2022

2022 LEARNING SYSTEM
VERSION 5.0

MODULE 1

SUPPLY CHAINS, DEMAND MANAGEMENT, AND FORECASTING

CSCP

CERTIFIED SUPPLY CHAIN PROFESSIONAL

APICS

ASCM ASSOCIATION FOR SUPPLY CHAIN MANAGEMENT

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APICS Certified Supply Chain Professional (CSCP) Learning System

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Certified Supply Chain Professional Learning System

Welcome to the Certified Supply Chain Professional (CSCP) Learning System. This course is divided into eight modules that correspond to the eight domains of the 2022 v5.0 CSCP *Exam Content Manual (ECM)*. The course has the following modules:

- **Module 1: Supply Chains, Demand Management, and Forecasting.** This module introduces supply chain management and addresses the demand management process, including forecasting and forecast error management. The operations planning and control process is illustrated, and then the module delves deeper into the consensus-building process of sales and operations planning.

- **Module 2: Global Supply Chain Networks.** This module helps supply chain managers design a supply chain network, including its IT strategy and tools and its methods of providing end-to-end connectivity and visibility. The module also addresses the importance of master data management and supply chain metrics.

- **Module 3: Sourcing Products and Services.** This module shows how to align sourcing activities with demand, such as by the use of make-or-buy analysis. Category strategies show how categorizing various types of supply reveals the vital few categories to manage. The supplier selection and purchase order processes are covered.

- **Module 4: Internal Operations and Inventory.** This module covers master scheduling, material requirements planning, and capacity evaluations. Inventory management discussions include replenishment strategies, traceability, and inventory accuracy. Operational and inventory management metrics are reviewed.

- **Module 5: Forward and Reverse Logistics.** This module addresses warehouse and transportation strategy development. It covers distribution services such as shipping and receiving as well as transportation mode and provider selection. Trade considerations such as import/export regulations and Incoterms® are then described. The module also covers reverse logistics and the waste hierarchy.

- **Module 6: Supply Chain Relationships.** This module addresses the importance of customer and supplier relationship management. These methodologies (along with related software) help transform the supply chain into a cohesive system that can provide real value from suppliers, through manufacturers, to customers (systems thinking).

- **Module 7: Supply Chain Risk.** This module represents the vital need of today's supply chains to be proactive and resilient in how they identify, assess, and respond to risks.
- **Module 8: Optimization, Sustainability, and Technology.** This module shows how to optimize and redesign the supply chain. It also covers sustainable supply chains and reviews emerging technology trends. It closes with advice on implementing new technologies in a way that promotes their success.

Module 1: Supply Chains, Demand Management, and Forecasting

The first module in this learning system starts with an overview of supply chain management. There is a discussion of the flows of product, information, and funds. Various levels of supply chain maturity are also addressed.

After this introductory material, the module gets into the daily processes of supply chain management, which starts with the customer. Forecasting and managing customer demand requires analysis of the organization's competitive environment using tools such as market research. Product assessments are then addressed, because it is important to validate that the right products and services are being offered given updated information from environmental scanning.

The process of influencing demand through marketing activities is then reviewed, including a discussion of the four Ps (product, price, place, and promotion) as well as product life cycles and product life cycle management (PLM).

Once these higher level planning processes are done, the next step is to build the forecast. Forecasting methods are reviewed so that supply chain managers will be familiar with the various methods as well as how to fine-tune the methods and evaluate whether they are reliable enough from a forecast error perspective.

Then the discussion turns to how to align supply with demand, which involves leveraging the sales and operations planning (S&OP) process. Since S&OP is one part of a larger process, this larger process, called operations planning and control, is also reviewed along with some of its subsets, such as master scheduling.

Section A: Introduction to Supply Chains

This section is designed to

- Describe fundamental concepts of supply chains and supply chain management
- Define and illustrate the supply chain in terms of entities, structures, and flows
- Differentiate between vertical and horizontal (lateral) integration
- Describe the stages of supply chain evolution globally and within companies.

Before getting into the details of supply chain management, it is important to take a step back and consider what a well-functioning supply chain should be able to accomplish for its constituents as well as to envision the lofty heights a superior supply chain can achieve.

Topic 1: Supply Chain Models

Supply chain models are useful because they simplify complex real-world supply chains and help them become more understandable. Here, we start with the most basic supply chain and then we discuss vertical versus lateral integration.

Basic Supply Chain

An organization's supply chain can have many forms. It can be a simple chain or a complex network or a structure that is somewhere between these two extremes. No matter whether it is a product or service chain, or what types of entities are involved, companies require their supply chains to guarantee a steady flow of supply at an acceptable cost. They can improve operating efficiency by employing the right supply chain structure.

According to the *APICS Dictionary,* 16th edition, a **supply chain** is a

> global network used to deliver products and services from raw materials to end customers through an engineered flow of information, physical distribution, and cash.

A supply chain, in this view, comprises a network of both entities and processes (the engineered flow). The massive chains that interest us in this course—the ones that run through corporations such as Walmart, Nestle, Boeing, Airbus, or Caterpillar—are decidedly global in scope.

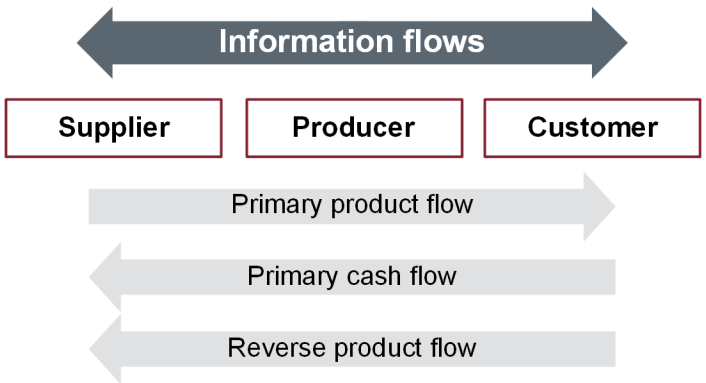
The *Dictionary* defines **supply chain management** as

> the design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand, and measuring performance globally.

(In this case, "globally" can mean either worldwide or the supply chain as a whole rather than to a particular entity within the chain.)

Exhibit 1-1 illustrates a very basic supply chain with three entities—a producer with one supplier and one customer.

Exhibit 1-1: Basic Supply Chain for a Product



Three Entities and Four Flows

The "entities" that perform the processes can be business or governmental organizations or individuals. They can also be departments or functional areas or individuals within a larger organization; there are internal as well as external supply chains. For the most part the model applies to corporations.

Most work on supply chains involves a manufacturing company in the middle (although service companies also have supply chains) with a supplier of materials or components on the upstream side and a customer on the downstream side. Technically, a supply chain needs only those three entities to exist; global supply chains have many more.

The simplified chain in Exhibit 1-1 might be made up of these organizations:

- A supplier, a provider of goods or services or a seller with whom the buyer does business, as opposed to a vendor, which is a generic term referring to all sellers in the marketplace. The supplier provides materials, energy, services, or components for use in producing a product or service. These could include items as diverse as fabric, aircraft turbines, electrical power, or transportation services.
- A producer that receives services, materials, supplies, energy, and components to use in creating finished products, such as dress shirts, airplanes, electrical service, or delivered products.
- A customer that receives shipments of finished products to deliver to its customers, who wear the shirts, lease the planes, turn on the lights, or receive the products.

Four basic flows connect the supply chain entities together:

- The **flow of information** back and forth along the supply chain (also back and forth within the entities and between the chain and external entities, such as governments, markets, and competitors)
- The **primary product flow,** including physical materials and services from suppliers through the intermediate entities that transform them into consumable items for distribution to the final customer
- The **primary flow of cash** from the customer back upstream toward the raw material supplier
- The **reverse flow of products returned** for refund, replacement, repairs, recycling, remanufacturing, resale, or disposal. This is called the reverse supply chain, and it is handled by reverse logistics, which involves different arrangements than the forward logistics that carried materials and products in the other direction. The reverse chain, like the forward chain, comprises information flows and cash or credits. Reverse flows can also refer to the flow and disposition of manufacturing or service waste.

The supply chain concept seems fairly solid when you consider the chain as linked organizations—supplier, producer, and customer connected by product, information, and payment flows. But the supply chain is more accurately viewed as a set of linked processes that take place in the extraction of materials for transformation into products (or perhaps services) for distribution to customers. Those processes are carried out by the various functional areas within the organizations that constitute the supply chain. When considered as a set of processes rather than a succession of companies, the supply chain becomes just a little more difficult to conceptualize.

Funds Flows

The flow of money in a supply chain goes upstream from customer to producer and from producer to supplier as intermediate or final products or services are paid for. This funds flow is not linear, since

some upstream payments may occur long before the final good or service is even purchased.

While the flow of funds is mandatory for a supply chain to exist, it is often an uncoordinated and suboptimized flow. Many mid-size and even some large corporations still work with paper invoices and checks. However, this practice appears to be declining given that many international transactions require the buyer to pay up front with a credit card, wire transfer, or letter of credit.

Why is it critical to improve the flow of funds within a supply chain? There are several advantages to better flows:

- The improved turnover of funds improves customer-supplier relationships through lower perceptions of risk, greater reliability, and better communications, which, in turn, tend to further improve the flow of funds. More prompt and consistent payments also tend to improve relationships, yielding a win-win situation throughout the supply chain.
- Improved cash flows tend to reduce imbalances between the larger and smaller players in the supply chain. Consistent rules for integrated cash flows across the supply chain help avoid the situation in which sizable retailers request more liberal payables terms from manufacturers and large manufacturers do the same with their smaller suppliers.

The cash-to-cash cycle time (also called the cash conversion cycle) is a key metric for measuring the efficiency of the flow of funds. It basically measures how long it takes for an investment of cash into operations to be returned in the form of cash receipts from sales to customers. Supply chain innovations have reduced cycle times in many ways, as is addressed throughout this course. For example, cross-docking keeps inventory moving instead of putting it in storage.

Value and Balance

Here are some other highlights of supply chain management.

- **Supply chain management is about creating net value.** Early efforts at managing supply chains often focused only on cost reduction—on making the chain leaner. Unfortunately, these efforts sometimes reduced the ability to create value more than they reduced costs, for a net negative effect. As we'll see, there's more to creating value than simply squeezing costs out of the supply chain.
- **There should be value-creating activities in the supply chain that transcend the activities of particular entities in the chain.** Supply chains are generally organized by one strong company—a channel master or nucleus firm such as a manufacturer, a designer and patent owner, or a powerful retailer—which often manages the overarching value-creating activities. Nevertheless, the chain has to produce value for each stakeholder in addition to generating value for consumers or investors. (The *APICS Dictionary,* 16th edition, defines **stakeholders** as "people with a vested interest in a company, including managers, employees, stockholders, customers, suppliers, and others.")

- **Managing supply chains requires balancing competing interests.** Given the complicated nature of group dynamics, this can be a challenging task, especially in global supply chains. Consider the rivalries that arise among the American states, the nations in the European Union, and the diverse cultures around the globe.

Many Variations

There are many variations on the basic supply chain model presented so far. Here are some basic points to keep in mind:

- A supply chain involves, directly or indirectly, everyone and everything required to extract or harvest materials, transform them into a product, and sell the product to a user.
- Supply chains include various entities, such as raw material extractors, service and component suppliers, a material product manufacturer or a producer of services, distributors, and end customers.
- Supply chain structures vary based on demand history, business focus, and needs for connectivity, technology, and equipment.
- Supply chains can be viewed in terms of processes, such as the gathering and processing of marketing data, distribution and payment of invoices, processing and shipping of materials, scheduling, fulfillment of orders, and so forth. Such functions cut across entities.
- Supply chains include various flows as well as various entities. Materials and services flow from suppliers toward customers; payment flows from customers toward suppliers; information flows both ways. Materials and funds also run in reverse.

Supply chain expertise is so important in today's business world that Gartner conducts an annual survey to identify the top 25 supply chain leaders. Check the online Resource Center for a link to these survey results and to see which companies are top-ranked for their supply chain management expertise.

Vertical vs. Lateral Integration

Companies have generally pursued one of two types of supply chain management, called vertical integration and lateral (or horizontal) integration.

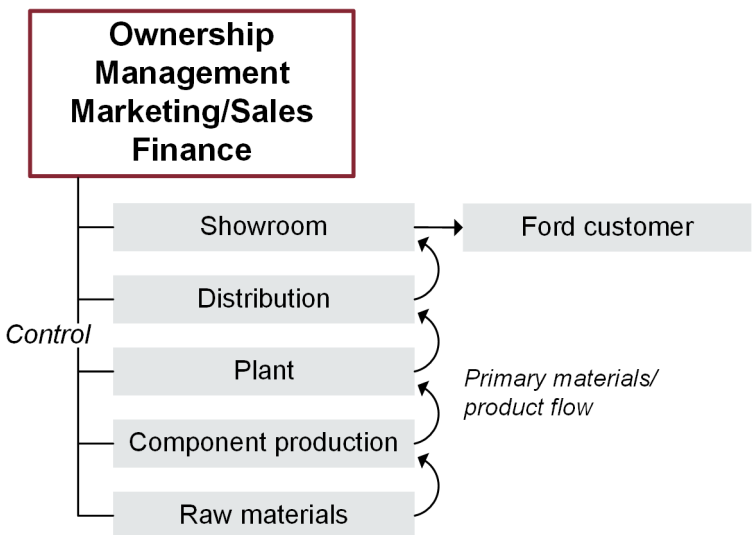
Vertical Integration

Vertical integration, or vertical supply chain management, refers to the practice of bringing the supply chain inside one organization. An example is a paper company that owns its land and trees, replanting for future harvests, owns the related equipment it uses, and manages all of its product processing, palletizing, and shipping. (The company purchases only its chemicals from an outside source.)

A vertically integrated enterprise may grow from an entrepreneurial base by adding departments and layers of management to accommodate expansion, or it may be built through mergers and acquisitions to acquire more supply chain capabilities. In an attempt to create a self-sufficient enterprise, Henry Ford owned iron ore mines, steel mills, and a fleet of ships as well as manufacturing plants and showrooms.

Exhibit 1-2 illustrates the vertical integration of a supply chain.

Exhibit 1-2: Vertical Integration/Supply Chain Management of Henry Ford



The primary benefit of vertical integration is control. A department or wholly owned subsidiary with no independent presence in the marketplace can’t work with competitors. Its operations are completely visible to the parent company (at least in theory) and can be synchronized with other company functions by directives from the top. Its schedules, workforce policies, locations, amounts produced—all aspects of its business—are controlled by the overarching management.

By bringing many supply chain activities in-house and putting them under corporate management, vertical integration solves the problem of who will design, plan, execute, monitor, and control supply chain activities. It can also be used to address supply risks. For example, while McDonald’s doesn’t directly own its upstream supply chain, it has dedicated long-term supply contracts with numerous

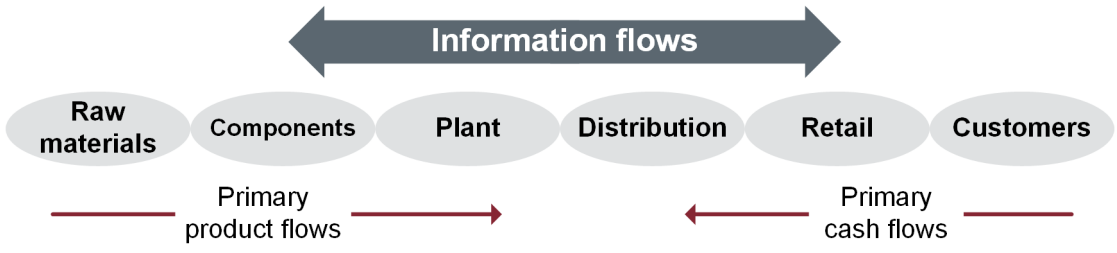
farms, processing facilities, and other suppliers to ensure availability of sufficient quality and quantity of supply at a fair price. Its supplier contracts use a “vested interest model” to ensure that the suppliers are motivated to create value for McDonald’s because doing so helps them profit appropriately themselves. Downstream, McDonald’s owns the land upon which all of its retail sites sit and operates as a landlord to what are primarily franchised facilities. This omits independent landlords and provides significant rent revenue. While it is not strictly a vertically integrated supply chain, McDonald’s has been heralded as a modern vertical integration success that can exercise a great deal of control over its supply chain partners and especially over control of processes. Ikea and Shell have similar partial vertical integration.

While the vertical structure is still in use at least in some form for certain aspects of many supply chains, it is very challenging to be fully integrated end to end.

Lateral (Horizontal) Integration

Exhibit 1-3 shows a lateral supply chain.

Exhibit 1-3: Lateral (Horizontal) Supply Chain



It’s difficult for one corporation to garner the expertise needed to excel in all elements of the supply chain, and it increases their risk, so corporations around the globe have turned to outsourcing those aspects of their business in which they judge themselves to be least effective. In this lateral integration, an organization specializes in its core competencies and relies on other specialists for the rest of the supply chain. Corporate ownership loses control of the outsourced activities and deals separately with members of the chain as suppliers or customers. Each will focus on their core competencies, such as extraction or production, and do business with each other through discrete transactions or longer-term contracts.

For example, Ford divested itself of the production of many components, as Chrysler Corporation shed its Mopar (motor parts) division and General Motors divested its component supplier as a separate organization, Delphi Corporation. The same organizations might then expand laterally, for example, by investing in their competencies or merging with direct competitors.

Lateral integration has replaced vertical integration as the favored approach to managing complex supply chains. This horizontal approach is assumed in most supply chain illustrations, including the

ones featured so far in this text. Lateral chains are now the way of the world and, therefore, the major focus of supply chain theory and application.

Some Japanese companies favor an intermediate form of integration called keiretsu. The *APICS Dictionary,* 16th edition, defines **keiretsu** as

> A form of cooperative relationship among companies in Japan where the companies largely remain legally and economically independent, even though they work closely in various ways such as financial backing. A member of a keiretsu generally owns a limited amount of stock in other member companies. A keiretsu generally forms around a bank and a trading company, but “distribution” (supply chain) keiretsu alliances have been formed of companies ranging from raw material suppliers to retailers.

Among the reasons for relying on a lateral supply chain, the following stand out:

- **To achieve economies of scale and scope.** No matter how large the corporation, its internal supply chain functions lack economies of scale when compared with the potential capacity of an independent provider of the same product or service who can have numerous clients to support those larger economies of scale. Moreover, a specialist organization can increase its market share by internal growth or grow through lateral mergers with direct competitors or other organizations who have complementary core competencies.

- **To improve business focus and expertise.** Vertical integration, in a globally competitive market, multiplies the complexity of managing disparate businesses spread across international borders, time zones, and oceans. The independent company that focuses entirely on its particular business can develop more expertise than an in-house department, leading to more attractive pricing, higher quality, or both.

- **To leverage communication and production competencies.** Today many of the barriers to doing business at a distance have been reduced or minimized. Nearly instantaneous communication means that information can be shared simultaneously by videoconference or in internal organization web boards or chat rooms. There are advantages to using already established companies that know their local markets. Many clothing companies in Europe, for example, work through Dutch logistics centers to take advantage of Holland’s central location and because a number of specialized companies exist there with well-developed capabilities in handling both the distribution and the return of clothing.

Despite the benefits of the lateral supply chain, however, synchronizing the activities of a network of independent companies can be enormously challenging. What each company gains in scale, scope, and focus, it may lose in ability to see and understand the larger supply chain processes.

Topic 2: Supply Chain Maturity and Complexity

Supply chain maturity refers to the level of integration and coordination with supply partners relative to those of competing supply chains. Organizations that want to create value from their supply chains need to determine their current state of supply chain maturity, their desired state, and how to close the gaps between the two. Understanding the possible levels of supply chain maturity will help with this analysis. After presenting these discussions, some examples of supply chain complexity are addressed, starting from very simple supply chains and adding layers of complexity.

Stages of Supply Chain Management Evolution

The advances made over the past few decades in supply chain management are generally reflected in each supply chain's development. Experts in the field agree that there are typically between four and five stages in this development. The various stages can go by many names. We'll use a five-stage model of supply chain management evolution:

- Stage 1—multiple dysfunction
- Stage 2—semifunctional enterprise
- Stage 3—integrated enterprise
- Stage 4—extended enterprise
- Stage 5—orchestrated supply chain

Many organizations made these leaps over time as computers and cultures progressed. However, an organization in a particular industry may have been sheltered from some of these changes and may be less advanced than another. Also, some small and midsize organizations may be at a lower level than their larger peers due to a lack of resources for improvements. Finally, an organization might believe it is in the highest stage but could actually have slipped down a notch through complacency. Therefore, these stages can also be seen as being relative to the capabilities of competing chains. Some enterprises are likely to exhibit behaviors from two or more phases of maturity, as this is an evolution, not a specific end state.

