Demand Shaping
Achieving and Maintaining Optimal Supply-and-Demand Alignment
Content for Demand Shaping: Achieving and maintaining optimal supply-and-demand alignment was provided by Vic Richard, a member of the Global Forecasting Solutions Practice at SAS in Cary, NC. Richard graduated from the US Naval Academy with a degree in naval operations analysis and earned MS and PhD degrees in operations research. He has had extensive experience applying the tools and techniques of operations research to improve decision making within the production and distribution areas of major corporations spanning many industries.
Introduction

The alignment of supply and demand is a fundamental issue for any organization that provides goods and/or services to a base of customers. The mantra “right product, right place, right time, every time,” which is often recited in supply chain discussions, goes to the heart of this alignment.

The degree to which the alignment of supply and demand can be achieved and maintained is critical to the success and profitability of a business enterprise. The demand side develops and continually refines a picture of “What can we sell?” The supply side performs a similar function, answering the question “What can we provide?”

When the available information indicates that the demand and the supply are no longer in alignment, the organization needs to develop an appropriate demand response. The development of this response is termed “demand shaping.” Our definition of this term includes the commonly accepted understanding but extends it to a significant degree: Demand shaping is the process that makes the most profitable demand-and-supply decisions by using all available demand-and-supply information.

Exercising the demand-shaping process requires the availability of sophisticated analytical tools to sense demand-pattern changes and supply anomalies, econometric models to address market response, optimization-based tools to develop and maintain an effective and efficient deployment of production and distribution assets, and scenario-analysis capabilities to evaluate alternative courses of action. Additionally, this approach requires an organizational culture amenable to analysis-based decision making.

Most organizations have, at the very least, basic capabilities in all the requisite areas. This is especially true if the organization follows a traditional sales and operations planning (S&OP) process. An organization that desires to implement the proposed demand-shaping approach may apply and extend the available capabilities. For example, the supply-planning component of S&OP will have a tactical production/distribution planning capability. This may be used to perform the feasibility checks that the demand-shaping process requires.

Figure 1: Demand-shaping process.
Sense-Interpret-Respond Architecture

The sense-interpret-respond paradigm is the ideal framework for a demand-shaping capability. The essence of this paradigm is that incoming signals from the underlying system are monitored for any deviation from the expected or norm. Once an anomaly or deviation is detected, the signals are interpreted to determine what type of system excursion is being presented. The necessary response is developed through the use of various analytical techniques.

Application of the sense-interpret-respond paradigm to the demand-shaping process is illustrated in Figure 2.

The sense function accepts incoming signals, usually in the form of KPIs and/or metrics from sales, marketing, customer service, manufacturing operations, distribution, and other departments or organizations positioned to monitor various aspects of the supply-and-demand alignment. The concept of data fusion has been applied with great effect in areas such as condition-based maintenance to improve the sensing function. Data fusion techniques combine data from multiple sensors along with related information from relevant databases. This technology set has improved accuracies and allowed more specific inferences than could be achieved by the use of a single sensor.

The role of the interpret function is to analyze the incoming signals from the sense function to determine if any deviations...
and/or anomalies have occurred. The techniques used to perform this function can range from examination of the basic KPIs and metrics to sophisticated pattern-recognition approaches.

When a demand/supply excursion is identified, it is the role of the respond function to determine the appropriate set of actions that will restore the overall system to the desired trajectory. The development of the required response will necessitate detailed analysis dependent on the type of excursion presented.

The type of analysis required can be grouped into two primary categories: investigation of the demand dynamics and investigation of the supply dynamics. The analysis of demand dynamics answers questions such as: “Can the demand for product ABC be increased?” and “What mechanisms should be used to achieve the desired increase in demand?” Analyzing the supply dynamics focuses on the ability of the supply organization to support the presented demand, which is a resource allocation problem.

The analytical tools and techniques used in each of the two categories are different. Econometric models, such as statistical forecasting and regression modeling, are used to analyze the demand dynamics, whereas optimization models are used to analyze the supply dynamics. The interaction between increasing and decreasing demand and the ability to support the desired levels is complex and must be looked at from a total profitability point of view.

**Sales and Operations Planning**

The sales and operations planning process is the mechanism that a manufacturing or consumer packaged goods (CPG) company uses to develop and maintain supply-and-demand alignment. It monitors the financial plan, the demand plan and the supply plan. The process provides the necessary review of the monitoring signals and the necessary analysis capabilities to identify a misalignment of the plans and prepare the remedial actions necessary to restore alignment.

