The Seven Principles of Sales-Forecasting Systems

By John T. Mentzer and Carol C. Bienstock

Sales forecasts are an essential input to logistics and supply chain management. They help the professionals running these functional areas make informed decisions on where to stage the raw-material inventory necessary for the timely production of the final products and how to move finished products to the specific locations where they will be demanded. Because of the nature of their operations, these managers need forecasts at the stock-keeping unit by location (SKUL) level for both long- and short-term time horizons.

Supply chain managers require the long-term sales forecasts to develop the production and storage facilities in various locations and provide the transportation equipment to move the products between the facilities. In many cases, bringing both these facilities and equipment online can mean a planning horizon of a year or more, certainly a long-term effort.

Short-term supply chain planning is more concerned with specific decisions about what finished products to move to what locations and when. Accordingly, the short-term sales-forecasting horizon is defined by the order-cycle time from the point of finished-goods production and/or storage to the various points of demand. This horizon can be extremely short term (often monthly, weekly or, in some cases, daily forecasts) and can involve many SKUL forecasts.

Managing the sales-forecasting function to meet these long- and short-term requirements of supply chain management and the other functional business areas involves several dimensions. These include the proper forecasting techniques, the appropriate managerial approach, sales-forecasting performance measures, and the appropriate systems. The last of these—sales-forecasting systems—is the computer and electronic communications hardware and software to develop, analyze, and

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distribute sales forecasts.

Sales-forecasting systems encompass all the computer and communication systems used by the developers and users of the sales forecast. In essence, they form the template that overlays all of the processes, procedures, and reporting associated with sales forecasting.

The information on sales-forecasting systems presented in this article flows from two principal sources. The first is the work that the authors have done in developing such systems for a number of companies. This work began in 1975 and continues to the present.

The second source of information is a continuing program of benchmarking research spanning the years 1982 to 1996, conducted by the Sales Forecasting Research Group, now at the University of Tennessee. This research includes two surveys of sales-forecasting practices (one conducted in 1982 of 157 companies and the other in 1992 of 208 companies), and an in-depth study done between 1994 and 1996 that explored the sales-forecasting management practices of 20 major companies. These studies, collectively referred to as the Sales Forecasting Benchmarking Studies, are described more fully in the sidebar on page 78.

Based on our experience in developing sales-forecasting systems for companies and the benchmarking surveys conducted among more than 400 firms, we have identified seven guidelines, or principles, for companies selecting or developing a sales-forecasting system. This article articulates those principles and discusses their significant implications for supply chain management.

Principle 1: The sales-forecasting system should serve as a communications vehicle between users and developers of the forecasts.

One company we worked with suffered from a longstanding distrust between marketing and operations (production/distribution) regarding each other's forecasting efforts. Not surprisingly, there was virtually no communication between the two functions when it came to sales forecasting. Production personnel maintained that they had no input or access to the sales-forecasting process developed by marketing. When operations did attempt to schedule production...
and distribution using marketing’s sales forecasts, the results were disastrous. The inaccuracy of these forecasts caused major problems with both suppliers and production scheduling.

As a result, operations personnel relied on sales forecasts they generated themselves. Meanwhile, marketing was concerned because it did not have access and input to production’s sales forecast. Both functional areas were frustrated because neither had access (electronic or otherwise) to the other’s sales forecasts or to the information used to develop the sales forecasts. Their frustration led to a duplication of effort, which saw both marketing and production developing independent sales forecasts.

The problems afflicting this company—namely, system disconnects and islands of analysis in the sales-forecasting process—were observed in a number of other companies in the Sales Forecasting Benchmarking Studies. System disconnects exist when the information needed to develop the sales forecasts is not electronically available to the developers of the sales forecasts. When information on market research, inventory levels, confirmed orders, EDI input from supply chain members, and sometimes even historical demand is not available to forecasters, they lack the information necessary to do their jobs. No one can forecast accurately in the absence of such information.