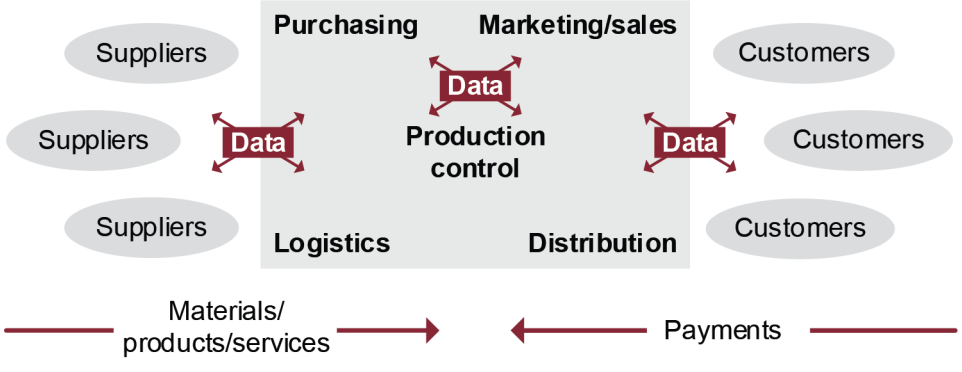
Early in the evolution of the supply chain, many organizations operate in a stable chain with predictable supply and demand. In a stable supply chain, costs are low due to predictable demand and minimal need for changes. Production runs can be long, and few line changes will be needed. This is the model that used to hold true for many industries, especially those that were regional and had only regional competitors, but as globalization and technology have connected the world, fewer and fewer industries have this level of stability. Since most industries are no longer predictable, most immature supply chains begin in Stage 1, as described below.

Whether the supply chain ownership strategy rests on vertical integration, lateral integration, or a hybrid, the relative sophistication with which the chain is managed develops along a continuum that we have divided into these stages.

Stage 1: Multiple Dysfunction

It's possible for the nucleus company in a lateral supply chain to lack any disciplined management for both its internal and external chains; it may lack clear internal definitions and goals and have no external links other than transactional ones. Exhibit 1-4 illustrates the lack of coordinated flows of information or solid relationships among potential partners.

Exhibit 1-4: Multiple Dysfunction



This is a **reactive** supply chain:

- It fulfills demand but without much concern as to costs.
- It is perceived as a cost center.
- It needs minimal competitive or connectivity technologies and capital assets to respond to demand.

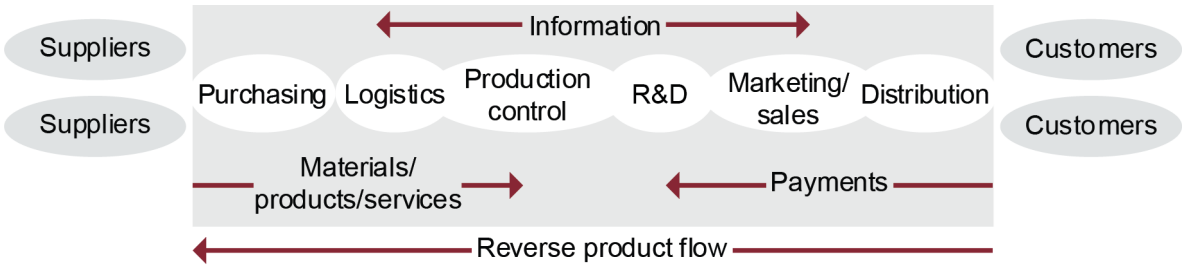
In the dysfunctional organization, this is what tends to happen:

- Internal activities tend to be undertaken ad hoc rather than by plan.
- Management provides only the most general sense of mission, communicated perhaps by pep talks at best or threats at worst.
- Forecasting tends to be mostly guesswork, often inflated by unwarranted marketing optimism.
- Products are designed without advice from other areas that could provide guidance, such as manufacturing or marketing.
- Warehouses are sited near each market, stocked with an overabundance of inventory in anticipation of a big sale, and staffed with manual laborers who have little training.
- Trucks or trains are unloaded when they arrive and loaded when an order comes in, without much advance warning in either case.
- There may be payment flows (but collection may be poorly executed) as well as material flows, but the information exchange tends to be tied mostly to giving orders internally, accepting bids, and sending invoices.
- Material requirements planning (MRP) takes place at a basic level, involving a bill of material, a master schedule, and current on-hand/on-order data.
- Purchasing is ad hoc and transactional. There may not be preferred suppliers or they may not be consistently used. Purchasing may not consult with logistics at all.

Stage 2: Semifunctional Enterprise

Exhibit 1-5 provides an illustration of the semifunctional enterprise. Information flow has been improved and functional areas have been defined—but they tend to perform their functions one after the other without collaborating on the most effective ways of creating value. At this stage, there are no partnerships with customers and suppliers.

Exhibit 1-5: Semifunctional Enterprise



This is a **reactive efficient** supply chain:

- It supports competitive positioning by serving as an efficient, low-cost, and integrated unit.
- It focuses efficiency and cost management on the total delivered cost of finished goods.
- It places greater importance on connectivity technology and new equipment to automate functions to reduce labor costs and improve capacity and throughput.

In this second stage of supply chain evolution, an individual company undertakes initiatives to improve effectiveness, efficiency, and quality in specific functional areas. Here are some examples:

- The largely manual operations in warehouses may be augmented by the addition of basic materials-handling equipment.
- Inventory management may find ways to reduce levels of inventory within the company's own facilities.
- Procurement might take advantage of new purchasing strategies to obtain supplies and services at the lowest possible prices.
- The traffic department may reduce transportation costs by strategic selection of carriers and routes.
- Some departments may institute more effective hard skills training and adopt strategies for making jobs more challenging.
- Marketing may develop more reliable research and forecasting techniques.
- Manufacturing resource planning (MRP II) software may be in place, and the company may have cross-functional integration of planning processes.

While some or all functions engage in initiatives designed to increase efficiency within their departmental walls, there is little or no overlap in decision making from one department to another. When the nucleus company concentrates only on improvements within its separate departments, it may find its efforts wasted through lack of communication. For example, market researchers and well-trained sales representatives may uncover market opportunities among current and potential customers without being provided an opportunity to share this information in a structured collaboration with product designers. And this lack of collaboration may play out repeatedly among the departments. In this stage some functions may be automated—MRP software, for instance, may include bills of material as part of online workflow. But new software in one department may be incompatible with software in other areas. Mergers and acquisitions can also result in incompatible systems.

Stage 3: Integrated Enterprise

In the third stage of supply chain evolution, the individual company begins to focus on companywide business processes rather than individual compartmentalized functions. Historically, this shift in supply chain strategy is associated with the late 1980s and early 1990s—when computers were becoming powerful and affordable.

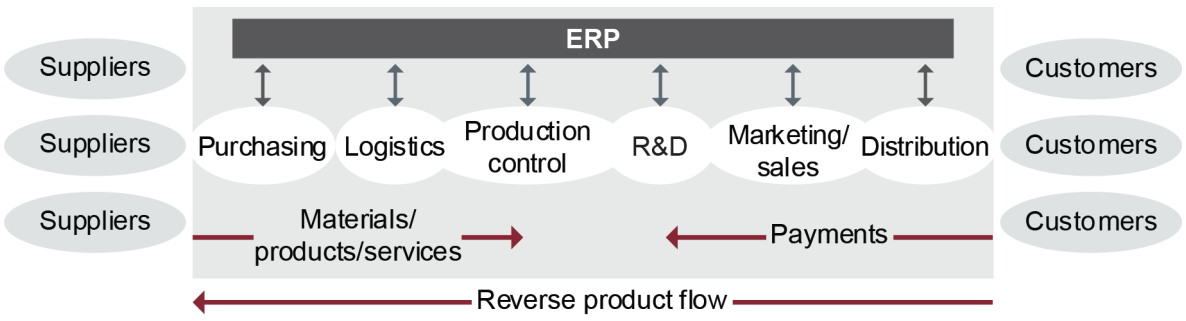
Milestones of this phase include introduction of manufacturing and enterprisewide software, increased cross-functional communication and training, centrally located and easily accessible databases and files, and periodic sales and operations planning meetings attended by representatives for all departments involved.

This is a **proactive efficient** supply chain:

- It proposes new raw materials or product designs to lower complexity and costs.
- It instigates changes to product designs for greater efficiencies.
- It invests in integrated information systems to facilitate sharing of information across functions.

Exhibit 1-6 provides a visual representation of a linked internal supply chain with collaboration between functions and sharing of information through companywide enterprise resources planning software (ERP).

Exhibit 1-6: Integrated Enterprise



This stage is markedly different from the previous one because of the following:

- The focus on business processes is facilitated with the increased availability of electronic communications, file transfers, powerful databases, and enterprisewide software applications. Cross-functional cooperation becomes much faster and easier and takes place almost instantaneously across functions, time zones, and international boundaries.

- A variety of initiatives reduce the time it takes to get an order from a supplier, create the product, and deliver it to the customer, including MRP II and ERP:
  - MRP has been upgraded to MRP II, a breakthrough development that allows cross-functional communication between manufacturing and finance.
  - ERP extends that process by adding modules for each functional area until the most advanced versions tie together entire companies. Further advances have reached through the corporate wall to tie supply chain partners together.

- Product design in some companies is now a team effort in which production engineers and other stakeholders, such as marketing and purchasing, collaborate with design engineers to “design for manufacturability,” “design for logistics,” or “design for the environment.” This approach results in products that are on target for customer desires and are ready to be manufactured without making costly modifications in processes, equipment, or staffing.
- There are improvements in customer service due to astute segmentation of markets and more efficient replenishment policies suited to each segment.
- Inventory is treated more strategically as Just-in-Time procedures, more accurate demand planning, and improved logistics work together to make fulfillment more efficient and reliable.
- Warehousing and transportation decisions are carried out in tandem to achieve the optimal balance of cost-effectiveness and customer service.
- Warehouse management benefits from more advanced equipment and automation.

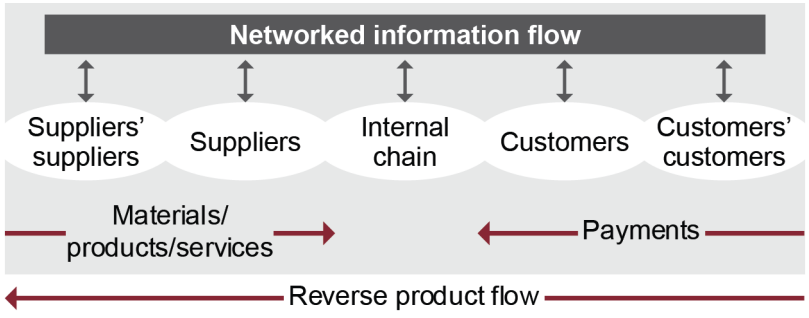
At this point, the nucleus company may begin to take a step toward integration with the external members of the supply chain by contracting with a logistics supplier, such as United Parcel Service (UPS), to “insource” by using its expertise to help optimize logistics decisions.

Stage 4: Extended Enterprise

The hallmark of this stage is the decision to extend at least one business process beyond the boundary of the individual corporation. When the nucleus company decides to collaborate on planning, design, replenishment, logistics, or another business process with one of its suppliers or customers, the barrier to developing the extended enterprise from end to end of the supply chain has been overcome. The company integrates its internal network with the internal networks of selected supply chain partners to improve efficiency, product/service quality, or both. The starting point is generally one inside/outside partnership that points the way toward the completely networked enterprise.

Exhibit 1-7 shows how the supply chain has changed.

Exhibit 1-7: Extended Enterprise



This is a **strategic driver** supply chain:

- Demand generation and fulfillment are fully integrated.

- The supply chain contributes to development of the organization’s overall strategy.
- Forecasting, planning, and replenishment are fully integrated and visible.
- Technological improvements, knowledge, and real-time information are shared with chain partners.

What is unique to this stage is the following:

- There is an initial exploratory collaboration between a channel master and one or several partners in the supply chain—often a manufacturer and one component supplier or a retailer and one supplier of finished goods. It may involve only one component or product; the famous collaboration between Procter & Gamble and Walmart began with diapers. If this first collaboration succeeds, it can lead to a more fully networked relationship between the first two partners—more products might be involved, there might be more complete sharing of information across integrated electronic networks and more formal team building and planning across corporate boundaries, and so on. And that relationship can become the model for other partnerships and, eventually, for multicompany collaborations that stretch from retailer through manufacturer into one or more tiers of suppliers.

- Technology enables the extended enterprise to reach farther, to add new partners, to move faster in response to market changes, and to operate with broader scope than in Stage 3. With MRP II merged with other functional applications and transformed into ERP, enterprisewide planning software is able to link the entire internal supply chain together on one platform.

- The networked enterprise is built on a variety of networking platforms. Partners begin to synchronize their ERP systems across corporate boundaries so they can share data as necessary for their efficient collaboration. A retailer may send information from the point of sale to suppliers each time a customer purchases an item to trigger production of a replacement. For example, Dell Computer is able to fill internet orders without keeping its own inventory because customers’ specifications are sent immediately through to component suppliers so the computer can be assembled to order.

- Cross-functional approaches are implemented with certain processes, such as CPFR (collaborative planning, forecasting, and replenishment). In place of traditional “silo” production planning by sales, marketing, and production, Stage 4 companies institute periodic sales and operations planning meetings in which representatives of sales and marketing, production (or operations), and other functions meet to coordinate demand planning and production scheduling.

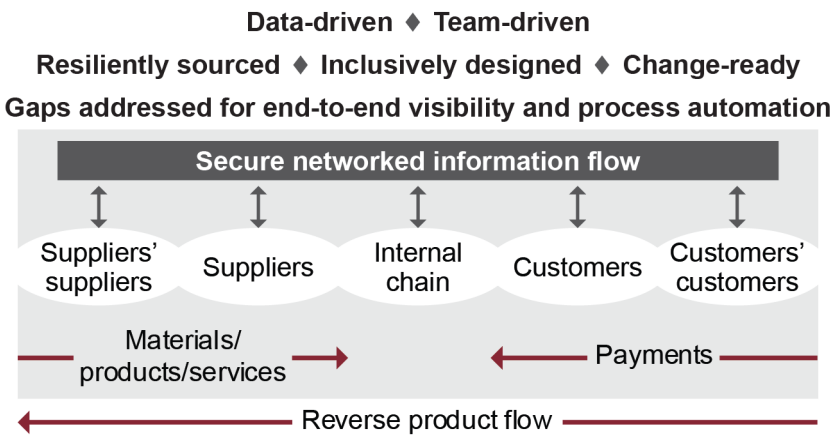
- In Stage 4, there are advances in e-commerce such as interactive sites where customers can order products and services, track their shipment, and communicate with customer service immediately upon their arrival. Behind the scenes of such business-to-consumer e-commerce, there is also increasing business-to-business e-commerce taking place on wired and wireless networks. In the global arena, competition no longer takes place only among individual companies; whole supply chains are now battling one another for customers, for workers, and for capital in multiple countries across the globe. Cooperation among companies is integral to competition among supply chains.

Stage 5: Orchestrated Supply Chain

The orchestrated supply chain level of supply chain maturity is often expressed as the supply chain digital transformation; in Europe it is sometimes called Industrie 4.0. This stage is all about realizing the benefits of all of the individual improvements in the different parts of the supply chain. More so than any of the prior stages, this stage is relative to the capabilities of competing supply chains. A supply chain is truly in this stage only when it realizes an actual competitive advantage from becoming better orchestrated than its competitors. Orchestration requires more than just seamless technology; it requires skilled leaders and teams who can leverage these technologies and adapt quickly to change. Therefore, supply chain digital transformation requires maturity in a number of areas for all significant parties in the supply chain.

Exhibit 1-8 shows how the core model of the supply chain is mostly the same as the prior level but with more emphasis on security, resilience (i.e., building in risk management), value realization, and orchestrating people and processes.

Exhibit 1-8: Orchestrated Supply Chain



This is a **consistent and systematic** supply chain:

- Improvement and change management teams are cross-functional and are both technically and socially skilled.
- Change management and readiness is a common skill and value.
- Data has integrity, is secure, and is actually used in decision making.
- Technology gaps are being resolved to realize end-to-end visibility.
- Sourcing is right-sized but resilient (quickly adaptable).
- Product designs are inclusive, and the number of products is right-sized.
- Processes are shared, policies are enforced, and automation is common.

It is essential that the teams who will be closing technology or social gaps be cross-functional among key supply chain partners and have multiple layers of expertise. Strong leadership and the right contributors drive the needed changes. A common area for needed relationship improvement is with IT professionals. These relationships sometimes have suffered because prior initiatives have failed to realize the envisioned benefits. Also, IT professionals may have become too reactive (i.e., putting out

fires) and need to be given the resources to be more strategic. However, IT relationship building is especially needed because the advances in connectivity with partners creates more avenues for cyber attacks that IT will need to address comprehensively. Also both technical depth and breadth are needed to determine technology gaps or how to make use of the latest technologies such as blockchain.

This people- and process-based transformation requires organizations and their partners to embrace change management. Change management is built into the organization's culture and perhaps its organizational structures. People embrace change because they have become accustomed to it and because they receive the support they need. Organizations embrace change because they will share in the benefits of the change.

The digital transformation goes way beyond simple digitization of trade documents or even digitalization of control systems such as remote sensors triggering an automated response. The digital transformation takes these advances a step further, such as by ensuring that electronic documentation travels seamlessly among supply partners, trade intermediaries, and customs authorities. Demand data from customers may feed directly into not only finished goods planning but also raw materials and suppliers' planning systems. Digitalized control systems are moved from being locally controlled to being controlled remotely and centralized such as by using a control tower.

Data on supply chain inventory and assets is truly real-time, and it feeds directly into decision-making tools and predictive analytics (e.g., predictive maintenance scheduling). Things that require little or no human intervention are fully automated. However, before they are automated, the process itself is reviewed to ensure that it is efficient and is intuitive for end users.

Product development is a key beneficiary of data-driven decisions, resulting in products that reflect actual customer requirements while also being designed for the supply chain, for sustainability, and so on.

Supply Chain Maturity as an Input to Strategy

Evolved and sophisticated supply chains in the higher stages have network partners with highly integrated and synchronized connectivity that focus more on creating net value than on pure cost minimization.

The goal for a supply chain strategy is to assess if there are gaps that are keeping the supply chain from fully realizing connectivity and visibility goals. After such gaps or misalignments have been resolved, it is important to continually monitor supply chain maturity, since there is no end to this process. Reassessments may be needed after major reorganizations, mergers and acquisitions, or changes in the external environment.

Supply Chain Examples

Consider, as a stripped-down supply chain model, a street vendor who sells snacks. This could be fresh crepes in Paris, hot dogs in Washington, D.C., or small tapas plates in South America. These may be small family businesses.

The supplier is probably a small wholesale food distributor that sells basic ingredients to many food kiosks. The worker is the “producer” who turns the raw ingredients into menu items. The stand, operated by one or two owners, is the retailer.

Notice that even in this simplest of supply chains, the actual situation is more complex. For instance, there are more suppliers. Tap water to warm the stainless steel food containers comes from a government entity. Nearby is a food preparation area with refrigeration; electricity is provided by another supplier. There is also the supplier of the cart or food truck itself. Somewhere in the supply chain, though they remain invisible in our model, are the suppliers’ suppliers, who bring materials, components, or services to the food wholesaler and the utility companies.

Even the flows in a street vendor example aren’t simple. The product flows include ingredients, paper and plastic products, and products used in the manufacturing process such as fuel. Information flows include orders submitted by end users (consumers) of the product, by the distributor (the person on the street with the cart) to the manufacturer (the cook), and by the manufacturer to the suppliers. Planning will include recipes and shopping lists, discussions of potential demand, and reviews of last year’s results. The flows of cash may be based on cash register and credit card receipts.

Cash travels in several separate flows from the manufacturer to suppliers of products and services and, of course, to any lenders or investors for debt or dividend payments. There are also logistics concerns: transportation from one entity to the other—perhaps drawing upon the private fleet of a car or two—as well as warehousing decisions. And, finally, reverse flows are used to return any unacceptable menu items, to compost the food waste, and to recycle.

