service levels and reduced cycle times, among a host of others.

References

Abend, J. (1998, May). “SCM is Putting a Buzz in Industry Ears,” *Bobbin*, Vol. 39, No. 9, pp. 48–51, 54.

Anonymous. (1998c). ”KPMG Study Points the Way Toward a More Efficient Supply Chain,” *Chain Store Age*, Vol. 74, No. 10, p. 6c.

Chase Jr., C. W. (1998). ”The Role of the Demand Planner in Supply Chain Management,” *Journal of Business Forecasting Methods and Systems*, Vol. 17, No. 3, pp. 2, 24–25.

Dalton, G. (1998, September 14). ”Their Own Brand of Supply Side Economics,” *InformationWeek*, No. 700, pp. 129–132.

D’Amico, E. (2000). ”Wanted: Customer Contact at Hubs,” *Chemical Week*, Vol. 162, No. 43, p. 55.

Fisher, M. L. (1997, March-April). ”What is the Right Supply Chain for Your Product?” *Harvard Business Review*, pp. 105–116.

Fliedner, E. (1989). ”A Comparative Analysis of Hierarchical Forecasting System Strategies with a Traditional Forecasting Methodology,” unpublished doctoral dissertation, Indiana University.

Fliedner, G. (2001). ”Hierarchical Forecasting: Issues and Use Guidelines,” *Industrial Management and Data Systems*, Vol. 101, No. 1, pp. 5–12.

Fliedner, G. (1999). ”An Investigation of Aggregate Variable Time Series Forecast Strategies with Specific Subaggregate Time Series Statistical Correlation,” *Computer and Operations Research*, Vol. 26, pp. 1133–1149.

Fliedner, E. B. and Lawrence, B. (1995). ”Forecasting System Parent Group Formation: An Empirical Application of Cluster Analysis,” *Journal of Operations Management*, Vol. 12, pp. 119–130.

Fliedner, E. B. and Mabert, V. A. (1992). ”Constrained Forecasting: Some Implementation Guidelines,” *Decision Sciences*, Vol. 23, No. 5, pp. 1143–1161.

Gross, C. W. and Sohl, J. E. (1990). ”Disaggregation Methods to Expedite Product Line Forecasting,” *Journal of Forecasting*, Vol. 9, pp. 253–254.

Hamilton, P. W. (1994). ”Getting a Grip on Inventory,” *Dun and Bradstreet Reports*, Vol. 43, No. 2, p. 30–32.

Harrington, L. H. (2000). ”Collaborating on the Net,” *Transportation & Distribution*, Vol. 41, No. 2, pp. 8–15.

Hickey, K. (1999). ”Hosting Heaven,” *Traffic World*, Vol. 260, No. 9, pp. 39–40.

Hill Jr., S. and Mathur, S. (1999). ”A Net Gain,” *Manufacturing Systems*, Vol. 17, No. 11, pp. 34–35, 39, 41, 43.

Hill, S. (1999). ”CPFR Builds the United Partnerships of Apparel,” *Apparel Industry Magazine*, Vol. 60, No. 10, p. 54, 56–58, 60.

Ireland, R. and Bruce, R. (2000, September/October). ”CPFR: Only the Beginning of Collaboration,” *Supply Chain Management Review*, pp. 80–88.

Joachim, D. (1998, April). ”Workflow Automation Crosses Company Lines,” *InternetWeek*, No. 709, p. S04.

Katz, M. and Hannah, D. (2000). ”A Closer Look at CPFR Processes: Working with Forecast Exceptions,” *Bobbin*, Vol. 41, No. 10, pp. 78–82.

Lapide, L. (1999). ”New Developments in Business Forecasting,” *Journal of Business Forecasting Methods and Systems*, Vol. 18, No. 3, pp. 24–25.

Lewis, L. (1999). ”CPFR: One Giant Business Plan,” *Progressive Grocer*, Vol. 78, No. 4, pp. 69–72.

Lewis, L. (2000). ”CPFR Solutions,” *Progressive Grocer*, Vol. 79, No. 4,, pp. S28–S32.

Lewis, T.G. (1998). ”Electronic Warehouses,” *Datamation*, Vol. 44, No. 1,, p. 17.

Loudin, A. (1999). ”Spicing up the food Chain,” *Warehousing Management*, Vol. 6, No. 10, pp. 1–5.

McGregor, J. (2006, April 24). ”The World’s Most Innovative Companies,” BusinessWeek, No. 3981, pp. 63–74.

Muir, J. W. (1979). ”The Pyramid Principle,” *Proceedings of 22nd Annual Conference*, American Production and Inventory Control Society, pp. 105–107.