Conversely, the more information that is available, the better the resulting forecast. Yet not having that information available in an electronic form leads to errors in the forecasting process because of the mistakes inherent in manual entry. System disconnects can be cured by providing the forecasters with electronic access to the systems containing the information needed to develop informed sales forecasts.

The second systems communication problem is islands of analysis. These occur when the users of the sales forecasts lack electronic access to the sales-forecasting system. Managers responsible for supply chain management and their counterparts in the other functional areas (marketing, sales, finance, and production) need sales forecasts. But when functional managers cannot obtain electronic access to them, they must manually enter the forecasts into their systems. This inevitably results in data errors. Even worse, these managers become frustrated with their inability to interact with the forecasts and to provide input while they are being developed. This frustration often results in each functional area’s independently developing forecasts for its own use, as was the case with the example cited above.

The islands of analysis typically result in serious problems within each of the functional areas—lack of access to all of the information needed, duplication of

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Summary of the Benchmarking Studies

The Sales Forecasting Benchmarking Studies referred to in this article were conducted by the Sales Forecasting Research Group, now located at the University of Tennessee. The studies were conducted in the following three phases:

Phase 1, which was conducted in 1982, was designed to extend earlier research on sales forecasting. It included responses from 157 U.S. companies to a mail survey on sales-forecasting practices. Specifically, the survey examined the respondents’ familiarity with sales-forecasting techniques as well as the use, application, and satisfaction with such techniques.

To replicate the findings on sales-forecasting techniques from Phase 1 and examine the state of sales-forecasting management and systems, Phase 2 was undertaken in 1992. An eight-page mail questionnaire was sent to a random sample of forecasting executives in 478 companies. The questionnaire included measures of familiarity, satisfaction, usage, and application of forecasting techniques, paralleling those used in the first phase. Questions about forecasting systems and management also were included. Two waves of response in Phase 2 resulted in 208 completed questionnaires, a 43-percent response rate.

Phase 3 of the Sales Forecasting Benchmarking Studies focused on 20 companies widely considered to be top performers in terms of sales and profitability. In addition, companies at various levels of the supply chain—suppliers, manufacturers, wholesalers, retailers, and transportation providers—were included in the sample in Phase 3. To obtain this supply chain perspective, researchers arranged site visits with 15 manufacturers, three distribution firms, and two retailers. These companies were Anheuser-Busch, Becton-Dickinson, Coca Cola, Colgate Palmolive, Federal Express, Kimberly Clark, Lykes Pasco, Nabisco, JC Penney, Pillsbury, ProSource, Reckitt Colman, Red Lobster, RJR Tobacco, Sandoz, Schering Plough, Sysco, Tropicana, Warner Lambert, and Westwood Squibb. During these site visits, anyone who either developed or used sales forecasts was considered a prospective interview candidate. Phase 3 was conducted between 1994 and 1996.
effort, and lack of input from the other functions. For logistics and supply chain management, this translates to the development of SKUL-based forecasts that are less than accurate because they lack the necessary market information.

The cure for both system disconnects and islands of analysis is a client/server-systems architecture that is both internal and external to the organization. The internal architecture means that all the systems used by the functional areas, sales forecasting, and the management information systems (MIS) area are tied together to a central server system with access to a corporate data warehouse. All information gathered by MIS is stored in a central location in that data warehouse so that any information relevant to sales forecasting can be obtained easily and electronically. Through the central server system, all of the functional systems (including sales forecasting) can access one another.

An internal client/server system means that anyone involved in developing the sales forecasts can access electronically whatever information is needed—sales history, order history, market research information for regression analysis, financial plans, production schedules and/or capacity, inventory levels by location, and so on. Through the internal client/server, managers using the sales forecasts can electronically provide input to the sales-forecast developers. In addition, they can conduct their own analyses and planning based on the existing sales forecasts. Supply chain managers thus can obtain information on expected future demand levels electronically and plan their operations accordingly. At their most sophisticated, these sales forecasts can be used as direct electronic input to supply chain or logistics planning models.