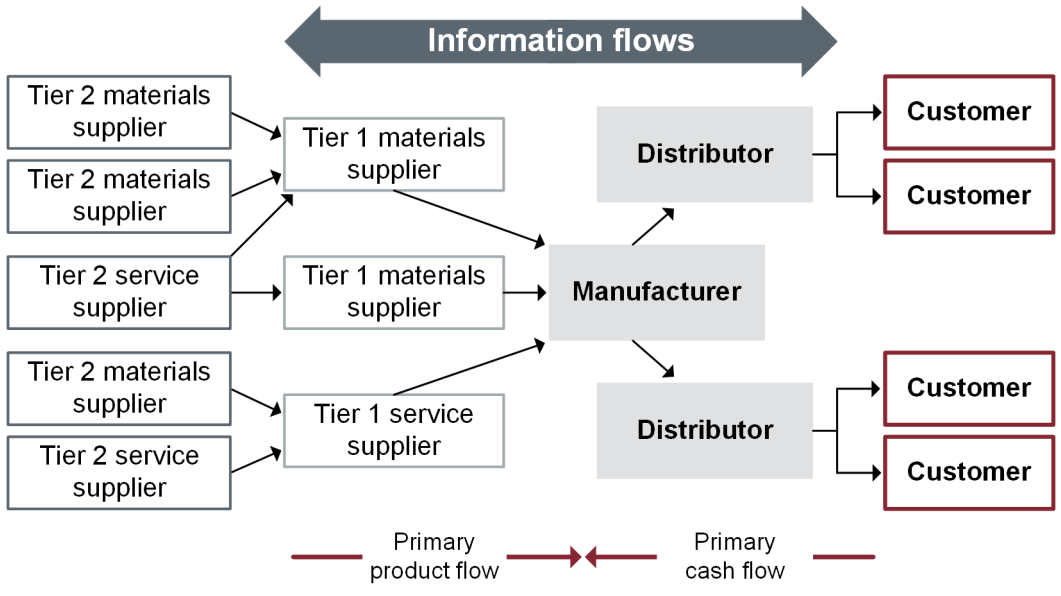
Many global businesses had very humble beginnings. Perhaps the food vendor comes up with a new recipe for crepes; a customer is impressed and asks if the vendor can make 50 crepes for a lunch; someone at the lunch owns a neighborhood restaurant… and before long the vendor has space in a small commercial kitchen facility and a catering business. It’s surprising how many challenges and opportunities can be anticipated in a very simple model.

Now let’s get a little more complex. Illustrations of manufacturing versus service supply chain models follow. After that there is a discussion of specialized supply chains.

Manufacturing Supply Chain Model

In Exhibit 1-9, two tiers of suppliers and distribution centers and customers are shown.

Exhibit 1-9: Manufacturing Supply Chain Model



Discussions of supply chains typically put manufacturing at the center and suppliers of components to the immediate left. These days, the nucleus firm may actually be a designer of products and a decision maker who outsources all manufacturing. Alternately, it may be that component suppliers are the most crucial consideration when designing and managing a supply chain for manufactured products, but utilities and other services are important contributors to the cost of operations.

The exhibit shows that Tier 1 suppliers have their own suppliers in Tier 2. The wholesale food distributor that supplies the daily ingredients and raw materials for the menu items has its material and service suppliers—and they have their suppliers, and so forth. The flour for the crepes, for instance, is not a raw material but a product with its own supply chain that begins in a farmer's wheat field and is processed in a plant, shipped to a wholesaler, and distributed. No matter how far you travel toward the left, you will never run out of new tiers of suppliers.

Even a raw material extractor, such as a coal mine, has its own suppliers of extraction machinery and services. In fact, the coal mine may ship coal to a generating plant that supplies power to the manufacturer that produces a machine that is shipped to a distributor that sells mining equipment to the same mine that began the process; supply chains can double back on themselves. (A distributor is a business that does not manufacture its own products but purchases and resells these products.)

Service Industry Supply Chains

According to the *APICS Dictionary,* 16th edition, a company in the **service industry** is

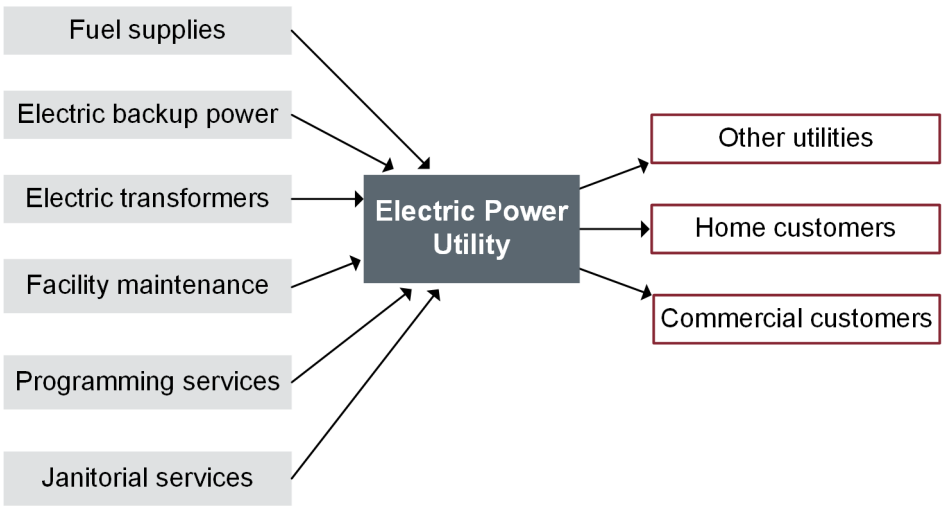
> 1) In its narrowest sense, an organization that provides an intangible product (e.g., such as medical or legal advice). 2) In its broadest sense, all organizations except farming, mining, and manufacturing. Includes retail trade; wholesale trade; transportation and utilities; finance, insurance, and real estate; construction; professional, personal, and social services; and local, state, and federal governments.

In the case of our food vendor, services most obviously include utilities, transportation, warehousing, carpentry, and cleanup, among others. Utilities, which are suppliers to all manufacturers, are crucial

considerations when locating plants and warehouses. If water and electricity (or natural gas, or both) are not available at a proposed site, they cannot be readily made available.

Service-oriented supply chains also require sophisticated management. Exhibit 1-10 illustrates, in simple form, the supply chain of an electric utility. It receives products, services, and supplies of its own and dispenses its services into three distribution channels: home customers, commercial customers, and other utilities.

Exhibit 1-10: Electric Utility Supply Chain



Specialized Supply Chains

Service industries are included in the category of specialized supply chains, as are humanitarian and disaster relief, nonprofits, and retailers. Other supply chains that might be considered specialized are industry-specific, virtual or e-business, or small- or medium-size companies' chains. Maintenance, repair, and operating supplies (MRO) might also be considered an example of a specialized supply chain.

If your organization is running one of these types of supply chains, learning how it differs from the large design- and manufacturing-oriented supply chains described elsewhere in these materials is critical. However, even if a supply chain manager doesn't operate a specialized chain, studying these supply chains can help him or her learn from the experiences of the chains. Here are some examples:

- A humanitarian and disaster relief supply chain has to be developed quickly yet be resilient against theft, misappropriation, and transportation mode disruptions. Since organizations that provide humanitarian aid and disaster relief are continually operating in an environment filled with uncertainty, they learn to maximize responsiveness. They become agile in operating a supply chain where supply and demand are routinely unbalanced, where demand can spike quickly, and where roads, electricity, or the full rule of law may be compromised. One way they stay agile is by developing ongoing relationships with persons in the community that they can trust. For example, the charity Feed My Starving Children distributes food to children in poor regions as well as to regions recovering from natural disasters. It develops personal relationships with local charities that handle the final distribution of food to those people who need it most.

- For hospitals (considered a service industry), cost cutting is vital, but the primary goal must always be safe and effective provision of patient care. To this end, visibility and quality are strongly emphasized. Supply chain costs are a significant expense for hospitals. To manage these costs, hospitals are working to ensure that the right level of inventory is kept on hand to avoid shortages while also avoiding carrying too much perishable inventory (e.g., past its expiration date). Automating ordering and validating that actual prices match contract prices also help control costs. Hospitals are investing in keeping databases clean and up to date. They use unique device identifiers (UDIs), required in the U.S. since 2014, to improve tracking and billing accuracy. From a quality perspective, administrators are looking at best outcomes over lowest cost for devices, which often shortens hospital stays and thus reduces total costs.

  Shortages caused by the COVID-19 pandemic have been addressed in a number of ways, including by centralizing supplies of critical resources to provide risk pooling and centrally coordinating information on available beds, respirators, and even trained staff resources. This information sharing occurs in some cases not only with government services but also with competitors. Hospitals can work not only to alleviate current bottlenecks but to also forecast potential new bottlenecks in the weeks ahead so they can plan rather than just react. They are also being proactive in carefully scheduling patient services that have room for delays in order to reduce the volatility of demand on the system.

- Today’s retailers are under tremendous pressure to redesign their supply chains to compete against online retailers like Amazon, who is putting huge cost pressures on retailers with its world-class supply chain. For example, Amazon has so many distribution centers that most orders are shipped within just one shipping zone, while most multichannel retailers have to ship through more zones at a higher cost. From an inbound freight perspective, Amazon picks up most supplier items itself using its own transportation network, while most multichannel retailers pick up less than half of items themselves. From an inventory perspective, Amazon’s distribution centers (DCs) keep the top-selling items in every DC and unevenly distribute the rest to reduce inventory holding periods; this, plus integrated track and trace, significantly reduces inventory holding costs. Most multichannel retailers have DCs designed for cross-docking. This works well for retail efficiency but not for online order fulfillment, because a key purpose of cross-docking is to create full-truckload assortments for retailers while online orders consist of multiple individual parcels.

When redesigning their organization’s supply chain strategy, retailers need to think big and not only close the gaps that keep their supply chains from being less efficient than those of online-only retailers but also become an effective multichannel option that is quickly responsive to the changing marketplace. For example, a retailer can use online sales to test new products and move only top sellers to retail spaces. In another example, some retailers are using their stores as distribution centers and are using store inventory to fulfill online orders.

Section B: Demand Analysis and Patterns

This section is designed to

- Describe the importance of understanding the marketplace as it relates to the supply chain
- Discuss the importance of scanning the external environment for competitor capabilities, market conditions, and global perspectives
- Explain how to use strengths, weaknesses, opportunities, and threats (SWOT) analysis, market research, and product assessments
- Explain how to use macro- and microeconomic theories and analyses when evaluating demand at strategic levels
- Interpret demand patterns of trend, seasonality, cycles, and random variation as well as the impact of sales promotions.

Demand analysis such as market research or competitor analysis is needed for strategic, tactical, and operational levels of planning. At strategic levels, this research takes the form of assessing the macro- and microeconomic environments as well as using tools such as SWOT analyses to determine how well adapted the organization is to the current environment. At the tactical and operational levels, analysis includes studying trends, seasonality, and other demand patterns.

Topic 1: Demand Analysis

Demand analysis tools include SWOT analysis, market research, and product assessments.

Demand Analysis Road Map

Strategic, tactical, and operational plans can run right into the brick wall of a harsh economic climate, changing tastes, a competitor with superior offerings at lower prices, or a new government with new priorities or regulations. Therefore, an environmental scan is needed to validate the current plans. The idea is to develop organizational and related supply chain strategies, tactics, and operations that are flexible enough to adopt changes quickly as demanded by the situation.

Demand analysis looks at the organization in relation to its external environment. Demand can be analyzed over the long, medium, or short term. Long-term demand analysis looks at the **macro environment**, which the 16th edition of the *APICS Dictionary* defines as "the environment external to a business including technological, economic, natural, and regulatory forces that marketing efforts cannot control." While an organization's macro environment includes external influences on strategy that can only be understood, not controlled, the organization can shape itself or its products and services over time in reaction to or in anticipation of a given environment.

The organization can exercise some degree of control over demand at the tactical and operational levels, however. It can influence demand by changing tactics, such as by changing prices, promotions, and customer or employee policies/procedures. At the operational level it can exert control by managing and prioritizing demand.

At the long-term strategic level, tools such as a SWOT analysis can be used to look inward at the organization's strengths and weaknesses and outward at opportunities and threats. A medium- to short-term demand analysis will include market research to identify external influences on demand. Marketing can use this information to determine how to influence that demand, since marketing efforts can have an impact on demand at this level. The process may also include an assessment of the organization's product and service offerings to see if changes are needed to what is being offered.

Before looking at these demand analysis tools, let's explore how demand analysis fits into the big picture.

Processes for Procuring and Delivering Goods and Services

Demand needs to be planned (analyzed and forecasted), communicated, influenced, and prioritized. Operations planning and control then links supply with demand. Inventory management methodologies need to be selected and supply analyzed using tools such as total cost of ownership or make-versus-buy analysis. Logistics, including warehouse management, capacity forecasting, materials handling, transportation, and delivery patterns are then planned and executed based on the consensus picture of supply and demand.

The key processes that supply chain managers need to be able to perform related to procuring and delivering goods and services are

- Developing supply chain personnel's knowledge, skills, and abilities
- Developing supply chain infrastructure
- Performing supply and demand planning and scheduling
- Identifying logistical requirements
- Developing logistical capabilities to support delivery of goods and services
- Executing the plans.

The following is a general overview of these processes.

Developing Supply Chain Personnel's Knowledge, Skills, and Abilities

The process of developing supply chain personnel's knowledge, skills, and abilities involves the following steps:

- Setting learning goals with one's manager
- Providing opportunities for independent learning, including certification
- Developing formal or informal coaching or mentoring programs
- Providing access to training courses as needed for specific skills or industry-specific knowledge
- Meeting periodically to assess goal progress and set new goals

Developing Supply Chain Infrastructure

The process of developing the supply chain infrastructure involves the following steps:

- Completing design of the supply chain infrastructure, including relevant total cost of ownership and make-versus-buy analyses

- For all "make" decisions:
  - Completing supply chain infrastructure or process development projects for manufacturing or service delivery, logistics (including warehousing and transportation), and information and funds flows
  - Staffing new roles
  - Providing training on new processes or systems
  - Using change management to ensure that processes and systems are fully adopted in policies and culture

- For all "buy" decisions and key customer relationships:
  - Working toward desired supplier and customer relationships
  - Developing supplier and customer contracts
  - Implementing, monitoring, and controlling agreed-upon supplier and customer relationships

Performing Supply and Demand Planning and Scheduling

The process of performing planning and scheduling involves the following steps:

- Influencing other business functions toward a shared view of demand management
- Planning, communicating, influencing, and managing and prioritizing demand
  - Analyzing and then forecasting demand
  - Servicing orders
  - Influencing customers to buy or influencing them to alter purchases if there are supply and demand imbalances
- Performing master planning, including resource planning (long-term capacity)
- Performing sales and operations planning to develop a consensus plan as an input to master scheduling
  - Reviewing performance
  - Evaluating demand levels
  - Evaluating supply capability
  - Reconciling demand, supply, and financial plans
- Planning inventory
- Performing master scheduling to produce the master schedule and rough-cut capacity plan (medium-term capacity)
- Performing material requirements planning
- Performing distribution requirements planning for inventory
- Performing capacity requirements planning (detailed production capacity)
- Forecasting and planning warehouse and transportation capacity

Identifying Logistical Requirements

The process of identifying logistical requirements involves the following steps:

- Determining logistics objectives and considerations
- Determining warehousing objectives and considerations
- Specifying warehouse capacity requirements
- Specifying materials-handling requirements
- Determining transportation objectives and considerations
- Selecting preferred modes of transport
- Balancing warehousing, transportation, and other logistics requirements

Developing Logistical Capabilities to Support Delivery of Goods and Services

The process of developing logistical capabilities to support delivery of goods and services involves the following steps:

- For internal logistics provision:
  - Completing projects related to logistics, including warehousing and transportation processes, infrastructure, and equipment

    - Staffing new roles
    - Performing training on new processes, infrastructure, and equipment
    - Using change management to ensure that logistical capabilities are incorporated in policy and culture

- For logistics outsourcing:
    - Selecting logistics service providers
    - Developing contracts with logistics service providers

Executing the Plans

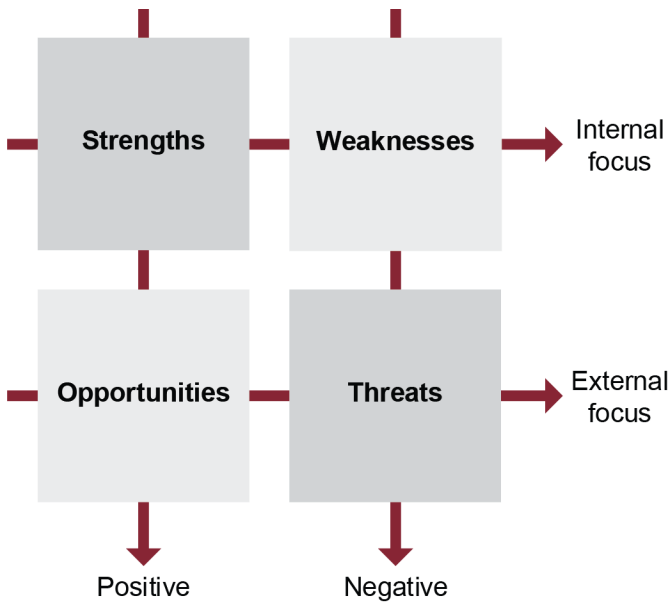
The process of executing the plans involves the following steps:

- Performing production activity control
- Measuring, managing, and controlling capacity
- Controlling inventory
- Monitoring and controlling delivery patterns and transportation modes
- Monitoring and controlling third-party service providers
- Expediting supply and transportation processes
- Complying with all legal and regulatory requirements

SWOT Analysis

SWOT stands for **S**trengths, **W**eaknesses, **O**pportunities, and **T**hreats. It is a tool useful for strategic planning as well as long-term demand analysis. As seen in Exhibit 1-11, the SWOT analysis is usually in the form of a quadrant in which distinctions are made between internal versus external focus and positive versus negative points.

Exhibit 1-11: SWOT Analysis



How are each of these determined?

- **Internal strengths and weaknesses** are typically derived from comprehensive data collected about the organization. This may include information on skill sets by function, professional development and training activities, facilities, the company's reputation or standing in the community, etc. Ideally input from external customers and suppliers provides substantiated evidence, as to weaknesses in particular, which can then be appropriately addressed.

- **External opportunities and threats** are based on market trends and risk analyses. Environmental scanning may be required to assemble data on external forces. This involves collecting and analyzing external data on market forces; demographic changes; changing customer needs; competitor pricing and offerings; current and emerging technology; new taxes, laws, and regulations; and social, political, and economic conditions.

Opportunities can be acted upon to help move an organization toward achieving its goals. However, if those opportunities are ignored or improperly developed, they can transform into threats (like IBM giving Bill Gates the green light to market his disk operating system [DOS] because they weren't in the "software business"). Other opportunities may arise from competitors' activities or products or new markets or from other data seen during environmental scanning.

Threats are defined as risks that can impact a company negatively if they are not handled appropriately. External risks include unforeseen events outside the control of an organization that can

diminish productivity, profits, or market share, for example, the March 2021 grounding of the ship *Ever Given* that fully blocked the Suez Canal for six days and held up nearly $10 billion in trade per day. Of course, there can be internal threats that arise due to a company's actions, such as overzealous geographic expansion or excessive outsourcing.

This valuable information feeds into a written document called the market plan.

Market Research

When engineers design a product, they don’t necessarily have anything in mind other than overcoming technical challenges. They assume that others will appreciate the beauty and usefulness of their creations. This, however, is not necessarily the case.

Someone must act as a liaison between the manufacturers (product specialists, technicians, engineers) and the potential consumers who either will, or will not, buy their products, and marketing is all about customers. Marketing plays a role in finding, forecasting, influencing, and sustaining demand—from the product concept to the end of the product’s life cycle. Marketing and sales have different but complementary objectives. Marketing translates the external perspective for internal audiences (What does the market need?), while sales translates the internal perspective for external audiences (Why do you need what we have to offer?)

Marketing can do these tasks with in-house personnel and/or by contract with an outside company. Market research can begin when the product is merely a sketch or the inkling of an idea. It can also take place for an existing product or service, especially one that seems not to be living up to its sales potential.

In order to design a supply chain that can meet its ultimate goal of delivering the right product at the right place and time and at the right price, it’s important to understand the marketplace.

Market Plan

The **market plan** (shown in Exhibit 1-12) is defined in the *APICS Dictionary*, 16th edition, as including

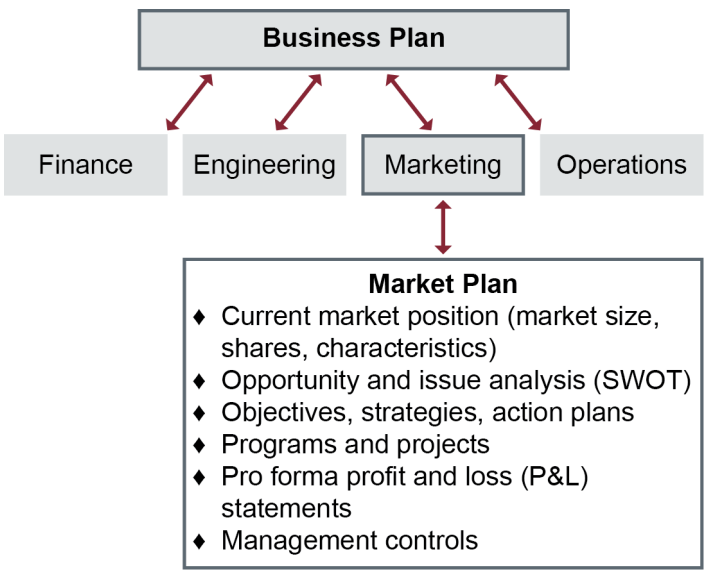
> the current market position, opportunity and issue analysis [SWOT results], marketing objectives and strategies, action plans, programs, projects, budgets, and pro forma profit and loss statement and management controls.