The expanded definition of demand shaping, as proposed earlier, positions this process and its associated activities squarely within the realm of sales and operations planning. A typical sales and operations planning process is a structured, formal set of steps that is initiated on a fixed timetable. The incorporation of a sense-interpret-respond-based demand-shaping component has the potential to allow a more continuous approach.

There are multiple forms of plan misalignment that can occur. If the price we are getting for our products is below what was planned for, the financial results will be below plan even though the demand is materializing as planned, and production and distribution capacity is on target. Competitor actions or general economic conditions may result in the demand being below what was forecast. An unanticipated failure of a piece of equipment in the manufacturing network can decrease the productive capacity.

Each of the above situations, as well as many others, may cause the supply and demand to become misaligned. The ability to quickly identify a misalignment and rapidly develop a remedial response is crucial to the organization’s profitability. The techniques necessary to develop a viable response is dependent on the type of misalignment but can include econometric models, optimization models and simulation models. The broader definition of demand shaping that is being advocated in this paper requires the application of multiple technology sets to understand both demand dynamics and supply dynamics.

The sense-interpret-respond architecture introduced earlier may be specialized further, yielding a basic process to maintain supply-and-demand alignment that includes the expanded demand-shaping activity.

![Figure 3: Econometric and optimization models are used during the demand-shaping process.](image)
The financial plan, demand plan and supply plan are monitored for alignment. This may be carried out periodically as a part of the S&OP process or continuously, depending on the degree of automation currently implemented. When a misalignment is identified, an analysis activity is initiated. The intent of the analysis is to discover the underlying cause(s) and develop a set of remedial actions that, if undertaken, will restore the required alignment. The selected actions then are executed to restore the desired alignment.

The monitoring, analysis and execution loop illustrated in Figure 4 occurs in the context of three planning processes: financial planning, demand planning and supply planning. These are the three major planning processes that participate in sales and operations planning.

Demand planning is the process that determines the global demand for an organization’s products and services, and facilitates the decision as to what part of that demand the organization will attempt to acquire.

The major components of demand planning are:

- Forecast.
- Review.
- Analyze.
- Adjust.
- Propagate adjustments.
- Monitor.

These activities, along with data acquisition/preparation and presentation and reporting, are the basic components of any demand-planning process.

The demand-sensing activity is a specialized type of monitoring focused on the identification of near-term changes in the demand patterns. Owners are alerted if it is determined such changes have occurred in the process. This could trigger the demand-shaping process that has been the topic of this paper.

The set of activities across the top of the demand-planning diagram (Figure 5) represent activities that support and provide detailed input for the development of the demand plan. This includes the traditional demand-shaping activities such as market response modeling and promotions planning, as well as those that include both supply-and-demand considerations such as allocation planning and price/revenue optimization.

Supply planning is the process of determining the quantities of an organization’s products and services that are, or will be, available to meet presented demand. It requires the examination of systemwide inventory levels and the capacity for additional production and/or procurement.
Figure 5: The demand-planning process.

Figure 6: The supply-planning process.
The analytical models utilized in the supply-planning process have two primary roles. The first of these is the efficient and effective allocation of the organization’s resources that support the production and distribution of goods and services. The second is to project forward in time the availability of products, what is termed an inventory projection.

The basic classes of models utilized to support supply planning include:

- Production planning.
- Distribution planning.
- Procurement planning.
- Inventory requirements planning.
- Operations scheduling.

Once a detailed inventory projection capability is established, an available-to-promise (ATP) capability can be implemented. If the necessary plant-information systems are available, this capability may be extended to provide support for capable-to-promise (CTP) queries.

**Financial planning** is the process that determines how a business will afford to achieve its strategic goals and objectives. Usually, a company creates a financial plan immediately after the vision and objectives have been set. The financial plan describes each of the activities, resources, equipment and materials that are needed to achieve these objectives, as well as the time frames involved.

The financial planning process involves the following tasks:

- Assess the business environment.
- Confirm the business vision and objectives.
- Identify the types of resources needed to achieve these objectives.
- Quantify the amount of each resource (labor, equipment and materials).
- Calculate the total cost of each type of resource.
- Summarize the costs to create a budget.
- Identify any risks and issues with the budget set.