External client/server architecture means that your corporate system has access to the corporate systems of as many supply chain partners as possible. Availability of accurate, timely information about the demand your customers are experiencing from their customers—and the inventory they are carrying to meet that demand—enhances the ability to forecast accurately. With this information, more accurate forecasts can be derived on a customer-by-customer basis, thus reducing overall forecasting error.

Similarly, availability of accurate and timely information about material availability from your suppliers’ suppliers will improve forecasting accuracy for both you and your suppliers. This should translate ultimately to lower costs for your suppliers and better prices for your company.

In effect, the establishment of an external client/server architecture with suppliers _and_ customers affords the opportunity to forecast demand across the entire supply chain and plan logistics flows more effectively.

Exhibit 1 illustrates this internal and external client/server architecture. To the degree that the complete architecture can be achieved, communication between the functional areas and sales forecasting will be improved, manual data entries minimized, and islands of analysis eliminated. Overall, supply chain sales forecasting will become a much more informed and accurate process.

**Principle 2:** The tool (that is, the sales-forecasting system) should fit the problem, not the other way around.

This guideline follows from a fundamental business principle that systems exist to serve the business, not the other way around. This means that a sales-forecasting system should be tailored to meet the company’s forecasting needs.

If the company wants to forecast logistics needs weekly—with rollups monthly (for marketing), quarterly (for sales), and yearly (for finance)—the system...
should be customized to provide forecasts for those intervals. If the company wants to forecast at the stock-keeping unit by location (SKUL) level for logistics, at the stock-keeping unit (SKU) for production, at the product line for marketing, and at the corporate level for finance—with adjustments to any level automatically reconciled at all other levels—the system again should accommodate this. And if the company wants analysts and managers to be able to make qualitative adjustments to the forecasts and capture the effect of each adjustment on forecasting accuracy, this should be possible too.

The impact of this kind of systems flexibility on supply chain management (or any other functional area, for that matter) is profound. It means that forecasts are available in a time horizon and organizational level that is most useful for the long- and short-term planning needs.

**Principle 3: Complex systems do not have to look that way.**

Given the procedures, logic, and information gathering involved, the task of developing accurate and useful sales forecasts can be quite complex. The effort typically involves accessing information from multiple sources and requires hundreds of thousands of calculations.

None of this complexity, however, needs to be apparent to the sales forecaster. His or her job is to understand (1) the uses and limitations of the two major groups of quantitative sales-forecasting techniques (time series and regression) and (2) how each technique is used in his or her sales-forecasting system to arrive at the system-generated forecast. With the benefit of this understanding, sales forecasters then can apply their own business and forecasting experience to qualitatively improve the system forecast that has been generated quantitatively.

There is nothing in this procedure that requires an in-depth knowledge of the actual systems functions or the mathematical calculations necessary to bring the quantitative forecast to the forecaster. The systems functions are the responsibility of MIS. The mathematical calculations are the responsibility of the developers of the actual sales-forecasting system. What the sales forecaster should see is the quantitative forecasts, laid out in an easy-to-use format that lends itself to the analyses needed to make qualitative adjustments.

Findings from the Sales Forecasting Benchmarking Studies revealed that spreadsheets offered one of the best environments in which to perform these qualitative analyses. The complex systems functions and mathematical calculations required for sales forecasts can be performed in a separate computing environment, without direct input from the sales forecaster. Once these functions and calculations are performed, the sales forecaster can be provided with access to a spreadsheet that contains the results of the complex quantitative analyses. The forecaster then can use the results to qualitatively finalize the sales forecasts.

Supply chain managers using the sales-forecasting system do not require extensive training in making quantitative sales forecasts. Their education, instead, should concentrate on what quantitative techniques are used by their sales-forecasting system, the limitations and advantages of these techniques, and how to bring their business (that is, supply chain management) experience to bear on qualitatively improving the resultant quantitative forecasts.