The market plan is a subset of the organization’s strategic business plan, which drives several important functions like finance, engineering, marketing, and production. These functions also have input in shaping the overall business strategy. Here we’re going to focus on the marketing function and how it provides foundational information about the marketplace. Knowing your market, customers, competitors, and product can heavily influence how you design your supply chain to meet long-term objectives.

The marketing function develops its own strategically oriented plan based on the strategic business plan. These plans must be in alignment and there should be consistency between them.

As seen in Exhibit 1-12, the marketing strategy is based on a number of key elements.

Exhibit 1-12: Marketing Strategy and Plan



Current market position information may include data and findings about demand patterns, products and pricing, customer satisfaction, and service level agreements with partners, distributors, and retailers. (Note that a profit and loss statement is another name for an income statement. Pro forma means that the statement is based on forecasted information rather than historical information.)

When designing a supply chain, one must carefully consider the market plan. For example, if the market plan shows that Europe will be the primary source of demand for product X, it may make sense to assemble that product in the Netherlands instead of China, despite comparatively higher labor costs. By assembling a product in Europe, import duties may be much lower than for importing a finished product. (For example, Tesla assembles battery-powered cars in Tilburg.) The shipping volume of the parts may also be much smaller than the shipping volume of the finished products, so postponed assembly can save money in transportation costs.

In addition, one must keep in mind that marketplace factors may evolve over time, and, if they do, that may require modifications to the design of the supply chain and its organization.

Market Research and Its Types

Market research is "the systematic gathering, recording, and analysis of data about problems relating to the marketing of goods and services." Also referred to as marketing research, it may be done by impartial agencies, business firms, market research agents, or an internal marketing staff.

Market research can use a variety of information-gathering tools, such as customer surveys, interviews, focus groups, direct mail questionnaires, websites providing opportunities or incentives for visitor feedback, and market reports sold by research firms. The internal marketing department staff can also do research about potential markets, products, etc. The SWOT analysis is commonly used for this purpose.

There are several types of market research:

- Market analysis: the study of the size, location, nature, and characteristics of markets (for example, product potential), resulting in information useful for market segmentation (i.e., distinct lines of

business to offer).

- Sales analysis (or research): the systematic study and comparison of sales (or consumption) data and **market share** ("the actual portion of current market demand that a company or product achieves," *APICS Dictionary*, 16th edition).
- Consumer research: the discovery and analysis of consumer attitudes, reactions, and preferences (including motivation research), resulting in information useful for customer segmentation (i.e., categorizing customers in various ways, such as by their requirements or the types of products and services they demand).

Sales analysis and consumer research are addressed more elsewhere. More information on market analysis follows.

Market analysis assesses the state of the global, local, and industry economy, the impact of recent events or disasters, and the relative market share that the organization has in a given region at present. Market conditions can be considered challenging when the organization needs to break into a market dominated by other competitors or when the prospective customers are less likely to make a purchase because of the state of the economy. In such situations, the organization's competitive strategy needs to show how the organization's offerings will have a clear competitive advantage.

During times of recession or when working to make inroads against an established competitor in a region, an organization can look at these challenging situations as an opportunity to capture significant market share. To do so, it will need to satisfy customer requirements more completely or at less cost than its rivals. Another strategy that often works during recessions is to purchase organizations that are showing signs of weakness at a discount. This can help an organization grow into new global markets.

Information on market conditions can be found from government or third-party reports, surveys, or white papers on economic conditions. Some of these reports make predictions based on leading market indicators or confirm trends using lagging market indicators.

Purposes of Market Research

The purposes of market research include finding potential markets, analyzing markets, and refining product design to fit the markets.

- **Finding potential markets.** The most basic question about a product is "Does anyone care?" Is there a significant and unmet need out there for the better product? In an existing company, the sales force may provide the first clue that current customers have unmet needs that seem compatible with the company's mission. Market research can begin from that point to quantify the need. The process can also begin among the engineers—the folks who look at the current products and see a way to improve them. In that case, marketing and sales can present the idea to current customers to see if there are any signs of interest. They can also begin a wider research campaign to identify the potential for new markets for the suggested product.

- **Analyzing markets.** As product design gets underway, marketing can ask more detailed questions about the potential market to divide the market into segments, as is discussed elsewhere in a section on segmentation. As stated there, the basic questions are the best questions: Who? Where? When? Why? What? How many? The answers to such questions constitute market segmentation.

  Once you know who and where the likely customers are, you can ask how best to reach them with news about the product. Do they shop at a large retail chain store or at the local hardware store? Do they buy from catalogs or over the internet? Is telemarketing the best way to reach them?

  Marketing personnel can find out why and how prospects are interested in your product by using phone surveys, online questionnaires, focus groups, analysis of past customer complaints or feedback, or a combination of those approaches. Marketers also want to know when prospects are likely to start buying. Are they ready for the new product, or will market penetration take some time as your prospects get used to the new idea? Will the product have a long or short life cycle? How often will it need to be replaced? How soon will customers demand an upgrade?

  Demand forecasting is a marketing and sales activity. In collaborative arrangements, such as vendor-managed inventory (VMI) and collaborative planning, forecasting, and replenishment (CPFR), the forecasts need to be shared with cross-functional and intercompany teams to ensure that everyone works from the same forecasting information.

  Remember: When it comes to forecasting demand, marketing has a natural bias toward optimism—a bias that may be magnified by top management policies. (Management seldom looks favorably on cautious estimates.) Demand plans based on overly optimistic forecasts can lead to problems. Most obviously, it can cost money if the company increases capacity to meet the demand plan and winds up with unnecessarily large capital expenses and/or inventory hangover. An optimistic bias in marketing can also lead supply areas to distrust the demand plan and compensate by coming up with their own plans, which may well be biased in the other direction. Cross-functional teams and supply chain collaboration can overcome such problems.

- **Refining product design.** As market researchers learn more about market and customer segments, the information should contribute to the product's design. Market research into customer attitudes can help identify features of the product, including a strategic price that will be most attractive to the various customer segments. Some prospects may strongly feel that the new product should contain certain features, while others desire the opposite features. The features that positively contribute to the profit margin should be adopted, and unprofitable variations should be avoided. A proliferation of SKUs (stock keeping units) typically increases inventory overhead and dilutes marketing efforts.

  In some cases a product's features can be varied to match differences in market requirements. For example, computers can be assembled with different components to meet the specialized needs of various segments. A basic version will appeal to customers with limited funds or limited computing

needs. Add a powerful processor and sophisticated subsystems, and your basic computer appeals to “power users.” Add a choice of colors and shapes, and you add value for the style-conscious buyer. Other products will not be as profitable with multiple variations, and the marketing input to design will be identification of the most profitable segments.

At this point, researchers can also contribute to the reverse supply chain aspect of product design. What sort of support will be necessary to satisfy end users and keep them as loyal customers? Will they need product documentation? How many languages will be necessary in the pamphlets? Will phone, text, or email support options be necessary? What will be the return policy? What is the attitude of potential customers to ease of disposal and impact on the environment?

Competition

Organizations need to scan the market for what the competition is offering and at what price. They need to know who has what market share in each region in which they would like to compete and whether there are any customer requirements that are going unsatisfied. For example, Haier found that since the power went out frequently in many African countries, there was an unsatisfied demand for a freezer that could stay cold for a long time. They developed a frost-free refrigerator that could keep food frozen for 100 hours without electricity. This helped them keep the majority of the market share in Nigeria.

Getting a foothold in areas where the competition already has established strong market share requires a well-thought-out strategy. When attempting to get a foothold selling mini-fridges in the U.S., Haier started by negotiating contracts with large retailers, including Walmart, Best Buy, and Home Depot. However, a good strategy that is poorly executed can still result in failure.

One way to get an idea of the competition’s strategy is to use benchmarking. SWOT analysis can also be used to get an understanding of the organization’s current state of supply chain maturity. Other environmental scanning could involve determining how mature competitors’ supply chains are relative to one’s own supply chain. What your organization believes is a world-class supply chain may in fact be surpassed by other chains.

Global Perspectives

Global connectedness is causing supply chain management to evolve into a more strategic role. Managers recognize that the actions taken by one organization in the supply chain can influence the success of the rest of the network. While in the past the strategic focus for many organizations was on improving their internal quality and reducing costs, the focus for many now is on implementing total supply chain solutions that require collaboration from partner organizations both upstream and downstream.

These new global forces are being met by corresponding technological solutions in supply chains in most nations. Collectively they are revolutionizing supply chain management.

Here are some of the powerful forces that impact virtually every supply chain:

- **Global expansion.** The globalization of sourcing and manufacturing is making supply chains longer and more complex than ever before, thereby requiring more formal coordination and collaboration. Many manufacturers and retail chains have expanded both nationally and globally, creating the need for more formal mechanisms to coordinate supply chain activities. In addition, companies that have created their own e-commerce sites can now have global exposure.
- **Increased project complexity and scope.** Project size and complexity are increasing. Projects involve, in some cases, large teams operating at different remote sites. Moreover, the information involved is more important than ever, in larger amounts than ever, and more difficult than ever to manage manually with the required speed and accuracy.
- **Greater market volatility.** Demand is becoming more volatile and harder to predict due to the increasing power and speed of information available to both consumers and competitors.

A successful global organizational strategy will account for these complexities while developing a deep understanding of local customer requirements. This understanding often requires investing in local managers, experts, and salespersons to develop local sales channels that are attuned to the differences in the given region. Haier has done all of these things in each market it enters, but it keeps track of each region using the standardized measurements of the SCOR® model (a framework for supply chain management), looking at the organization's flexibility, velocity, and predictability, among other things. This way Haier can compare success region to region.

A globalized organization will also need the flexibility to withstand global disruptions. The disruption of just one critical link in a globally interconnected supply chain can impact the whole. When the 8.9 magnitude earthquake and resulting tsunami hit Japan and damaged their Fukushima Daiichi nuclear plant in March 2011, initial concerns and the world's focus were on the people of Japan. As the weeks progressed, it started to become clear in just how many ways we are all connected. Factory operations were affected, raising fears of shortages or price increases for a number of widely used components. Manufacturers were affected by disruptions of the transportation of finished goods to airports or ports as well as the movement of employees and supplies to production plants. Concerns grew that the earthquake and tsunami could lead to a long-term disruption in the world's supply of automobiles, consumer electronics, and machine tools. As millions of people around the globe extended their condolences to the people of Japan for the lives lost and suffering, companies around the globe had to quickly assess whether their business would be impacted by this tragedy thousands of miles away.

Even after this and other major crises and disasters (the wildfires in California and Colorado in 2020, the record 30 named storms in 2020 with five consecutive years of at least one category 5 hurricane), some companies are hesitant to realize that with the global economy, actions in one part of the world,

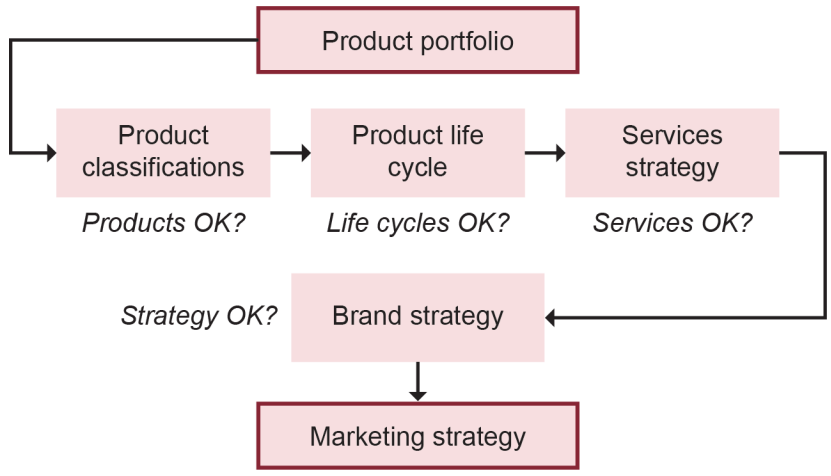
whether planned, unplanned, human-induced, or naturally occurring, seem to affect us. We are all connected.

Our goal is to prepare you to grasp these concepts, be confident in your actions, and eventually thrive in the world of supply chain management. Remember that “the beginning of knowledge is the discovery of something we do not understand” (Frank Herbert, science fiction author and writer, 1920–1986).

Product Assessments

The product portfolio needs be reviewed early in demand management to determine whether the organization's products and services are still appropriate for the market and the organization. The organization's products and services form the core of the organization's brand and value proposition. The organization's product portfolio is the mix of product classifications, families (groups of products with manufacturing similarities), products, and services that the organization offers. Exhibit 1-13 shows how product and brand management involves a series of verification steps that help ensure that the product portfolio is aligned with the market and the marketing strategy.

Exhibit 1-13: Product Portfolio Management



Source: Ross, Distribution Planning and Control, 3rd edition.

The various steps shown in the above process are discussed more next. Note that once these aspects of the plan are validated, the plan should also be validated against the logistics plan to ensure that customer service goals can be met.

Product Classification Review

A review of product classifications starts with the big picture. The broadest categories of product classifications are durable goods, non-durable goods, and services. Durable and non-durable goods have physical substance; services are intangible and non-inventoriable. (This classification specifically excludes any products associated with the service.) Durable goods are expected to last for an extended time period, while non-durable goods deteriorate quickly and may need to be consumed quickly.

The next major classifications of physical goods are industrial versus consumer goods, each of which has subcategories, as shown in Exhibit 1-14. The exhibit also lists common rankings of strategic priorities for each type. (Generic strategic priorities include speed, dependability, flexibility, quality, and cost.)

Exhibit 1-14: Product Classifications and Typical Strategic Priorities

Product Classification	Typical Ranking of Strategic Priorities

Product Classification	Typical Ranking of Strategic Priorities
Industrial Goods	
Raw materials and components	Cost and services related to speed, dependability, and/or flexibility
Capital goods (e.g., finished goods, industrial equipment, automobiles)	Quality, cost, flexibility (e.g., product features), and services (speed, dependability, and/or flexibility)
Maintenance, repair, and operating (MRO) materials	Cost, dependability (e.g., availability), and speed
Consumer Goods	
Convenience goods (e.g., groceries, drug store items, commodity clothing)	Cost and dependability
Shopping goods (e.g., home furnishings, fashion clothing)	Quality (including perceived brand quality), dependability (including service warranty), and cost
Specialty goods (e.g., art, high fashion)	Quality (including brand prestige)

A product portfolio review at this level can look at whether the portfolio is adequately diversified. The review can also look at other factors, such as

- Whether product form (e.g., size, shape, color) fits with the manufacturing and distribution models
- Whether product durability, reliability, and replacement rates (frequency of repurchase) are appropriate to the production strategy and distribution channel size/costs
- Whether the costs of quality, the degree of customization allowed, and warranty, repair, or training expenses meet customer expectations and organizational cost goals.

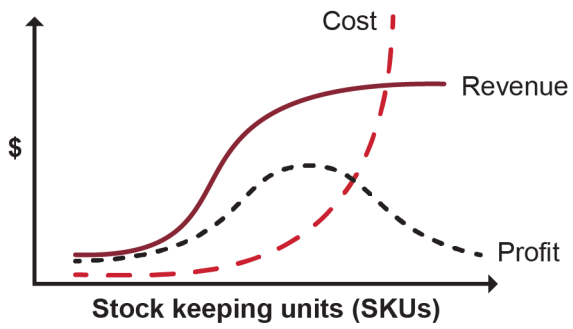
A review of the appropriateness of the organization’s product family hierarchy and its various levels is also conducted. For example, it may be necessary to change the number of units offered in a case or pallet if this would help profitability as a product enters a different life cycle stage.

Another element of a product portfolio review is a review of product portfolio complexity.

Product Portfolio Complexity Management

Product portfolio complexity management involves a review of the number of stock keeping units (SKUs) that the organization is maintaining. Product SKUs can differ based on product features, colors, number of units in a package, and so on. Different SKUs may also have an impact on the number of different manufacturing variations or paths that are required to produce the variety of SKUs, and increasing complexity in this manner lowers manufacturing economies of scale. In addition to impacting manufacturing complexity, other supply chain costs also increase costs at a steadily increasing rate as more SKUs are generated. These costs include higher purchasing costs, inventory carrying costs, and service costs. Marketing messages are also diluted, and the multiple messages confuse customers. However, as shows, too few SKUs can also stifle revenue and profit because customers do not find the varieties that suit their needs, especially if competitors offer more variety.

Exhibit 1-15: Portfolio Complexity Impact



Source: Bowersox, et. al. Supply Chain Logistics Management, 5th ed., which cites David Closs, Mark Jacobs, Morgan Swink, and G. Scott Webb, "Toward a Theory of Competencies for the Management of Product Complexity, Six Case Studies." Journal of Operations Management,26.

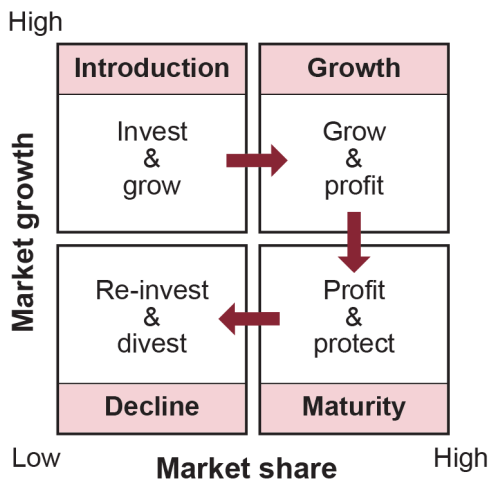
Note, in the chart, how initially increasing the number of SKUs helps provide a rapid increase in sales revenues and profit. However, the steadily increasing rate of cost increases eventually causes profits to fall. Also, adding more and more SKUs results in revenues flattening off after a time due to more marketing confusion as well as some SKUs competing with each other for the same sale. Staying in the sweet spot and avoiding either unprofitable end of this spectrum may require

- Performing this complexity review separately for each product category or family
- Developing holistic metrics that highlight total cost of ownership and profit over revenue only (which promotes too many SKUs) or cost only (which promotes too few SKUs)
- Balancing the demands of marketing (promoting more SKUs) against the demands of operations and supply chain management (promoting fewer SKUs)
- Differentiating customer wants from needs (In other words, is a feature a true order qualifier or winner, or would most customers be likely to accept a substitute that is stocked?)
- Evaluating whether a different manufacturing method such as modular design could alter the cost curve and enable the profit curve to likewise shift.

Product Life Cycle Review

While product life cycle durations will vary by product and industry, no product is immune to changes in customer demand over time. Therefore, it is important to conduct a life cycle review to determine whether the product has shifted to a new life cycle stage and, if so, to determine how the manufacturing, supply chain, and marketing strategies will need to change. Exhibit 1-16 shows product life cycle stages of introduction, growth, maturity, and decline, with a comparison of how they relate to market share and market growth.

Exhibit 1-16: Product Life Cycle and Market Growth versus Market Share



Source: Ross, Distribution Planning and Control, 3rd edition.

During introduction, product availability, product volume, and sales volume are low. All three increase during growth, are level in the maturity phase, and are low during decline. Therefore, changes in sales volume trends (especially in the absence of macro events such as a change in the economy that would explain the trend change) are a potential indicator that the product is entering a new life cycle stage.

When it is determined that a product is entering a new life cycle stage, demand plans need to be altered to reflect the new situation so that supply plans (including supply chain plans) can adapt to the new reality. Since demand for products is often directly impacted by the value attached to associated services, the next area to review is services. In other cases, the services are the main offering, and, if so, a services review would be the main task in this process.

Services Review

A services review needs to determine whether customer perceptions have been changing relative to the service. A review of services such as warranties, technical support, repairs, trade-in allowances, user training, transportation, or bulk-purchase discounts could reveal whether customers perceive the service to be value-added.

When a service enters maturity because all competitors are offering it, this is called saturation. Services in saturation still need to be offered, but they will be order qualifiers rather than order winners. This will impact demand unless new services are developed.

Brand Strategy and New Product Introduction Review

The results from the product portfolio, product life cycle, and services reviews are used to determine how to invest the organization’s limited marketing resources. Better information on long-term demand can impact the financial returns expected from marketing campaigns and therefore can affect the decision of whether or how to generate marketing. Perhaps a less expensive form of marketing such as mailings or emails will be all that is warranted. In addition to ensuring that marketing and other expenses will generate more revenue than they cost, there will be more marketing budget left over for new products, which consume marketing funds at a very high rate.

Successful new product introduction (NPI) requires market analysis, research and development, marketing, and product phase-in/phase-out plans. NPI attempts to produce entirely new demand in unexpected areas or to build upon previous demand by focusing on the competitive attribute of new product features to enable the product/service package to be differentiated from similar past models or the competition’s offerings.

Estimating demand in the introduction or growth phases is especially problematic. An NPI that is entirely new will require significant marketing, but there is no guarantee of how well the sales pitch will convert into actual sales and there is no data for forecasting. The organization will need to rely on qualitative forecasting methods (forecasts that rely on experience rather than calculation) and determine a level of demand that fits within the organization’s risk tolerance levels. If demand is estimated too high, supply will have huge losses. If too low, supply will have inadequate capacity. For the scenario of upgraded products, the situation is somewhat more straightforward, because the demand plan can base forecasts on the prior model’s sales, which are somewhat more reliable.