Demand shaping must be performed within the context of the organization’s overall financial plan. This will ensure that the decisions made with respect to increasing/decreasing demand and the allocation of resources will be in line with the business vision and objectives as well as maintaining global profitability.

Demand shaping requires the analysis of both the demand dynamics and the supply dynamics and the fundamental interactions between the two areas. The typical approach taken to perform this type of analysis is to exercise the econometric models to develop a set of demand options, and then use the optimization models to perform the resource allocation analysis. A scenario analysis framework is used to structure the analysis. This approach utilizes proven technology sets and is therefore immediately implementable, requiring only the development of the demand-and-supply models.

**Scenario Analysis**

Scenario analysis, sometimes referred to as what-if analysis, is an approach where a set of conditions and/or events (a scenario) is presented and the outcomes determined through the use of a mathematical/logical model. The outcomes are then usually compared to a baseline scenario. For example, we may be able to increase demand for a product through the use of a promotion program. The market response models indicate the demand lift that can be expected. A scenario would be developed, incorporating the implementation of the promotion program. The scenario would then be simulated and the results compared to the baseline.

The following diagram (Figure 7) illustrates the conceptual approach of scenario analysis. This type of analysis can be very simple, where one or two well understood parameters are modified and a deterministic model is run again with the modified parameters and the results are compared.
This approach is a natural extension of the able-to-promise (ATP) and capable-to-promise (CTP) approaches often used in order-promising applications. Both of these approaches attempt to answer the question “Can we satisfy this order?” by examining the availability of the required resources and the timing of other booked orders. This may be easily accomplished using either an existing tactical production/distribution planning model or a detailed operations planning model. The price/revenue optimization approach extends this concept, allowing an organization to answer an additional question: “Should we accept this order?”

The resulting optimization problems are much more complex, usually both nonlinear and mixed integer analysis. This will necessitate the development of new algorithms. Given the progress that has been made in the past few years with this class of problems (MINLP), a viable solution that will scale to industrial-size problems is within reach.

An organization that develops a demand-shaping competency will have a significant competitive advantage.
Enabling Technology

Data Acquisition and Preparation

The data necessary to support the sales and operations planning process and the demand-shaping activities embedded within it is necessarily complex, requiring large volumes of very detailed data. This data usually resides in several different information systems. Robust and capable information technologies are required to acquire this data and prepare it for the analytical models that are used to create the information to support decision making.
Analytics

The core of any attempt to support demand shaping is the set of analytical engines that allow the supply-and-demand dynamics to be explored. The interaction between supply and demand in real-world supply chain systems is complex. This complexity must be modeled using the tools and techniques of mathematics and statistics. Only then can the optimal supply/demand alignment be achieved and maintained.

In order to accomplish the full range of demand-shaping capabilities that have been discussed, capabilities must exist in three primary modeling areas:

- **Optimization models.** Optimization models are required to perform the task of global resource allocation.

- **Simulation models.** Simulation models are required to develop the inventory projection, account for the stochastic nature of demand and equipment failures, and to maintain the complex system state that exists in supply chain networks.

- **Econometric/statistical models.** Econometric models are required to investigate the nature of demand and the drivers of demand.

Presentation and Reporting

The analytic models that form the core of the architecture create large volumes of very detailed information. It is not uncommon for an integrated production/distribution planning model to have 500,000-plus variables. Presenting this information in a form that the decision maker can comprehend is an important part of the design and implementation of such a system. The needs and abilities of the levels of decision makers participating in the sales and operations planning process requires a powerful and flexible set of reporting tools. The required delivery forms run from simple alarms and alerts, standard reports and spreadsheets through ad hoc reporting, such as that delivered through OLAP cubes.

Conclusion

The concept of demand shaping has been extended beyond the notion of demand manipulation that is commonly accepted. Combining the analysis of both demand dynamics and supply dynamics yields a much more complete answer to the alignment of supply and demand. It was further shown that demand shaping is a logical extension to the S&OP process and a major function within the demand-planning process.

Two methods have been positioned that will give an organization the ability to exercise a more complete approach to demand shaping: scenario analysis and price/revenue optimization. Either method will give a manufacturing organization a significant competitive weapon.

A technical architecture was presented that supports all aspects of demand shaping, incorporating data acquisition/preparation, presentation and reporting of results, and the advanced analytical techniques necessary to support the required analysis.