**Principle 4: Forecasters should use a “suite” of time-series techniques, not just one technique.**

Traditionally, forecasting systems had been centered on a single time-series technique. Consequently, prior to selecting or developing a sales-forecasting system, companies had to spend a lot of time and effort trying to figure out which particular technique worked best for the largest number of their products. Alternatively, they simply purchased a software package and hoped that the one time-series technique included in the package would work for them.

Modern computer technology has eliminated the need for such a narrow focus on one time-series technique. Sales-forecasting systems today can include a “suite” of time-series techniques, any or all of which can be used in forecasting each individual product. For example, exponential smoothing with an $\alpha$ of 0.14 might be best for forecasting one product, while the same technique with a different $\alpha$ might be best for another. And for a third product, exponential smoothing with trend and seasonality might be the way to proceed.
The point is that computer technology now available makes it possible to select the best time-series technique for each product to be forecast. The selection of each product-specific technique can be automatic, or it can be done by the forecaster. Regardless of how the selection is accomplished, the point of this principle is that a suite of time-series techniques first must be available in the system. There is no excuse today for using a sales-forecasting system that does not offer this feature.

**Principle 5: Use time-series, regression, and (not or) qualitative analysis.**

The three major categories of sales-forecasting techniques—time series, regression, and qualitative analysis—are frequently considered separate approaches to the design of sales-forecasting systems. In other words, the system designers assume that if a company uses one technique, the other techniques are not necessary. This leads to systems that take either a time-series or a regression approach, which often makes it difficult or impossible to make qualitative adjustments to the quantitative forecasts.

With respect to sales forecasting, however, time-series, regression, and qualitative techniques each have their unique advantages and disadvantages. And the advantages of one often offset the disadvantages of another. Time-series techniques are designed to identify and forecast trends and seasonal patterns in data and to adjust quickly when these trends or patterns shift. Their limitation is that they do not consider such external factors as price changes, competitive actions, or economic conditions.

Regression analysis, by contrast, does a poor job of identifying trends and seasonality—and an even poorer job of adjusting to changes in either. The large data requirements of regression analysis prevent this technique from readily adjusting to such changes. However, regression does consider external factors when formulating a sales forecast.

What neither time series nor regression does well is deal with changes in the business environment that have never happened before—or that have happened before, but for which no data exist in the system. That's where experienced forecast analysts and supply chain managers can skillfully combine their expertise with that of internal and external resources (such as the company's supply chain partners) to translate these inputs into qualitative adjustments to a quantitative forecast. Often, these adjustments are based on a keen analysis of the business environment, but involve no quantifiable data. What forecast analysts and supply chain managers do not do well is look at masses of data and precisely identify trends, seasonal patterns, or relationships with external factors.

In short, each of the three sales-forecasting techniques—time series, regression, and qualitative analysis—does something well that the other two do poorly. For this reason, the most effective sales-forecasting systems combine the advantages of all three categories. They start with a time-series forecast (using the suite approach) to develop an initial forecast and then do regression analysis of external factors to improve this initial forecast. Systems like these make it easy for the sales forecasters to analyze the resulting forecasts and make qualitative changes based on information that was not considered by the time-series or the regression analysis.

**Principle 6: The sales-forecasting system should tell the forecasters which techniques to use.**

This principle simply means that a well-designed sales-forecasting system has access to demand history for all the products to be forecast. Using this information, it can take each product, one at a time, try a number of different time-series techniques on that one product, and select the technique that provides the best forecast for that one product. The system then can proceed to the second product and repeat the process until all products to be forecast have been analyzed. This results in selection of the most accurate time-series technique to use for each product to be forecast.

The sales-forecasting system also should have access to data on all the variables that might affect demand for any of the products. With this access, it can automatically select the regression variables that do the best job of improving each time-series forecast for each product. Note that the regression variables used may be different for each product.