Other life cycle phases have different brand strategies to create or sustain demand. During growth, the brand strategy competitive attributes are availability and quality so that customers are able to acquire the good or purchase it again and provide testimonials. Mature products typically focus on a competitive price and dependability to minimize defections. Products in decline need to find innovative ways to provide availability at a low cost.

Topic 2: Demand Patterns

Demand patterns over the long term can be examined by looking at macro- and microeconomic reports or internal analyses. The demand patterns that require review for short-term demand planning are historical demand trends, seasonality, cycles, random variation, and the impact of sales promotions.

Demand Patterns Road Map

Demand patterns can be studied over the long term as well as over the medium to short terms. Long-term demand patterns can be analyzed using concepts from macro- and microeconomics. Medium- to short-term demand can be analyzed by using historical demand for the organization's products or by using a proxy such as a benchmark product from another organization.

Reviewing macro- and microeconomic reports or internal analyses can help supply chain managers better understand overall market forces and specific demand characteristics for an organization's products and services. Macroeconomics looks at the behavior of the economy as a whole, while microeconomics looks at the behavior of individuals and firms given changes in prices and resource allocations.

Supply chain managers can use this information to shape an opinion of how disruptive forces in the environment might impact the demand curve for the organization's specific products and services and thus set a strategy that compensates for weaknesses and capitalizes on strengths. If the supply or demand curve for a product shifts, analysts at the organization can predict the new equilibrium point for the product and then calculate profit margins assuming the market price reaches this point. Knowing the likely selling price of the product can help when setting cost goals for supply chain activities. At that point, they can use marginal analysis to make rational daily decisions for logistics or other areas of the supply chain.

Medium- to short-term demand patterns look at a product's or service's average demand over a period being studied as well as the volatility of that demand. Demand volatility can come from explainable causes, such as seasonality, or from unexplainable causes, which is called random variation. The impact of sales promotions or other internal drivers of demand can also be accounted for in forecasts of future demand. The demand patterns that are revealed through analysis then become a key input into selection of the best forecasting model(s) and the execution of the forecasts.

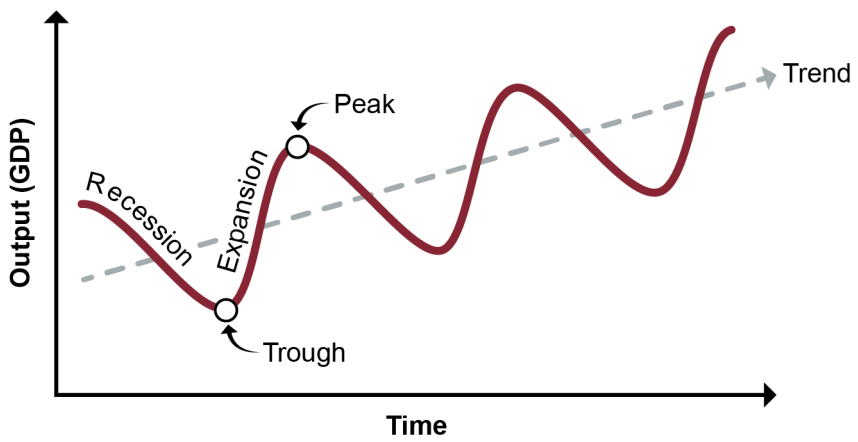
Macroeconomic Demand Patterns

Macroeconomics is the analysis of the behavior of the overall economy (supply and demand in aggregate) in response to various market forces. Supply chain managers use information on the trend of the economy by country or region or globally to estimate how this will impact the organization's industry, the organization, and its supply chain strategies.

Exhibit 1-17 shows how the overall economy goes through cycles between periods of expansion and recession (or depression) in terms of gross domestic product (GDP) over time. The size (amplitude) and duration of each wave can differ significantly from cycle to cycle, and, while the overall trend of the economy over many cycles has historically been upward-sloping, this growth trend is not guaranteed.

Near the peaks of a cycle, unemployment is low and production is at or near full capacity. Near the troughs, employment and output are low. Innovation can trigger periods of expansion; economic scarcity, political events, or financial instability can trigger recessions.

Exhibit 1-17: Economic Cycles and Long-Term Trend



Since these economic swings have such a large impact on supply and demand, economists study them to determine their causes, what shortens or sustains them, and how to promote stability through public policy.

Having a basic understanding of these theories and how current political forces align with them can help supply chain managers modify their strategic plans to reflect the current and predicted future economic conditions.

Real GDP and Weighted Average Price

Real gross domestic product is the total value of all final goods and services produced within a given set of economic boundaries such as a country's national boundaries. Sometimes real GDP is studied against the weighted average price of all products and services sold in the same economy. When overall prices shift higher, people can afford fewer goods and services; when prices are lower, people can afford more. Conversely, and as an opposing force to this effect, when overall prices shift higher, suppliers want to make more; when prices are lower, suppliers will be less motivated to produce and

will cut production and idle workers. These two opposing forces work to balance each other out in the long term to a point of equilibrium.

Let’s look at the impact of these macroeconomic forces at a few key points in the economic cycle. At the end of a period of growth, weighted average prices will have gone up to the point where people cannot afford as many goods or services. Supply will lag this trend and will be producing as much as it can to take advantage of the high profits that high prices entail. Note that even if demand is extraordinarily high just before this turning point, supply will not be infinitely high. There is a physical limit on an economy—the total amount the economy can produce based on the scarcity of labor and materials and diminishing returns created by ever-increasing business expenses. The high supply and low demand will generate a surplus of goods, which will further reduce profitability. Plant closings and layoffs will occur, helping to trigger a recession. Weighted average price will fall and the economy will work toward equilibrium, but perhaps the pendulum will swing beyond this point.

At the tail end of a recession, weighted average price will be low and so demand will be high. Even though suppliers will be less motivated, they will still want to produce some amount of goods, because labor will be plentiful and cheap and because they have equipment and other overhead that is costing them money regardless of whether or not they produce anything. So supply will start to rise. As long as the weighted average price stays relatively low, there will be high real GDP and a period of recovery will begin. During this period there may be shortages because aggregate demand outstrips supply, which will tend to increase prices and bring the economy toward equilibrium and perhaps beyond.

During the strong part of a growth phase, prices will be relatively low and total real GDP will be high, because there is more real wealth and thus more consumption spending. Real GDP will also be high, in part because as more money is circulating, interest rates fall, which increases capital spending. As the economy prospers but has not yet raised prices beyond the point people can afford, the point of equilibrium will be reached. The point of equilibrium will also be the point of full employment for the economy being studied. Full employment is when the only unemployment is from frictional or structural sources. Frictional refers to normal unemployment, such as new college graduates looking for work and people between jobs; structural refers to changes in the structure of available work (for example, workers who need retraining because their skill sets are obsolete). The potential output of the area’s economy at full employment is also called the long-range aggregate supply.

Interpreting Macroeconomic Information

Macroeconomic information cannot be directly applied to one industry’s or one company’s products. It relates to trends of all goods in the economy in the aggregate. How do economists put this information to practical use?

Changes in the macroeconomic environment, such as a market adjustment (e.g., the correction in prices for homes when the housing bubble burst in 2008), have effects that can be predicted using

economic models. Other factors, such as population demographics (e.g., a higher proportion of adults at retirement age), can also have a predictable impact. In general, factors that reduce household wealth will reduce demand since consumers will have less to spend. Market interest rates are also a factor. When they are low, businesses have an incentive to borrow to make capital investments and start projects because the return on investment is promising.

Similarly, if a country's net exports increase, aggregate demand increases, and vice versa. Export levels can change due to changes in exchange rates (depreciated currencies increase aggregate exports and demand, while appreciated currencies reduce them) or when other countries increase their GDP.

Note that if input prices (e.g., the cost of goods sold) increase, supply will decrease. If raw materials become scarce, supply will decrease, but abundance of materials increases supply. Similarly, an increase in taxes or regulatory costs decreases supply.

An increase in productivity relative to inputs will result in larger real GDP levels at any price. This could be due to a new technology or better-educated workers.

Inflation and Deflation

Inflation is a sustained increase in the general level of prices for an area, while deflation is a sustained decrease in prices. One way to detect inflation is with a consumer price index (CPI), which is a sampling of the actual prices of various consumer goods. Inflation occurs when consumers have more money available to spend but the supply is scarce. Creditors are harmed by inflation; debtors are helped. Inflation also harms consumers on fixed incomes.

A primary purpose of government central banks is to control inflation. A very small amount of steady inflation is desired (to minimize the risk of deflation), but high inflation or deflation needs to be prevented.

Recessions and Depressions

A recession is when real GDP declines for two consecutive quarters. If the long-range aggregate supply decreases during that time or if the contraction is severe or prolonged, it becomes a depression.

Metrics

Supply chain managers need to scan the macroeconomic environment for multiple countries and economic regions. In addition to the consumer price index, the consumer confidence index (CCI) provides leading information on likely future demand because it polls consumers' feelings about the economy and how likely they are to make purchases. (Modern economics accounts for the strong influence of often irrational human emotions, while in the past it focused on purely rational decision making.) Another index of value is the producer price index (PPI). The PPI measures the prices received by domestic producers for their goods and services, which can help indicate producers'

opinions of the economy. PPI can also help when determining how to set contract terms. Indices such as these may be known under different names in different countries, and some countries may have more historical data available for comparison than others. The methods of collection may also differ, so values for different countries may be more or less comparable.

Globalized sources of information are especially important for supply chain managers, since they buy and sell in so many different countries. For example, the World Bank provides “Worldwide Governance Indicators” for 215 global economies. (This resource can be found in our online Resource Center.) These key performance indicators track fairness of elections, rule of law, control of corruption, and other transparency and effectiveness measures. They also track the growth trends of GDPs.

In addition to GDP, the World Bank and other sources such as the International Monetary Fund (IMF) and the World Trade Organization publish economic indicators such as gross national income; government surpluses, deficits, and indebtedness; consumer savings; and foreign investment. (A link to IMF data is in the online Resource Center.) Government agencies publish metrics for their specific countries. Privately funded research organizations publish economic outlooks. Large organizations may have consultants or in-house economic experts on staff. Risk management business units may also have compiled economic reports and analysis that are available for review.

Microeconomics

The 16th edition of the *APICS Dictionary* defines **microeconomics** as “the analysis of the behavior of individual economic decision makers (individuals and firms).” Microeconomics focuses on specifics such as the price of a product, how sensitive customers are to changes in that price (how much price changes impact demand), cost trends for a business, or employment levels in a given industry. Supply chain managers can use microeconomic theories and models to determine when or where to expand output, what product mix to have where, when to raise or lower prices, and so on.

Supply and Demand on Microeconomic Scale

Since we are now talking about individual rather than aggregate supply and demand, some economic laws come into play.

- **Law of demand.** The law of demand states that as the price of a good or service increases, demand will decrease (all things being equal).

  When mapping supply and demand on curves, as price goes up, demand goes down. This is called the elasticity of demand. The elasticity of demand relies on economic assumptions about scarcity and the use of pricing in an open market. Scarcity means that goods and services are limited in availability, so businesses and consumers need to make choices about what goods and services they want more than others. Pricing is an efficient mechanism for distributing scarce resources. It creates a system of rationing, or doling out of those resources to entities who want them enough to pay more for them than others. These choices create opportunity costs. Opportunity costs are the other things that the entity is sacrificing to make the chosen good or service a priority.

  This is the simplified view of microeconomics. However, the marketplace is diverse, and there are goods and services that might be almost as good as the desired scarce item. These are called substitute goods. The substitution effect states that the prices of substitute goods are interrelated. As the price of one good increases, consumption of the substitute good may increase. The most cost-effective choice is selected when substitutes exist. With this in mind, the law of demand can be viewed in relative terms. If the organization lowers its prices but its competitors lower their prices more, consumer expectations will shift and the organization effectively has had a price increase.

  Additional forces reinforce the law of demand. The income effect increases demand at low prices. As prices go down, persons or organizations with limited funds will be able to buy more units. A related force is diminishing marginal utility. When consumers purchase units of a good or service, each additional unit purchased will have less utility than the previous one.

- **Law of supply.** The law of supply states that as the price of a good or service increases, supply will also increase. More sellers can sell at a profit.

Higher prices give producers more incentive to produce and sell goods, so they will make more supply available. For example, the central United States fracking oil boom created several years of explosive growth in the Midwest. When market oil prices plummeted in 2015, the number of new oil development projects also plummeted, even though the developers had the drilling rights. When oil prices rise again, these developers will have an incentive to resume drilling.

Two other microeconomic concepts related to supply are economies of scale and diminishing returns. Economies of scale means that as output is increased, the cost per unit of output decreases because all fixed costs (like overhead) are spread over a larger number of units. At a certain level of output, however, an organization may experience diminishing returns, or diseconomies of scale. This occurs when new costs are incurred to increase output, and these new costs can cause the cost per unit of output to slow its decrease until it is no longer valuable to produce additional units.

- **Equilibrium and the law of supply and demand.** Just as supply and demand on an aggregate scale tend toward equilibrium, so do individual prices. The law of supply and demand states that the price of any good will adjust until the quantity supplied and the quantity demanded are in balance. A surplus will result in price cuts to sell off the excess inventory, while a deficit will result in price increases related to the scarcity of the offering. Some goods adjust to equilibrium faster than others.

Price Elasticity

Price Elasticity of Demand

As household wealth rises, demand for some products will increase a great deal and others less so. Price elasticity of demand assigns a level of elasticity to various products. The *APICS Dictionary,* 16th edition, defines **price elasticity** as

> The degree of change in buyer demand in response to changes in product price. It is calculated by dividing the percentage of change in quantity bought by the percentage of change of price. Prices are considered elastic if demand varies with changes in price. If demand changes only slightly when the price changes, demand is said to be inelastic. For example, demand for most medical services is relatively inelastic, but demand for automobiles is generally elastic.

Innovative products like smartphones are elastic because they rise or fall strongly in demand as price changes. Staple products like eggs are inelastic because they may not have much increase or decrease in demand as price changes. In general:

- Low-priced items are generally inelastic and are less impacted by small price changes.
- Necessities are inelastic and luxuries are elastic.
- Demand is more inelastic over the short term and more elastic over the long term (e.g., people pay more for gas for a while but may shift to a more efficient vehicle or the bus if prices stay high for too long).

Supply chain managers can look up or calculate the price elasticity coefficients for their products and services. There are a number of ways to calculate the price elasticity coefficient, but a simple test is the total revenue test. If you drop the price and demand increases, and if the loss of revenue from the lower price is exceeded by the increase in revenue from more units sold, then demand is elastic. However, if you drop the price and the loss of revenue from the lower price is greater than the gain in revenue from the increase in unit sales, then demand is inelastic. A coefficient greater than 1.0 is elastic; less than 1.0 is inelastic. These coefficients tend to hold true over a particular price range. However, at a higher or lower price point, a good or service may shift from being inelastic to elastic or vice versa.

For example, consider the two products in .

Exhibit 1-18: Price Elasticity of Demand Example

Product A

Price/ Unit	Margin/ Unit	Demanded	Price Elasticity Coefficient	Elastic?	Revenue	Margin
$120	$40	1,000	n/a	n/a	$120,000	$40,000
$110	$30	1,100	-1.2	small	$121,000	$33,000
$100	$20	1,300	-2	small	$130,000	$26,000
$90	$10	1,600	-2.31	small	$144,000	$16,000

Product B

Price/ Unit	Margin/ Unit	Demanded	Price Elasticity Coefficient	Elastic?	Revenue	Margin
$120	$40	1,000	n/a	n/a	$120,000	$40,000
$110	$30	2,000	-12	big	$220,000	$60,000
$100	$20	4,000	-11	big	$400,000	$80,000
$90	$10	7,500	-8.75	big	$675,000	$75,000

Both products have the same characteristics for price per unit and margin per unit. The cost of goods sold is deducted. This shows that as the price goes down, so does profitability. However, the top example is a little elastic (demand goes up steadily as prices fall) while the bottom is highly elastic (demand skyrockets as prices fall). The elasticity coefficients are calculated for all but the first line of each example because the calculation requires a prior price/unit and prior demand amount.

In the top example, the US$120 per unit price would provide the highest gross margin, so it would be the best choice of the options shown. (Choosing based on revenue would be an error.) However, in the bottom example, a price of US$100 per unit would provide the highest gross margin.

From a supply chain management perspective, if the logistics costs are subtracted as part of the margin-per-unit calculation (i.e., included in the cost of goods sold), then these are the correct calculations. If, however, logistics costs are omitted from the analysis, the actual highest profit price point could be quite different. When analyzing economic tradeoffs of different prices and demand, all influencing costs need to be included.

Price Elasticity of Supply

Price elasticity of supply shows how sensitive suppliers are to changes in product price. Over the short term, suppliers will continue to supply products at lower prices, so they are inelastic in the short term. However, over time they will shift away from these products to produce products with higher profit margins, so over the long term, supply is elastic.

Marginal Analysis

Another microeconomic concept is marginal analysis. A marginal analysis focuses only on the marginal utility and marginal cost of the choice. Marginal utility is the extra usefulness or satisfaction gained from purchasing one additional unit of the good or service. Marginal cost is the additional cost incurred for making a given decision or the cost of producing one more unit of a good or service. Costs incurred regardless of what choice is made are ignored. The rule for marginal analysis is that if the marginal utility exceeds the marginal cost, it is a wise economic choice.

For example, if it costs €1,000 to move one truckload of freight between two major cities and a truck can haul 10,000 kilograms (kg) of freight, the average cost is €1,000/10,000kg = €0.10/kg. Should an offer to fill in some unused space in the truck for €0.05/kg be rejected? Using marginal analysis, one considers only the marginal costs and benefits. The marginal costs are a small amount of additional fuel to ship the increased weight and a trivial amount of added wear and tear on the vehicle, plus the fuel and driver mileage to another loading and unloading point and time spent in loading and unloading the other cargo. The rest of the driver's time, all insurance, and so on are already included in the planned trip cost, so these are ignored. They are sunk costs for purposes of this decision because they will be incurred regardless of the choice made here. If the marginal cost for this new freight is €0.02/kg, then the added €0.03/kg is a marginal net benefit. Accepting the offer is the rational economic decision.

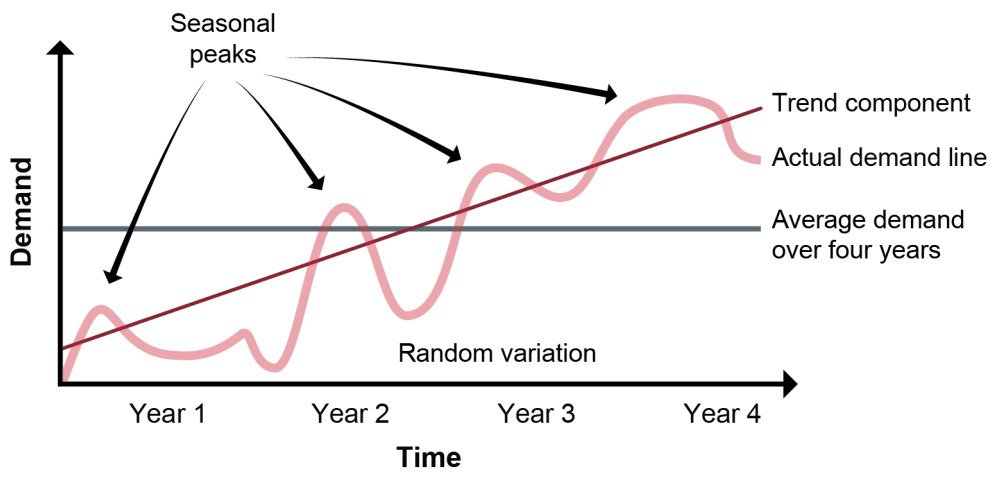
This concept of utility can drive supply chain design decisions as well, such as whether a facility or process is adding value in the eyes of the customer.

Short- to Medium-Term Demand Patterns

Base demand is the long-term average demand for a product or service. A number of factors can increase or decrease base demand, including trends, cycles, seasonality, random (irregular) variation, and promotions or other internal drivers.

Exhibit 1-19 illustrates several of these factors that influence demand. Base demand is the average demand over four years, seasonality is the large wave effect, and the trend is the increase in the size of the waves over time. (A linear trend line is added.) Random variation is the less-than-perfect shape of the waves.

Exhibit 1-19: Base Demand, Seasonality, Trend, and Random Variation



Trends

A **trend** is the "general upward or downward movement of a variable over time (e.g., demand, process attribute)" (*APICS Dictionary,* 16th edition). A trend is a long-term shift, and two common examples are linear (upward-sloping, neutral, or negative) or exponential (skyrocketing upward or downward). Trends can change direction at any time as a result of internal or external forces.

Cycles and Other External Drivers

Cycles are periodic upward, neutral, or downward shifts in demand lasting longer than one year. The economic cycles of recession and growth that form a wave pattern are a primary example. The economic cycle might be one of the causes of a trend.