Raghunathan, S. (1999). ”Interorganizational Collaborative Forecasting and Replenishment Systems and Supply Chain Implications,” *Decision Sciences*, Vol. 30, No. 4, pp. 1053–1071.

Schachtman, N. (2000, October 9). ”Trading Partners Collaborate to Increase Sales,” *InformationWeek*, No. 807, pp. 182–188.

Schenck, J. (1998a). ”CPFR: Stitching Together the Partnership,” *Apparel Industry Magazine*, Vol. 59, No. 8, pp. 72, 76.

Schenck, J. (1998b). ”CPFR: A Glimpse into Retail’s Future?,” *Automatic I.D. News*, Vol. 14, No. 12, p. 51.

Schliefer, Jr., A. (1992). ”L. L. Bean, Inc.: Item Forecasting and Inventory Management,” Harvard Business School Case (9-893-003).

Sherman, R. J. (1998). ”Collaborative Planning, Forecasting & Replenishment (CPFR): Realizing the Promise of Efficient Consumer Response Through Collaborative Technology,” *Journal of Marketing Theory and Practice*, Vol. 6, No. 4, pp. 6–9.

Stedman, C. (1998a). ”Customer Data Faces Rough Road to Factory,” *Computerworld*, Vol. 32, No. 39, pp. 1, 16.

Stedman, C. (1998b). ”Retailers Face Team-Planning Hurdles,” *Computerworld*, Vol. 32, No. 42, pp. 43, 47.

Stedman, C. (1999). ”Supply Chain Vendors Prep Application-Hosting Services,” *Computerworld*, Vol. 33, No. 27, p. 4.

Stein, T. (1998, June 15). ”Extending ERP,” *InformationWeek*, No. 686, pp. 75–82.

Tosh, M. (1998). ”Focus on Forecasting,” *Progressive Grocer*, Vol. 77, No. 10, pp. 113–114.

Ulfelder, S. (1999). ”Can You Keep Your Data a Secret?,” *Computerworld*, Vol. 33, No. 41, p. 72.

Verity, J. W. (1996, October 21). ”Clearing the Cobwebs from the Stockroom,” *Business Week*, No. 3498, pp. 140.

Verity, J. (1997). ”Collaborative Forecasting: Vision Quest,” *Computerworld*, Vol. 31, No. 45, pp. S12–S14.

Wolfe, J. (1998, October). ”Collaboration is the Name of the Game in Supply Chain,” *Chain Store Age*, p. 26.

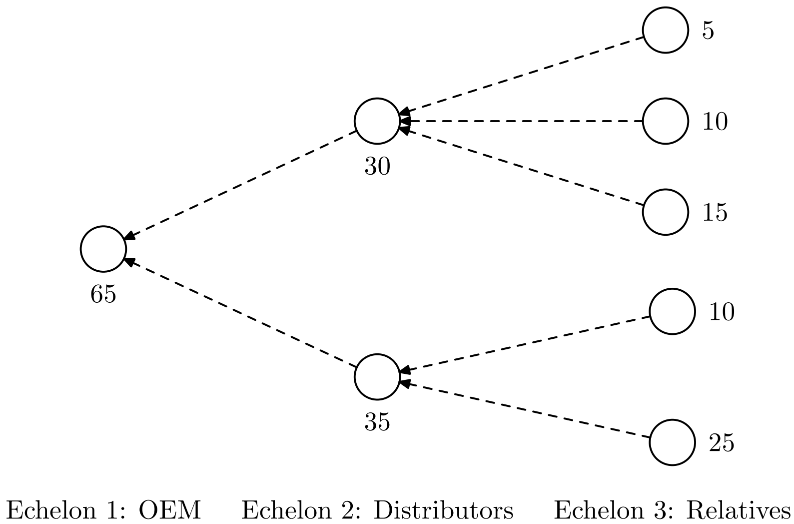
Appendix

The simplified numerical example below portrays steps three and four of the collaborative supply chain forecasting process. Assume a simplified supply chain consisting of three echelons similar to the supply chain structure previously portrayed in Figure 4. For simplicity, assume five retailers, two distributors and one OEM, as shown in Figure 5. Unit forecasts and demands are assumed throughout this example.