The result is that the sales forecasters see a quantitative forecast—with the trend, seasonality, and regression effects identified—without going through the tedious process of trying different time-series techniques and regression variables for each product. The sales-forecasting system does this for them. Once the forecaster has specified accuracy criteria for time-series-technique selection and validation criteria for regression analysis, the forecaster trusts the system to
do the analysis. Supply chain managers using the forecasting system then can concentrate on what they do best—qualitatively improving the forecast generated by the system.

* Principle 7: Forecasters should tell the system which forecasts are important.*

Sales-forecasting systems can do the analysis of the forecasting techniques to use. However, forecasters still must tell the system which forecasts are the most important and which are not as important. In large and small companies alike, forecasting systems used for supply chain management make thousands of forecasts a month. Of these, the supply chain manager (and managers in other functional areas, as well) must specify which forecasts require further qualitative analysis and which can be used as direct inputs to supply chain planning without further analysis. It's important to remember that additional analysis will require a substantial time investment from both the forecaster and the functional manager.

*A well-designed sales-forecasting system has access to demand history for all of the products to be forecast.*

Effective sales-forecasting systems incorporate management-by-exception criteria that help the sales forecaster make this determination. These criteria help the forecaster determine how to forecast each product and identify the acceptable level of forecasting error for each product. The management-by-exception criteria consider:

- **Differing stages in the product life cycle.** The importance of forecasting, predictability of demand, and achievable forecast accuracy varies by product life-cycle stage.
- **Whether or not the product has a short shelf life.** The shorter the shelf life, the greater the product obsolescence due to forecasting error—and, hence, the more accuracy needed from the forecast.
- **The product's value.** More valuable products are more costly to hold in inventory, thereby increasing the inventory cost of forecasting error.
- **The customer-service sensitivity of the product.** The greater the sensitivity, the higher the customer-service cost of stockouts due to forecasting error.

- **The raw-material leadtime.** Different forecasting horizons, forecasting techniques, and forecasting accuracy levels are required for products whose raw materials can be procured in a matter of weeks compared to products with longer leadtimes.
- **The production leadtime.** As with raw-material leadtimes, production schedule leadtimes affect the forecasting time horizon, techniques, and accuracy required. How often the production schedule can be changed has a similar impact.

This management-by-exception approach dictates that management agrees on what constitutes an acceptable error level for every product to be forecast, consistent with the criteria enumerated above. Each product for which the system achieves an error rate lower than the acceptable level does not show up on the exception report. Any product for which the error rate achieved with time-series and regression analysis is greater than the acceptable level does show up on the exception report. The sales forecasters need to analyze these products qualitatively to improve sales-forecasting accuracy.

This does not mean that the sales forecaster cannot also analyze other products that are not on the exception report. It simply means that attention needs to be focused where it's needed most—on those products for which the system is not already achieving acceptable levels of accuracy.

**The Value for Supply Chain Management**

This article has enumerated seven principles of sales-forecasting systems, discussed within the context of supply chain management. By adhering to these guidelines, companies can more effectively select externally available sales-forecasting systems or develop one in house. In either case, the end result will be a sales-forecasting system that serves as a valuable tool for the sales forecaster and a source of improved decision making for the functional managers.

From a supply chain management perspective, improved sales-forecasting systems will provide more timely, accessible, and accurate SKUL-based forecasts over both the long and short term. The value of the long-term forecasts is improved input into:

- Planning facility size, design, and location.
- Planning transportation equipment needs (either through ownership, leasing, or long-term partnerships with transportation providers).
- Supply chain partnerships and long-term raw-material schedules.
- Long-term production-planning schedules.

The value of the short-term SKUL-based forecasts
An effective sales-forecasting system will lower the costs of inventory, production planning, and transportation. At the same time, it will raise customer-service levels throughout the supply chain. Implementing such a sales-forecasting system can sometimes be a formidable challenge. But the benefits of successful implementation will far outweigh the costs and effort expended. The seven principles presented here will go a long way toward assuring the success of that effort.

Footnotes