External demand drivers such as economic cycles, population growth, major events, or disasters are sometimes used to qualitatively adjust a quantitative forecast. A particular driver might also be used if its relationship can be tested and shows strong correlation. These drivers can be leading or lagging indicators. (Leading indicators can give early indication of a trend change; lagging indicators validate a given trend.)

Seasonality

Demand may fluctuate depending on the time of year, e.g., holidays, weather, or other seasonal events. **Seasonality** (also known as seasonal variation) is defined in the *Dictionary* as

> a predictable repetitive pattern of demand measured within a year where demand grows and declines. These patterns are calendar related and can appear annually, quarterly, monthly, weekly, daily and/or hourly.

Seasonality can refer to the seasons of the year or to changes related to any time-based recurring event—lunchtime, the weekend, Christmas, each February, or the first or last week of the month. Whenever seasonality is present to a significant degree, it needs to be removed before forecasting and then added back in later.

Note the difference between seasonality and cycles. Seasonality is a demand pattern that, based on history, will repeat itself on a calendar basis such as month, week, day of the week, hour of the day, etc., and therefore can be predicted. Cycles are demand patterns that repeat but follow a wavelike pattern that can span multiple years and may change at any time; therefore, they cannot be predicted easily.

Promotions and Other Internal Drivers

Promotions, such as discounts or advertising, and other internal drivers of demand, such as deals to gain favorable product placement, will have a measurable impact on demand if they are successful. Promotions that take place in regular patterns will resemble or reinforce seasonality. For many industries, promotions can explain 50 to 80 percent of sales variation. They are worked into forecasts using associative forecasting, for example, by using marketing spend as a driver.

Random (Irregular) Variation

Random variation is “a fluctuation in data that is caused by uncertain or random occurrences” (*APICS Dictionary,* 16th edition). It is the unpredictable part of a data series that cannot be explained by the other factors, basically the remaining variation after the other factors such as seasonality are accounted for. The idea is to minimize this component by finding more and more explainable factors.

Two terms from statistical process control can be used to help understand how random variation differs from the other components of demand. In statistical process control, which is used to track variations in manufacturing or other processes, all variations are categorized as either common cause (general cause) or special cause (assignable cause). Random variation is akin to a common cause. These are the multitude of small factors that affect demand but cannot be added to the model due to the need for simplicity. Demand that is stripped of everything but random variation should conform to a normal distribution (bell curve). Trends, seasonality, cycles, and promotions are akin to special causes, or causes that have an identifiable effect on demand. If the special causes in a data set can be identified prior to their use, a decision can be made about whether or not that data should be included in the forecasting process with or without modifications. In many cases, the impact of these special causes

can be removed from the data temporarily prior to forecasting. An example of this is the deseasonalizing process, as is discussed elsewhere.

Section C: Demand Management

This section is designed to

- Define demand and demand management
- Discuss the linkages among the components of planning, communicating, influencing, and managing/prioritizing demand
- Describe the inputs and outputs of planning demand, including the demand plan
- Understand the communication best practices of communicating soon to minimize surprises, structuring communications so they occur, and focusing communications to fit the audience
- Use the plan-do-check-action (PDCA) model to ensure that demand-influencing activities have a feedback loop
- Discuss the role of the four Ps of marketing in a customer-focused organization
- Explain how product life cycle stage affects requirements and supply chain design
- Describe how product life cycle management (PLM) helps shape early product design phases and end-of-life management as well as help with product traceability over the life cycles of individual products or lots.

This section describes the demand management process and delves into the first three of the four components of demand management. (The final element, managing and prioritizing demand, is reserved for the discussion of sales and operations planning elsewhere in this learning system.) Then it describes ways to manage this demand dynamically by coordinating activities between key internal areas of the organization and with the extended supply chain.

The section also shows how a feedback loop such as the plan-do-check-action (PDCA) model can be used to ensure that demand-influencing activities are properly designed and executed. Then the four Ps—product, price, placement, and promotion—are presented. The section concludes with a discussion of product life cycles and product life cycle management.

Topic 1: Demand Management

Demand management includes planning, communicating, influencing, and managing and prioritizing demand. After providing the big picture, the first two of these components are addressed here in more detail.

Demand Management Road Map

Demand is defined in the *APICS Dictionary,* 16th edition, as

> a need for a particular product or component. The demand could come from any number of sources (e.g., a customer order or forecast, an interplant requirement, a branch warehouse request for a service part or the manufacturing of another product).

Demand management is defined by the *Dictionary* as

> (1) The function of recognizing all demands for goods and services to support the marketplace. It involves prioritizing demand when supply is lacking and can facilitate the planning and use of resources for profitable business results. (2) In marketing, the process of planning, executing, controlling, and monitoring the design, pricing, promotion, and distribution of products and services to bring about transactions that meet organizational and individual needs.

The supply and demand functions in an organization or an extended supply chain each make plans for identifying/creating and satisfying demand. Demand management is the art of synchronizing supply and demand plans.

Demand management is necessary at each of the levels at which supply and demand plans are generated:

- Long-term strategic needs, including long-term forecasting, product development, or capacity development
- Medium-term aggregate demand forecasting and sales and operations planning
- Short-term demand forecasting and item-level master scheduling

Note how the amount or unit of demand becomes more and more specific, from total revenue at the highest levels (not in units at all), to aggregate demand (categories of units such as product families), to specific items. Demand management analyzes the rate of consumption at these various unit levels not only to match the level of needed precision to the time scale of the decision but also to increase forecasting accuracy, as is explained more when discussing forecasting.

In organizations with multiple plants and/or supply chain collaboration efforts, demand management can help organize multiple sources of supply and demand. Sources of demand that could require coordination include domestic and foreign demand or wholesale and retail demand; sources of supply that could require coordination include plant capacities or specialization and inventories in plants, warehouses, and retail locations.

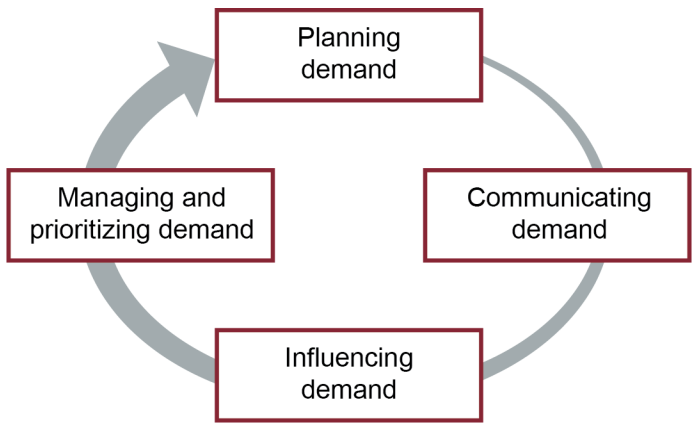
The *APICS Dictionary,* 16th edition, defines the **demand management process** as

> a process that weighs both customer demand and a firm’s output capabilities, and tries to balance the two. Demand management is made up of planning demand,

communicating demand, influencing demand, and prioritizing demand.

These components of demand management, shown in Exhibit 1-20, are used not only to generate and communicate a balanced and realistic demand plan but also to proactively ensure that the demand plan is realized.

Exhibit 1-20: Four Components of Demand Management



Demand management relates to business and customer requirements in that one of its purposes is to influence the organization to produce a product or service that satisfies actual customer requirements and expectations. If marketing professionals succeed in influencing the organization to produce products and services that meet customer requirements, the product/service package should have certain competitive characteristics that enable demand-influencing activities to have a chance to succeed. The following marketing terms from the *Dictionary* relate to a product or service's ability to compete for a customer's business:

> **Order qualifiers**: Those competitive characteristics that a firm must exhibit to be a viable competitor in the marketplace.
>
> **Order winners**: Those competitive characteristics that cause a firm's customers to choose that firm's goods and services over those of its competitors.

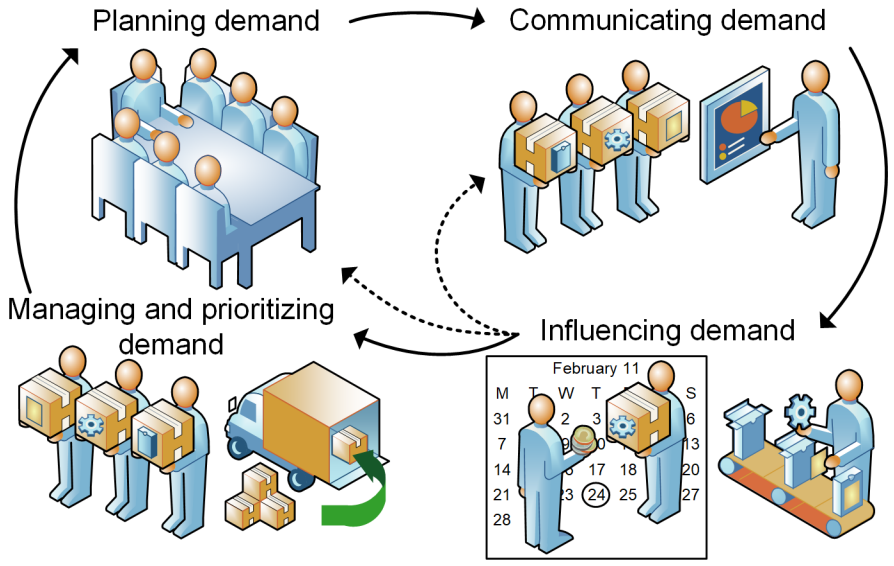
If marketing has successfully influenced the organization to produce a product or service that has the capability of being an order winner, product and brand management, marketing, and sales can work together to convince customers to purchase the organization's products and services in ways that the organization's business objectives are met or exceeded.

Another purpose of demand management is to convince customers to purchase an organization's products and services in a manner that supports business requirements, organizational strategy, and objectives (i.e., in a profitable manner). Marketing professionals use the elements of demand management to accomplish these goals.

Planning, communicating, influencing, and managing and prioritizing demand can be linked in several ways, including cycling through each component iteratively. Organizations may also prioritize certain components to match organizational strategy. Exhibit 1-21 shows, on a conceptual level, how the

demand management components are cyclical. All of the components are necessary for long- and medium-term planning (e.g., product development). However, the dotted lines in the exhibit show how the cycle can be shortened at the short-term operational level to reduce the need for management and prioritization and/or planning demand when the principles and technologies of demand management are implemented throughout the supply chain. For example, by transferring customer demand data from the point of sale immediately to all supply chain partners, the short-term forecasting portion of planning demand can be replaced with actual demand data (i.e., moving from a push system to a demand-pull system). Timely communications will also tend to reduce the need for managing and prioritizing demand because supply will more quickly respond to changes in demand.

Exhibit 1-21: Linkages Among the Components of Demand Management



Let’s look at four organizational capacity strategies that focus primarily on one of the four components of demand management.

- **Planning demand (fixed high capacity strategy).** This organizational strategy involves meeting demand to the maximum extent possible by providing the necessary capacity to meet peak demand at any time. Ensuring that capacity will be available requires a focus on planning demand, especially in terms of long-term planning. Such a strategy could be pursued if the costs of maintaining excess capacity are considered to be less than those of losing business.

- **Communicating demand (highly variable capacity strategy).** This organizational strategy involves matching supply to demand as closely as possible by being flexible enough to increase or reduce capacity spontaneously as demand changes. Matching strategies such as these require a focus on communications so that the changes in supply can be proactive rather than reactive. Such strategies may employ a great deal of contract work, outsourcing, and flexible work scheduling.

- **Influencing demand (moderately variable capacity strategy).** This organizational strategy involves leveling production and carefully managing demand to meet optimal capacity. The focus is on influencing demand so that there is little need to change capacity. Sometimes this process is called demand shaping because it involves convincing customers to buy certain models based on

excess inventory. Demand is influenced by carefully scheduling delivery of products and services (e.g., offering discounts for accepting longer lead times) and timing promotions to operational requirements. Demand could also be influenced by convincing customers to buy in a different quantity per order (bulk purchases or more frequent smaller purchases).

- **Managing and prioritizing demand (fixed average capacity strategy).** This organizational strategy involves controlling demand to the maximum extent possible through scheduling, promotions, queues, and rationing. The focus is on managing and prioritizing demand because fixed average capacity will, by definition, result in periods of insufficient supply. This strategy could be beneficial for products or services that require development and retention of expert personnel or other expensive resources. Airlines that promote early ticket purchases with promotional fares and penalize flyers who buy a ticket at the last minute are examples of companies using this strategy.

Planning Demand and Demand Plan

Planning demand includes forecasting activities, but that is just its start. Planning demand moves beyond predicting what demand will be because it is a plan for action based partly on those predictions.

A key output of the demand planning process should be regular updates to the demand plan. The demand plan is a consensus document requesting products and services from the supply side of the organization to meet the expected future demand for the organization's products and services in each period. It is an estimate of how many products customers will purchase, in what unit sizes, at what price, and on what timetable so the organization and its suppliers can determine how much to produce, when to produce it, and when to ship it. The demand plan is based partly on forecasting and partly on commitments by the demand side of the organization to generate the necessary demand to meet the plan and the goals set in the organization's business plan.

Planning demand can be highly collaborative. For example, collaborative planning, forecasting, and replenishment systems help formalize the coordination of forecasting and demand plan creation.

Demand Plan Inputs

The demand plan, as shown in Exhibit 1-22, influences and is influenced by forecasting; by commitments by product and brand management, marketing, and sales to create, influence, manage, and prioritize demand; and by the business plan and strategy.

Exhibit 1-22: Demand Plan Inputs

In addition to the plans listed in Exhibit 1-22, other key inputs to the demand plan are the assumptions used and the level of uncertainty encountered by the persons responsible for preparing the forecasts. These assumptions and uncertainties should be documented, reviewed, and challenged in the monthly S&OP review process to validate that the demand plan is realistic and actionable. Knowledge of assumptions and uncertainties will also help the organization determine the best way to arrive at a consensus regarding demand plan numbers.

Uses of Demand Plan

The demand plan is used by multiple areas of the organization because it indicates demand both in units and in monetary amounts such as euros or dollars. In this way, each audience for the demand plan can view the information in the most meaningful terms. Operations, logistics, customer service, and product development can view the plan in units; finance can view the plan in monetary amounts; marketing and sales can view both units and monetary amounts.

For example, the plan may provide sales with an indication of the types and numbers of units that will be available to sell per product family and also expected sales goals.

Another use of the demand plan is for validation and control of the plans of individual departments within an organization. Operations and logistics can verify that resource plans are sufficient to meet the expected levels of demand. Finance can use the plan to forecast revenues, product costs, profit margins, and cash flows. Executives can review these projections and determine if the demand plan and related plans of product and brand management, marketing, and sales will have the desired financial and market share results. If not, executives and managers can use the replanning process as a business control. However, the demand plan should not be arbitrarily changed to match the business plan: This would send a signal that the demand analysis and consensus activities at an organization are not valued or respected.

A key control to keep demand plans realistic is to treat the plans as a request for product from the supply side of the organization. In making this request, the demand side of the organization is stating that it is committed to creating this amount of demand and selling the products in the requested amounts. Holding the demand side of the organization accountable for the consequences of producing too much inventory can be an effective control over unrealistic demand plans.

Close scrutiny of the demand plan can also reveal when inputs may be biased or assumptions unrealistic. For example, if the demand plan input by sales shows a reduction in demand but there is no change in the underlying assumptions from the prior periods, executives could question why the demand was lowered. If the sales force is compensated based on meeting its sales targets, it may have been a case of lowering the target so that success would be easier to achieve.

Planning Horizon and Revision Period

A best practice is to produce a demand plan that has at least an 18-month planning horizon and to revise it by replanning on a regular basis. Many organizations use the S&OP process to incorporate these regular revisions to the plan and to reconcile and synchronize their internal department plans. Regular revision allows the plan to quickly reflect changes in external factors, such as the economy or competitor actions, as well as internal factors, such as branding and product life cycle decisions, lower- or higher-than-expected results from marketing activities or sales promotions, and efforts to bring the plan into alignment with the business plan and strategy.

An 18-month minimum horizon has other advantages:

- It ensures that each period’s demand has been planned and reviewed multiple times, with increasing accuracy each time.
- Planned product and brand management and marketing activities typically span at least an 18-month horizon, and sales activities typically span at least a 12-month horizon, so the most current and reliable information on internal plans and likely actions of customers and competitors falls within this 18-month range.
- If the demand plan does not seem to be capable of achieving the goals in the business plan and strategy, a longer horizon allows organizations time to plan and execute additional activities to meet the revenue goals.
- If the demand plan shows a need to increase capacity, it gives the organization sufficient time to approve and execute capital expenditures.
- By midyear the demand plan will show the next year’s projected demand and can be used as a key input to the annual business plan.

Communicating Demand

Communicating demand is the second component of demand management. While clear internal communications are necessary and important, the real power of communicating demand is found when it is extended to supply chain partners.

Supply chain managers can counteract supply chain demand variability such as the bullwhip effect by communicating demand effectively to all parties in the supply chain. On a basic level this involves order processing. **Order processing** is “the activity required to administratively process a customer’s order and make it ready for shipment or production” (*APICS Dictionary,* 16th edition).

From a collaborative demand management standpoint, this may involve producing and forwarding a sales order to the most efficient supply channel, such as

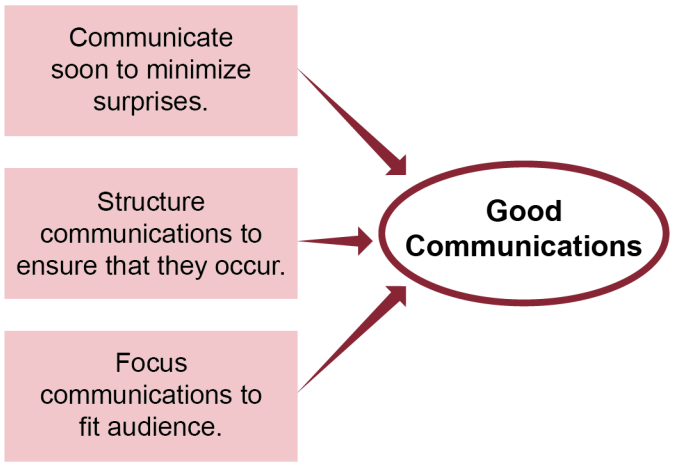
- An inventory storage location, authorizing the goods to be shipped
- A production plant, authorizing production and specifying all information required by the master planner (what, how much, and when).

The demand manager or another demand-side professional may also send a copy of the sales order to the customer to communicate the terms and conditions of the sale. In this way, demand management serves as an intermediary between the customer and production planning.

Organizations can use information-sharing tools such as collaborative planning, forecasting, and replenishment (CPFR) to find a balance between the desire for centralized supply chain planning to provide network integration and optimization and allowing each region to analyze its own market from a local perspective. Each regional partner can be encouraged to share this local expertise with the larger network.

Communicating demand, both internally and externally, rests on the principles of effective communication shown in Exhibit 1-23.

Exhibit 1-23: Principles of Effective Communication



Communicate Soon.

Communicating soon to minimize surprises is the principle that information communicated promptly is of far greater value than communications delayed for any reason. This is true for both good news and bad news as well as for information that is still uncertain. This communications principle is easy to understand but sometimes challenging to put into practice consistently. For example, a marketing person could delay communicating a sales promotion because the effect on demand is proving difficult to quantify. While this is a poor reason not to communicate the promotion, it is also a common example of how people rationalize communications delays. In this case, the promotion might be very successful but the lack of planning for it would contribute to stockouts and the bullwhip effect in later periods. Developing a structure for communicating uncertainty is one mitigating technique for this situation.

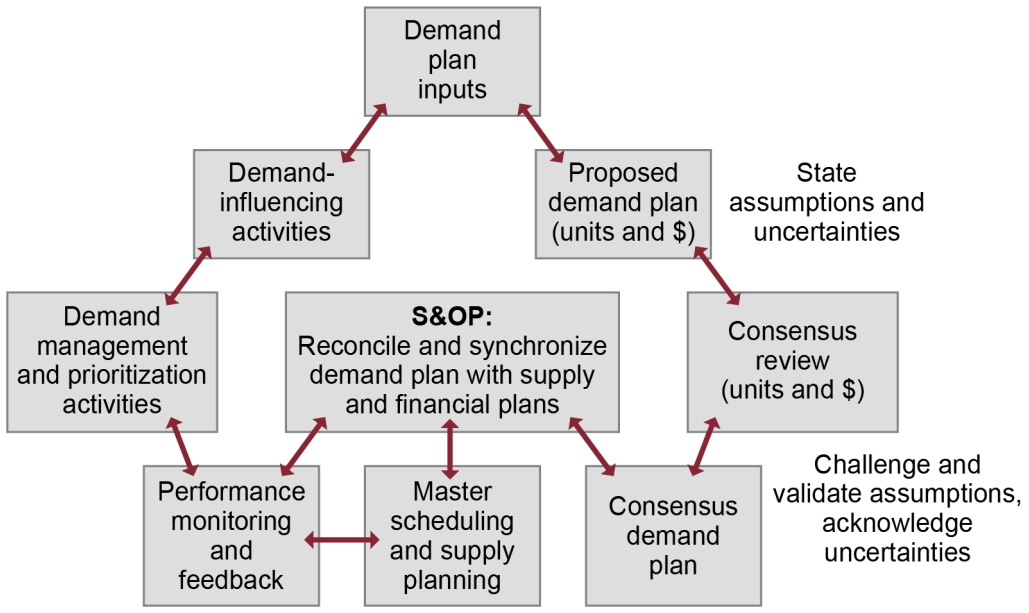
Communicating bad news is another example of a communication that would be more useful sooner rather than later but is often delayed. For example, a salesperson may hope that poor sales will turn around or that a big customer will finally commit to an order. A forecast analyst may hope that an economic downturn will turn out to be only temporary. The tendency to delay bad news is compounded by a psychological tendency to blame the messenger of bad news, which makes people less likely to want to share it or fully disclose the extent of the issue. The negative effects of delaying bad news could include products that are built for which there is no demand and use of capacity that could have been devoted elsewhere. Developing a culture that rewards early sharing of good and bad news could improve demand communications significantly.