Development of direct demand forecasts: Demand aggregation

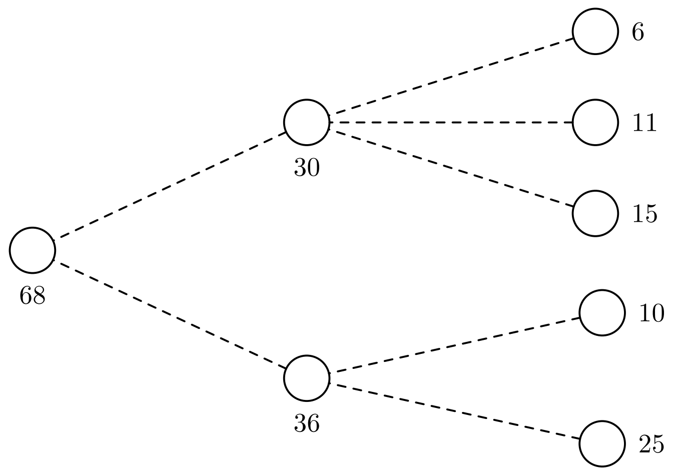
Demand aggregation is performed for each node in the multiechelon supply chain following equations (1) – (3). This part of the process begins with a posting of retailer's demands on a shared web server between the retailer and its distributor. In kind, distributors post semi-aggregated demands on a shared web server with the OEM. Assume demand values portrayed in Figure 5.

Figure 5
Example Multiechelon Supply Chain Structure with Demands



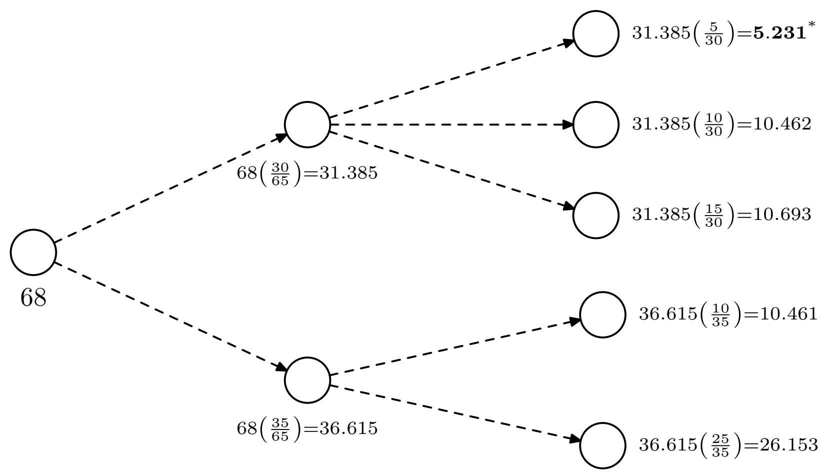
Note: dashed arrows represent information flows

Figure 6
Direct Multiechelon Supply Chain Forecasts



Note: dashed lines represent supply chain relationships

Figure 7
Derived Multiechelon Supply Chain Forecasts



*exception notice issued assuming a 5% threshhold: (6-5.231)/6=12.817%

Note: dashed arrows represent information flows

Development of direct demand forecasts: Forecast generation

A forecast for each item i for any participant in the multiechelon structure is then determined for any future period p ($F_{i,e,t+p}$). This is done for all items comprising a firm's product line. These forecasts are referred to as "direct" forecasts as the respective demand time series for each item may be used to directly determine it. Within commercial HF systems, simple averaging techniques are often used to determine these direct forecasts due to the large number of items and the frequency of forecast generation. Assume the direct, independent forecasts generated (using Figure 5 demand values) are as depicted in Figure 6.

Development of derived demand forecasts: Sharing forecasts

Once the direct, independent forecasts depicted in Figure 6 have been developed, these are also posted on the dedicated shared web servers between trading partners. At this point, consensus forecasts between trading partners have not been achieved. Therefore, the direct forecasts are subsequently used within the top-down process in order to derive consensus forecasts. A operational planning forecast for any item is determined by prorating the forecast determined at the immediate upstream (parent) echelon. The process begins with the direct forecast of the OEM. It is used to determine ”derived” child forecasts with the proration procedure of equation (4). Following this procedure yields the forecasts portrayed in Figure 7.

Development of derived demand forecasts: Variance checking

At this point in the development of derived demand forecasts, consensus of expectations between trading partners now exists. However, it neglects explicit recognition and inclusion of expert knowledge concerning internal operations and external factors. At this point, each partner would compare its corresponding direct forecast, which reflects the expert knowledge, with its derived forecast for variance. An exception notice would be issued for any forecast pair where the difference exceeds a pre-established safety margin (e.g., 5%). As noted above, for one retailer, an exception notice would be issued given the size of the forecast variance. Noting that the safety margin is exceeded, planners from both firms may collaborate electronically to derive a consensus forecast used ultimately for customer planning and for further downstream collaboration.

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