Structure Communications.

Structuring communications to ensure that they occur means that communications cannot be taken for granted. In the prior example of the failure to communicate a sales promotion, a structured process for communicating uncertainty in estimates would have helped the marketing person to communicate sooner. A structured process must be more than just assuming that transactional data will be forwarded along by the organization's information systems. While data automation has freed an organization's professionals from spending all of their time on this level of communications, technology is no substitute for interpersonal relationship and consensus building. Person-to-person interaction is needed when setting priorities, explaining nuances, and resolving conflicts.

Exhibit 1-24 illustrates some of the types of communications in the demand planning process that should be structured so they can be reliably repeated.

Exhibit 1-24: Communications Structure for Communicating Demand



The exhibit uses arrows to show the required two-way communications and interactions in the process. Starting with demand plan inputs, communications occur in both directions regarding inputs, including assumptions and uncertainties.

Note that other inputs include demand-influencing and prioritizing activities planned by the demand side of the organization. During the consensus review, a key communication step is to challenge and validate assumptions and to acknowledge uncertainties.

The result of this process is a consensus demand plan that is integrated with finance plans and supply plans during the sales and operations planning process. Communications in the S&OP process of reconciling and synchronizing plans must be structured so that all parties consistently feel listened to and understand the rationale behind the consensus numbers. Communications can lead to greater buy-in and commitment to action that will be needed to realize the plans. An output of the S&OP process is that the supply side of the organization uses the consensus numbers to perform master scheduling and supply planning.

Finally, monitoring performance and providing feedback is a communications process that links to demand-influencing and prioritization activities, to master scheduling and supply planning, and to the S&OP process itself. One way to ensure that these communications occur and feedback is used to keep the plans realistic is to rely on a full-time demand manager.

Demand Manager

Demand manager is an organizational position that is responsible for

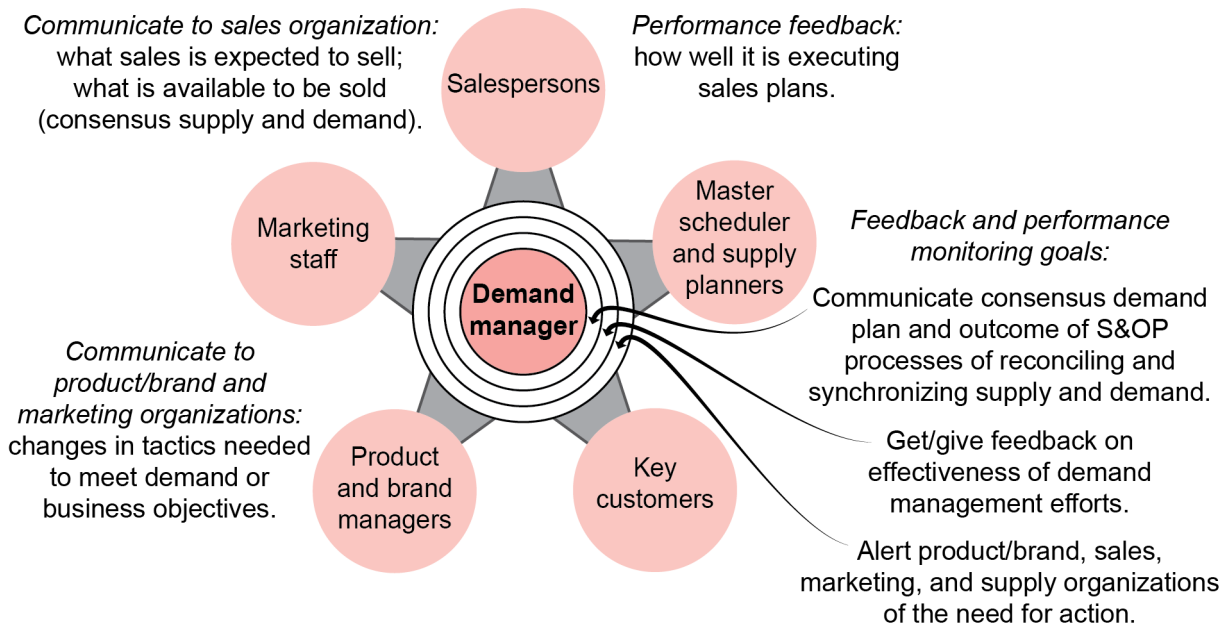
- Gathering information on demand volume and timing by product, product family, and/or customer segment
- Performing analytical work on the data and the demand plan
- Building consensus on a demand plan
- Communicating demand information to and from the various stakeholders involved in input, planning, execution, monitoring, and revision of the demand plan.

The demand manager may also play a lead role in the S&OP process, for example, by creating various scenarios of demand for supply and finance in an effort to tie the demand plan to the business goals.

A best practice is to have this be a full-time position because of the importance and multifaceted nature of the responsibilities. A demand manager needs to have good communication skills and sufficient authority to be successful. This is because the position may be required to respectfully challenge managers on their inputs or gain commitments on demand creation efforts and promises to produce goods according to the consensus demand plan. The position is also required to gather feedback on the results of actions taken to forecast, create, influence, or manage and prioritize demand. The demand manager is responsible for ensuring that the feedback is used to change course, preferably while there is still time to positively influence a developing situation in the organization's favor.

shows how a demand manager can serve as the primary facilitator of communications and feedback.

Exhibit 1-25: Use of Demand Manager as Communications Focal Point



The demand manager is at the center of communications because this position serves as an intermediary between supply and demand organizational areas. Note the three primary feedback and performance monitoring goals that are the responsibility of the demand manager. The demand manager is the recipient of feedback from the demand side of the organization regarding whether their demand-influencing or prioritization efforts occurred as planned or produced less or more demand than was planned for. The demand manager consolidates and communicates this feedback to all relevant stakeholders. When actual demand varies from plan, the demand manager could request additional influencing or prioritization efforts or start the process of altering supply, demand, or financial plans as needed. When demand is less than was planned for, the demand manager informs the supply organization so that they can alter the supply plan to keep supply and demand as synchronized as is feasible given the costs to change ongoing operations.

Note that key customers are listed in the graphic as one of the stakeholder groups with which demand managers may need to communicate. While sales and marketing may maintain all customer

interactions at some organizations, demand managers are increasingly communicating the organization's supply and demand synchronization efforts with key customers and gathering information from them to better understand actual demand requirements.

Focus Communications.

Being effective in communicating demand requires ensuring that the right individuals receive timely communications regarding changes in demand or the results of demand-influencing and prioritizing activities. Information must be disseminated to fit the needs of the person receiving the information, such as providing demand data in dollars for finance but in units for operations.

Focusing communications also requires that each person receive just the information he or she needs to make an informed decision. Too little information can lead to an inability to decide on the best course of action. For example, if inputs to the demand plan consist of just a set of demand numbers without the supporting assumptions, risks, opportunities, and uncertainties, the process of synchronizing and reconciling differing estimates will amount to guesswork. Too much information can also hinder decision making. If the demand data used in the demand consensus review meetings consist of multiple pages of detailed graphs and charts, it could result in key problems being hidden from discussion or an inability to get through the entire planning horizon (e.g., all 18 plus months) during the meeting.

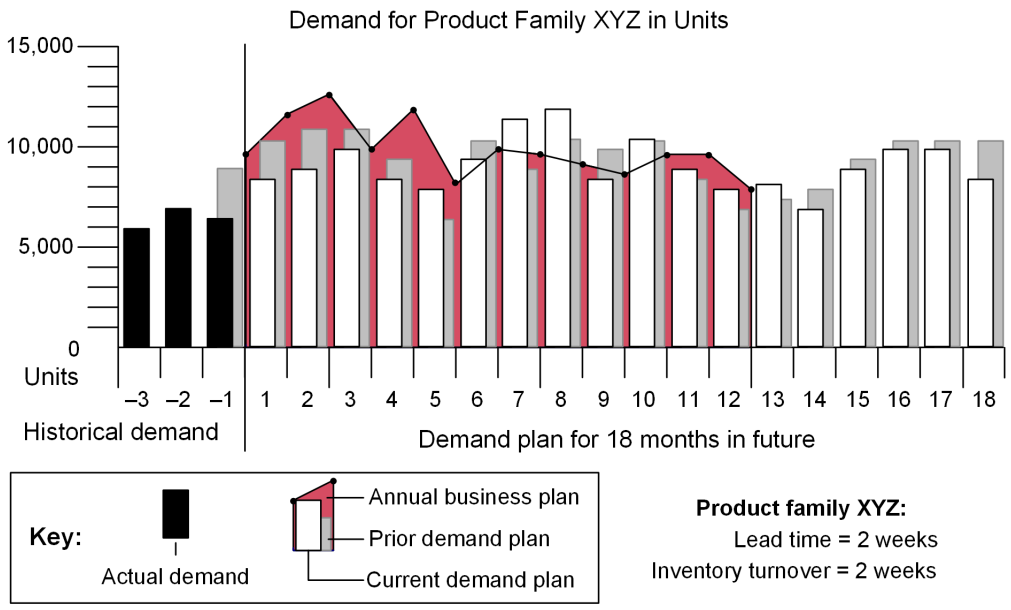
A key tool to help focus communications to fit the audience is to use dashboards, which are software presentations of key information from the organization's information systems. Dashboards can be tailored by each user to show just the key performance indicators and information useful to that person. The user can quickly determine when things are running smoothly and when exceptions require attention. For example, there may be two dashboards for a demand consensus review meeting, one in units and one in dollars showing the financial results of the unit plan.

The following elements are important to include in demand dashboards for demand consensus review:

- Historical demand data for the past three months or more, with relevant key performance indicators and metrics for each month
- Demand plan for the next 18 months or more (For each month, this shows the demand plan [actual request for product] and, for comparison, the demand that is necessary to achieve the goals in the organization's business plan.)
- Prior demand plan (Since plans are revised each month, the prior demand plan can be shown as a point of reference and reasons for significant changes can be discussed.)
- Assumptions made in demand numbers and pricing assumptions
- Planned branding, marketing, and sales promotions activities
- Key risks, opportunities, economic trends, and competitor actions
- Subtleties and uncertainties
- Events and issues of note and decisions that were made

Exhibit 1-26 shows just the graphic portion of a dashboard for a demand plan in units. The exhibit illustrates how the revisions from the prior demand plan can be made obvious so that significant changes can be discussed. Note that to be complete, the dashboard would also need the other information listed in the prior bullets. This nuanced information is what enables decision making regarding the true state of demand, plan feasibility, actions that need to be planned and executed to meet the plan and business objectives, and actions to keep supply and demand in synch.

Exhibit 1-26: Example of a Demand Plan Dashboard—Units



Topic 2: Influencing Demand

One structured, iterative process that can be used to ensure that demand-influencing activities are being continually adapted to current situations is the plan-do-check-action model. We also review the marketing side's demand-influencing levers: the 4Ps (product, price, placement, and promotion). After that, since different types of influencing are needed for different life cycle stages, these life cycles are first introduced and then their use in product life cycle management (PLM) is described. PLM involves additional focus on both the very early stages of a product life cycle as well as the ending of sales and service.

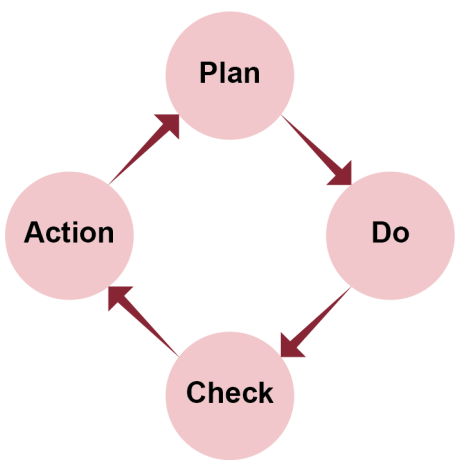
Plan-Do-Check-Action Model

Succeeding at influencing demand requires not only generating and executing marketing and sales initiatives but also determining if the plans are working as intended. If they are not, there must be a process in place to make course corrections during execution. One way to do this is by using the **plan-do-check-action (PDCA)** model**,** which is defined by the *APICS Dictionary,* 16th edition, as

> a four-step process for quality improvement. In the first step (plan), a plan to effect improvement is developed. In the second step (do), the plan is carried out, preferably on a small scale. In the third step (check), the effects of the plan are observed. In the last step (action), the results are studied to determine what was learned and what can be predicted.

The PDCA model, shown in Exhibit 1-27, incorporates performance measurement, feedback, and replanning into the processes of planning and executing activities. Note that while PDCA is described here for demand influencing, it can be applied to any process, including the other components of the demand management process and the sales and operations planning (S&OP) integration process.

Exhibit 1-27: Plan-Do-Check-Action Model



Plan Phase

During the “plan” phase, product/brand management, marketing, and sales perform research and develop detailed strategies and tactics for influencing demand. The plans should include a budget, a schedule, and a list of tasks assigned to specific individuals for accountability. The plans should also set measurable targets indicating the increase in demand that the activities should generate. The plans are reviewed and approved prior to the S&OP meetings and are adjusted as needed during those meetings, resulting in commitments to execute a consensus plan.

Do Phase

During the “do” phase, product and brand management, marketing, and sales execute the plans. Product and brand management professionals launch, manage, and retire products. Marketing professionals work to create demand and reinforce the brand value. Salespersons work to acquire new customers and retain and develop existing customers. Sales and marketing professionals may be

required to provide the demand manager with periodic data on actual results. The marketing and sales managers and the demand manager exercise management and control during this phase by serving as problem solvers and by verifying that the correct activities are occurring.

Check Phase

During the “check” phase, the demand manager and/or other demand-side managers review metrics against the plan and document other feedback, such as customer opinions on product pricing, features, and customer service levels. A key aspect of this phase is to determine the root cause of any differences between plan and actual results, that is, whether they arise from identifiable internal or external factors. These activities are performed periodically rather than waiting until the processes are complete. Dashboards are a common way to track and monitor metrics for demand-influencing activities.

Action Phase

During the “action” phase, the demand manager leads replanning efforts to respond to variances from the plan and address root causes of the variances. Replanning may call for increased or decreased investments in various activities depending on what is and is not proving effective. The replanning process could be part of the lead-up to the monthly S&OP process, or it could be performed more frequently if required. However, many marketing efforts take a long time to show measurable results, so a long-term focus is typically necessary.

Demand Influencing: Demand Generation

A key aspect of demand influencing is called demand generation. Demand generation involves translating latent demand identified during market research into active demand for a product or service using various forms of communications with potential customers.

Demand generation is critical for new product introductions since most new products fail. The market could either stay with the product it already knows or just not notice the new product. With no historical data to guide forecasts, marketing and sales have to operate on instinct, experience, connections to past products, and market research. A great deal depends upon that research. And the rest depends upon what the marketing experts do with that research, both in the product design phase and during the introduction.

Most of all, the product really has to give the market what it wants.

If market analysis has correctly identified the needs and desires the new product can satisfy, marketing at least has a good chance to develop a campaign that triggers robust sales. Of course, all those sales have to be matched by production and delivery so your supply chain doesn't run out of stock and have to turn away eager buyers.

Marketing's major responsibilities when developing a campaign for a new product or rebranding an existing product include educating customers and supply chain partners.

- **Educating customers.** The potential buyer has to know that your product is out there. Marketing has to know where buyers are and how to reach them. This means crafting the right message, one that emphasizes the product's unique benefits and connects them to customer needs and desires that were uncovered during market research. Generating product and brand awareness are activities that often take longer and require more effort than is planned and budgeted for. Therefore, a longer planning horizon and regular feedback on marketing progress are necessary to increase the chances of a successful product introduction.

The message also has to be conveyed through the appropriate media: print ads (Which periodicals?), television, or internet advertisements (Which programs and time slots or websites? Which ad agency? Which style of presentation?), social media presence, email, telemarketing, in-person visits, public seminars, and so on.

Finally, marketing has to know who the buyer is. That's not always as obvious as it sounds. For example, a new type of exterior junction box may have to be marketed to, and accepted by, developers, general contractors, carpenters, and electricians as well as regulators and inspectors. Getting the word out will probably require personal visits and demonstrations. The end user, the

homeowner who may eventually plug some outdoor lights into that box, is actually of no importance in the marketing campaign.

- **Educating supply chain partners.** Part of getting a product accepted is getting it understood by those who have to design, build, transport, and sell it. Working in conjunction with engineers, suppliers, logistics managers, retailers—and whoever may be involved along the way (like those homebuilders in the preceding junction box example)—marketing has to be certain that the product is produced, carried, stored, and sold by people who understand it. Training and job aids may have to be designed and delivered at multiple levels.

Before using product, price, placement, and promotion to influence demand, a foundational aspect of influencing demand is to influence the organization to support actual customer expectations and needs. However, this influence must be directed toward the organization's business objectives. Specifically, this means that the organization should support only products and services that have a positive contribution margin. A positive contribution margin means that the increased demand will increase net income (profit) rather than simply increasing sales volume or revenue. Expanding product mixes and varieties to satisfy all customers could otherwise result in unsustainable costs and growth.

Demand-influencing activities may also involve convincing customers to accept substitutions or changes in purchase timing. The purpose of demand influencing is to support the organization's business objectives, and sometimes the best way to support these objectives is to convince customers to purchase an alternative product or to delay purchases. Substitution may occur because one type of product is in surplus or because there is limited capacity and not all customers can be served without making full use of all products in a product family. Convincing customers to delay purchases or wait in some form of queue can also accommodate capacity limits. In another example, a promotion or discount could be timed to a period in which there is excess production capacity. Similarly, new product introductions or decisions to drop a product line can be timed to lessen the impact on other product lines.

Influence over departments such as marketing and operations is not a given, and this is especially the case when dealing with multiple organizations. Developing and maintaining influence requires leadership skills and a certain amount of humility. For example, a supply chain partner may have very good reasons for wanting to have a sale in a particular month. Collaboration on influencing demand may require listening, understanding positions, selling the benefits of changes to partners, and reasonable compromise.

The Four Ps of Marketing and Demand Shaping

The *APICS Dictionary,* 16th edition, defines the **four Ps** as

> a set of marketing tools to direct the business offering to the customer. The four Ps are product, price, place, and promotion.

The four Ps are part of what is called demand shaping. The *Dictionary* defines **demand shaping** as

> the practice of using the four Ps … and other market variables to influence the demand of a product or service so that the demand better matches the available supply.

Product and brand management, marketing, and sales activities influence demand by developing products that customers are actually demanding, settling on the most profitable product mix, setting strategic pricing, placing products at various physical or online distribution points to establish a presence and level of customer convenience, and promoting products through advertisement and other means.

Customer-focused marketing, customer segmentation, and customer relationship management (CRM) philosophies have transformed these components of traditional marketing to respond to the changes in today's marketplace. In traditional marketing, there was a product aimed at a single targeted audience. There was one price, one channel of distribution, and one marketing message. In customer-focused marketing, a product/service package might be marketed to a particular niche segment or customized to appeal to the needs and wants of several market segments.

A customer-focused strategy may contain all of the traditional components of a marketing program or may, depending on the situation, focus on one or two components. We will therefore continue to use the terms of traditional marketing to describe the components of a customer-focused program.

Product

"Product" for our purposes includes both products and services or product/service packages. In traditional marketing, a product or service was designed to appeal to a large group of consumers. The product was essentially static—perceived in much the same way by all customers. Consumer needs were important, but they were not the starting point. For example, electricity was offered to the public before the public expressed any specific needs that it would address. The technology was what was being sold; marketing and time would create the need. Similarly, the first home computers were introduced before there was broad consumer need; it took at least 10 years and the growth of the internet to create the need.

In a customer-focused world, the starting point for a product/service package is often customer need. Food products are often designed by specialized companies to appeal to the needs of certain groups. For example, a highly engineered meat substitute may deliver improved taste to a consumer who

doesn’t want to compromise on the desired taste experience but still wants a healthier alternative at times.

Increasingly, product/service packages may be designed to be customizable for specific customer segments. This allows the seller (or supply chain) to add desired value and competitive differentiation to the product and ideally sustain or grow profit. For example, a manufactured building like a barn or storage facility may have elements (like windows, doors, partitions, porches, or trim) that can be combined in various ways to create structures that meet very specific needs and tastes. The same credit card may actually be multiple card programs distinguished by features that offer values to specific groups, such as low transfer rates, frequent flier mileage, or co-marketing partners.

Value-added products have various implications for a customer-focused program:

- The product itself must be designed to fulfill customer expectations and pose few challenges for customer use. This necessitates extensive research and/or customer involvement.
- The product must be manufactured or created to meet quality levels that satisfy customer expectations and business profit margins. Performance must be continuously and scrupulously measured.
- Promotion and distribution must be customized as well to address the distinctive needs of a segmented audience. The performance of the program must be tracked so that the program can be retooled for higher performance.
- Sales methods may need to be customized and measured for effectiveness. The sales force must be thoroughly familiar with each product they sell—with its intended audience and use as well as with the marketing goals for the product. Ideally, they should be aware of what the customer has bought before.
- Customer care personnel must also be familiar with each product variation, its use, and its potential problems. Ideally, they should be familiar with what the individual customer has bought and the status of the order without having to be told by the customer.

Price

Pricing is generally a strategic decision, based on competition, perceived value, and brand identity. While some businesses may still calculate profit by adding an acceptable and competitive price margin to the total costs of creation, sales, and overhead, many take a more nuanced approach to pricing. If the market is highly competitive and a product has become a commodity, price will be dictated by the competitive situation, but in a more differentiated marketplace, pricing becomes more subjective.

In pricing a new drug, for example, a pharmaceutical company may consider not only their research and development, marketing, and manufacturing costs but also the value of the drug to patients. How much would a person pay for a drug that enabled him or her to return to work or that caused fewer side effects? How much would a person pay if there were no other products on the market that could do this?

In the customer-focused business model, price and product are tightly connected. Price may be another way to differentiate products for specific customer segments. For example, a credit card company may waive annual fees for highly desirable customers who carry a balance from month to month. A computer company may create product/service packages for different customers. Customers who buy more frequently or who buy more expensive systems may receive free upgrades to higher-performance features or may receive free in-home repair service.

Obviously, strategic pricing must be carefully and frequently analyzed to ensure that the pricing structure is attractive to customers but still profitable to the business. Specific sales data for customer segments are invaluable, as they can help automate delivery of messages intended to move customers into different pricing groups.

What pricing is too high to penetrate the market? What pricing is too low to cover salaries and bonuses and still return a profit? Demand is not an absolute; it increases and decreases depending on many factors, and price is often the major variable. Demand may rise as the price falls, but even that correlation has its limits. Some products sell better at a price slightly more than that of the competition, because a higher price adds to their status appeal. A light bulb may be perceived as a better value due to a higher price and a recognized brand name, even if its generic equivalent is produced on the same production line and is identical but for the name. But for some products, and in some markets, the “everyday low price” draws customers in. Synchronizing the selling price with the costs of design, manufacturing, and logistics is an area in which marketing can collaborate across functions and companies.

Placement

Placement, or distribution, is another task that falls to the marketing department. Where is the right place—or the right combination of places—to sell the product to the target market in sufficient quantity to meet the demand forecast?

Placement has traditionally referred to the way in which a product is sold—how the product or service gets into the hands of the customer. A company might decide, for example, to distribute its product through warehouses and retail outlets, through a direct sales force calling on customers, or through a website. It’s worth noting that placement was traditionally a one-way form of communication: product being placed by shipping it to outlets or selling it through a sales force, or customers placing orders.

In the most traditional location—retail store shelves—placement can include the design of the display. While this might seem to fall naturally within the competence of the retailer, in VMI (vendor-managed inventory) partnerships the supplier may design and construct the display as well as manage the replenishment.

In the customer-focused model, placement is often referred to as the contact channel strategy. It is a means to increase profitability, first by ensuring that the most cost-effective and customer-preferred

channel is used for distribution and second by securing lifetime customers through effective customer care and research activities.

Customer-focused placement may be determined by customer segment. Essentially identical product may be distributed through different channels that have been chosen because they match the communication and contact preferences of different customer groups. Airline tickets may be sold on the internet, at automated kiosks, at counters, over the phone, via mobile device app, or through intermediaries (agencies). Different means of placement may affect pricing, however. High touch customer service methods may command a premium price.

Improved transportation has made placement itself a key element in a product/service package. For example, placement may be customized according to the customer's need for fast delivery (regular speed, faster, overnight). Other transportation may specialize in consistent delivery that is neither early nor late.

Customer-focused placement requires a more interactive form of communication than traditional placement does. Since customers must be satisfied and since information about the customers' actions and attitudes is critical to the business, information must flow back and forth between the business and the customer. Thus, in the customer-focused model, placement includes the way in which the customer gains information about the product and post-purchase support. Interactive contact channels include call centers, online repositories that allow customers to find desired information, websites that incorporate live dialogue or email communication, and chat rooms for users. Many sites provide incentives for users to share more information, such as getting a free demo of the product for filling out a survey.

One-way channels may also be used in customer-focused placement; these include direct marketing (direct mail, mass mailings by fax or email, telemarketing, and social media presence) and media-based marketing (television, radio, newsprint, periodicals, trade publications, banner ads, billboards, etc.).

Throughout the communication process, information is continually being gathered. This information may point out commonalities and trends that suggest future product crafting, promotion, and support.

Technology has greatly changed customer care. It's hard to imagine a new product introduction campaign that doesn't use e-commerce as part of the mix. A website is necessary even if only for informational purposes. Many products can be both advertised and sold online through one's own site or through third-party sites. Customers can download software and hardware documentation and manuals, refer problems to automated expert systems, consult information databases, and communicate with technical support or even other customers about problems or questions. Digital products can be advertised, ordered, and shipped via the web; software applications, music, movies, and written materials are examples.

The channel strategy must be continuously evaluated to ensure that it is fulfilling the needs of both the customer and the business. From the customer's perspective, an effective channel has the following characteristics:

- **Accessible.** Are help lines toll-free numbers? Do the hours of operation facilitate different time zones or work schedules? Do websites reflect current or real-time changes? Can the customer contact the organization by chat or text?
- **Reliable.** Are materials or services available within the expected time frame without exception? Is the social website always operational?
- **Complete.** Can the customer get accurate, current, and complete answers?
- **Secure and error-free.** Is e-commerce adequately encrypted? Are orders taken accurately?
- **Direct.** Can the customer reach someone who can assume ownership for the issue, has decision-making authority, and can resolve a problem? Are questions easily answered by phone or automation?
- **Convenient.** How many handoffs does the customer have to pass through before reaching someone who can actually solve a problem or answer a question? How much hunting on the website is necessary? How long is a caller on hold?
- **Fast.** Does the customer have to repeat account and problem information or can all the customer care personnel access this information automatically? Does the customer receive a quick response to emails or phone messages?
- **Flexible.** Can the business be reached easily by those with and without computers? Are there accommodations for non-native speakers?

From the business's perspective, the channel must allow the following:

- **Control and consistency.** Does the channel promote the intended values, ideas, or content? Is every customer's experience the same?
- **Profitability.** Does the channel minimize the use of expensive human resources, for example, by using automation whenever possible?

Promotion

The last of the four Ps, promotion, includes such marketing activities as consumer research and market analysis; segmentation of customers or audience; setting of strategy for targeted segments; planning, creation, and placement of advertising; and creation of brand image. It also involves determining and

communicating the timing of marketing and promotional activities and collecting feedback on their impact.

All of the traditional promotional activities are still valid in a customer-focused business model. What is different is the level of research, segmentation, and customization of the promotional message or offer that is possible. With customer relationship management technology, businesses can capture information about every interaction with customers. This enables unparalleled opportunities to study buyer motivation and behaviors and to segment customers into groups with distinctive CRM programs. Printing technologies allow for cost-effective customization of advertising materials. The explosion of communication channels—including not only the web but also satellite radio, podcasts, and email—allows businesses to select alternative channels that offer clear advantages for specific audiences.

Let's look more closely at two factors related to promotion: branding and packaging.

- **Branding.** Customer-focused promotion helps to create the brand. As defined in the *APICS Dictionary,* 16th edition, **branding** is "the use of a name, term, symbol, or design, or a combination of these, to identify a product."

  An organization's or product's brand can be worth a considerable sum to market analysts. Google's and Facebook's brands were worth billions at the time of this printing. The worth of such brands is based partly on current market share and total number of customers and partly on image, which is an intangible quality that sums up a brand's awareness, popularity, and reputation. As is said about reputation, brand image is something that takes years to build up but that could be destroyed in an instant. Therefore organizations take great pains to protect their brand image.

  Part of educating customers about a new product is choosing a name and logo that emphasizes product characteristics that will attract targeted segments. If the initial research accurately measures customer needs and attitudes, and if the product's design successfully incorporates those selling points, then the name should follow suit. Automobile names often highlight concepts that appeal to a target market. Dodge Ram emphasizes toughness and power; Jaguar suggests grace, speed, and elegance; Honda Civic implies a sensible, economical city car.

  A new product's name and the logo that represents it visually can either link the product to an existing product family or set it apart. The name Macintosh kept the familiar association with Apple but also signaled the advent of a new line of products. Sometimes a new model can be created from an existing model simply by acquiring a different name.

  Perhaps because of the rate of change in product availability, customers are increasingly transferring their loyalty from specific products (e.g., a line of jeans) to the provider of those products (i.e., the retailer who keeps those jeans available in the right size). They grant their business to these organizations because they trust that they will find the products they are looking for and that they will

be taken care of if any problems occur. This means that businesses must keep in close touch with what customers want and are buying so that they can continually upgrade, alter, or customize product and supply chain options to meet customer expectations. They must also ensure customer satisfaction. Because customers are more aware of service, products, and the personal experience they should receive, a single failure may undo the brand image and drive customers to a competitor. Dissatisfied customers have the means to make their disloyalty well known. Complaints posted on popular apps, websites, blogs, tweets, chat rooms, or other social media can have a significant impact on today's internet-savvy customer and can destroy a once-strong business relationship.

- **Packaging.** The package that contains a product also serves a marketing purpose. The more obvious marketing elements of packaging—colors, images, words, even the textures of the wrapping—are marketing devices.

The package should command attention and reinforce the features and benefits that sell the product. (Market research such as focus groups provide this insight.) Some packages are educational or functional—like food boxes containing cooking instructions on the outside or packaging that facilitates proper cooking of the item.

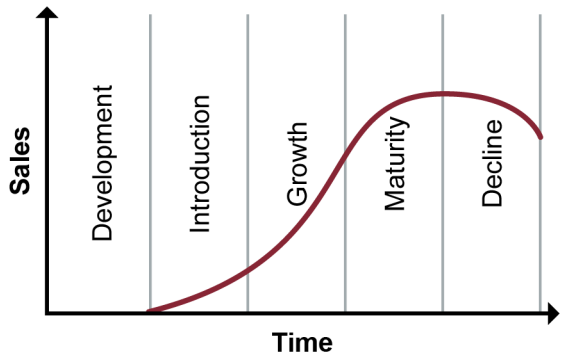
Packages can promote other organizational goals such as sustainability. Hewlett Packard's laser cartridges are packaged in a box that can be used to return the spent cartridge, thus solving the end user's reverse logistics problem and protecting the environment. Market research likely determined that such a box would increase the number of cartridges that were returned, which would reduce net costs even after the free shipping expenses were included.

Services, too, are "packaged" for sale. Presentation of meals, design of hospital waiting rooms, and the uniforms worn by many service personnel—all these matters of style and appearance serve a marketing purpose.

Product Life Cycle Stages

Product design is only the first step in a product's life cycle. In supply chains, it is important to remember that after a product has been designed, produced, and sent off into the market, the product life cycle undergoes different stages that impact how the supply chain for the product might be handled. The **product life cycle** can be defined as "the stages a new product goes through from beginning to end." (Refer to the *APICS Dictionary,* 16th edition, for more information.) As illustrated in Exhibit 1-28, an extended product life cycle includes development, introduction, growth, maturity, and decline.

Exhibit 1-28: Product Life Cycle



- **Development.** Product (or service) development is the incubation state of the product life cycle. There are no sales at this point as the organization prepares to introduce the product. Traditionally, this is the period when market research, product design or service definition, testing, and finalization are accomplished.

- **Introduction.** During the introduction stage, sales of the product or service will be low until customers become increasingly aware of it and its benefits. The organization is likely to have additional costs associated with establishing distribution of the product or service. The higher costs added to the low sales volume typically make this stage a time of negative profits.

- **Growth.** The growth stage is a time of rapid revenue growth. Sales increase as more customers become aware of the product and its benefits. Once the product has proven success and customers begin seeking it, sales will continue to increase as retailers become interested in offering the product. Distribution may be expanded at this point. During this stage, competitors may enter the market. The organization's promotional costs may increase in order to sustain market share.

  As the base of customers and distributors grows, businesses must commit increased resources to both satisfying the market's needs and gathering and analyzing data in an ongoing manner. Production and inventory levels must be managed to avoid stockouts or delays that could lead to customers switching brands. A make-to-stock strategy may work well for many products in the growth stage.

- **Maturity.** The maturity stage is the most profitable. While sales continue to increase, they do so at a slower rate. Competition will result in decreased market share and/or prices. The competing products may be very similar at this point, making it difficult to differentiate them from that of the organization.

- **Decline.** Eventually sales begin to decline as the market becomes saturated, the product becomes technologically outdated, or customers' tastes change. If the product has developed brand loyalty, profitability may be maintained longer, but with the declining production volumes and increased unit costs, eventually no more profit will be made. Organizations that used a make-to-stock strategy may need to transition to a make-to-order strategy to prolong profitability as long as possible. Ideally, new products have been developed and the cycle will continue.

One purpose of learning the differences between these phases is to enable product life cycle analysis. The *Dictionary* defines **life cycle analysis** as

> a quantitative forecasting technique based on applying past patterns of demand data covering introduction, growth, maturity, saturation, and decline of similar products to a new product family.

Product Life Cycle Management

The*APICS Dictionary*, 16th edition, defines **product life cycle management** as

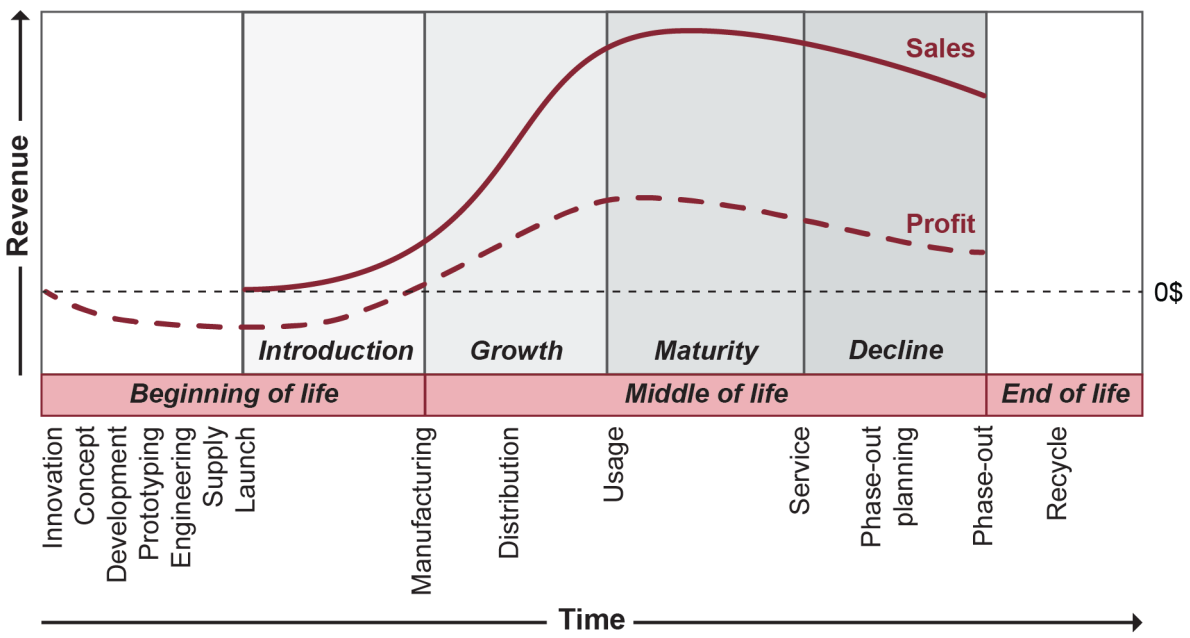
> the process of facilitating the development, use, and support of products that customers want and need. PLM helps professionals envision the creation and preservation of product information, both to the customer and along the reverse-logistics portion of the supply chain.

Product life cycle management (PLM) is a process of managing new product introductions, managing the life cycles of products throughout their phases, and creating and executing end-of-life plans. PLM may feature a sustainability component, especially if products at the end of their lives must or should be reclaimed or recycled. PLM can be managed using software of the same name or can be performed using a mix of manual tools and existing systems.

In addition to helping manage the product life cycle for a type of product, PLM software also has tools to help manage the individual life cycle of a unit or a batch. It often includes tools to help planners with product, component, and bill-of-material versioning, effectivity plans (plans for when to make a particular set of engineering drawings and documents be the official version as of a particular effectivity date), and traceability. PLM software can help track products by production lot numbers or serial numbers all the way to the customer for individual units or batches. This helps enable upgrades, recalls, and reverse logistics for units or batches at any stage of production.

PLM from a product and brand management perspective builds off of the product life cycle stages of introduction, growth, maturity, and decline but adds substeps. Some models also highlight three distinct phases: beginning of life, middle of life, and end of life. Beginning of life includes a new component of research and development plus the introduction stage. The middle-of-life phase encompasses growth, maturity, and decline. The end-of-life phase is new to the product life cycle (but implied by it). Exhibit 1-29 shows these phases and lists potential substeps in PLM. (Specific substeps may vary.)

Exhibit 1-29: Product Life Cycle Management



The substeps shown above contain many steps for the beginning-of-life phase. The middle-of-life phase shows how the focus area during growth starts by ensuring that manufacturing and distribution are capable and have the capacity for the demand. As the product moves into maturity, this shifts to a focus on how the product is used. The focus then shifts to service as the product enters decline. Decline also features phase-out or end-of-life planning. Actual phase-out ends the decline phase. There may be a mandatory support and service provision period for the expected life of the last products sold or, at a minimum, for the warranty period. The organization may be involved in helping recycle the products at the end of their lives, and this could also include recovering rare or hazardous materials, remanufacturing, repurposing or selling manufacturing equipment, reassessing suppliers, and so on.

New Product Introduction Schedules

Developing a new product introduction (NPI) schedule involves mapping out and managing the process. This may include using project management. NPI is a component of the development chain, which parallels the supply chain and interacts with it at many points. In addition to NPI, the development chain may include product engineering, make-or-buy decisions, early supplier involvement, concurrent engineering, strategic sourcing, supplier footprint, and contracting with capable suppliers. Here are some potential phases in NPI or the development chain:

- **Innovation**. During this phase, research is conducted. This can include market research (e.g., collecting and disseminating customer feedback), competitor scanning, experimentation, and invention.
- **Concept**. Research coalesces into a vision of the product/service that is vetted for customer demand and financial promise.
- **Development**. Engineering, manufacturing, and other functions may work together to add detail to the concept through a number of iterations. Concurrent engineering or design for manufacturability,

logistics, or the environment may be applied to ensure that the product will be cost-effective to source, make, and deliver.

- **Prototyping**. A working model of the product and related services is developed. A prototype's purposes include proving feasibility and eliciting feedback. A prototype schedule helps manage iterations of the prototype that capture feedback both from the demand side and the supply side. Demand-side inputs include focus groups and market-based release deadlines; supply-side inputs include make-or-buy analysis, supply availability, production feasibility and cost, product architecture (e.g., integrated versus modular), scalability and economies-of-scale plans, and capacity requirements versus current load.

- **Engineering**. Engineers develop the product structure and bills of material, including detailed drawings, tolerances, level of modularity, and manufacturing requirements. A document management system can be used to help manage configuration (versions) and collaboration efforts.

- **Supply**. Supply requirements are developed, capable suppliers are identified, and the supply footprint is mapped out. It is important at this point to review supply constraints that may impact the NPI schedule. In addition to finding capable suppliers fast enough, another supply constraint is lead time versus cost, which can be significant due to global sourcing. This differs by product type:
  - Innovative products typically require compressed timelines to shorten time to market.
  - Functional products tend to have low margins, making cost the primary factor.

- **Manufacturing**. While manufacturing is listed in Exhibit 1-29 as a middle-of-life activity, clearly manufacturing capability and capacity need to be developed earlier, at least to the degree needed for the first planned phase of demand. The manufacturing choices are also determined. Future demand growth may later require more investments in capacity and throughput.

- **Launch**. Marketing and sales launch the product and foster awareness of it.

Note the mention above of innovative versus functional products. Different sorts of products will require different NPI frequencies and different supply chain strategies to make them work, as discussed more next.

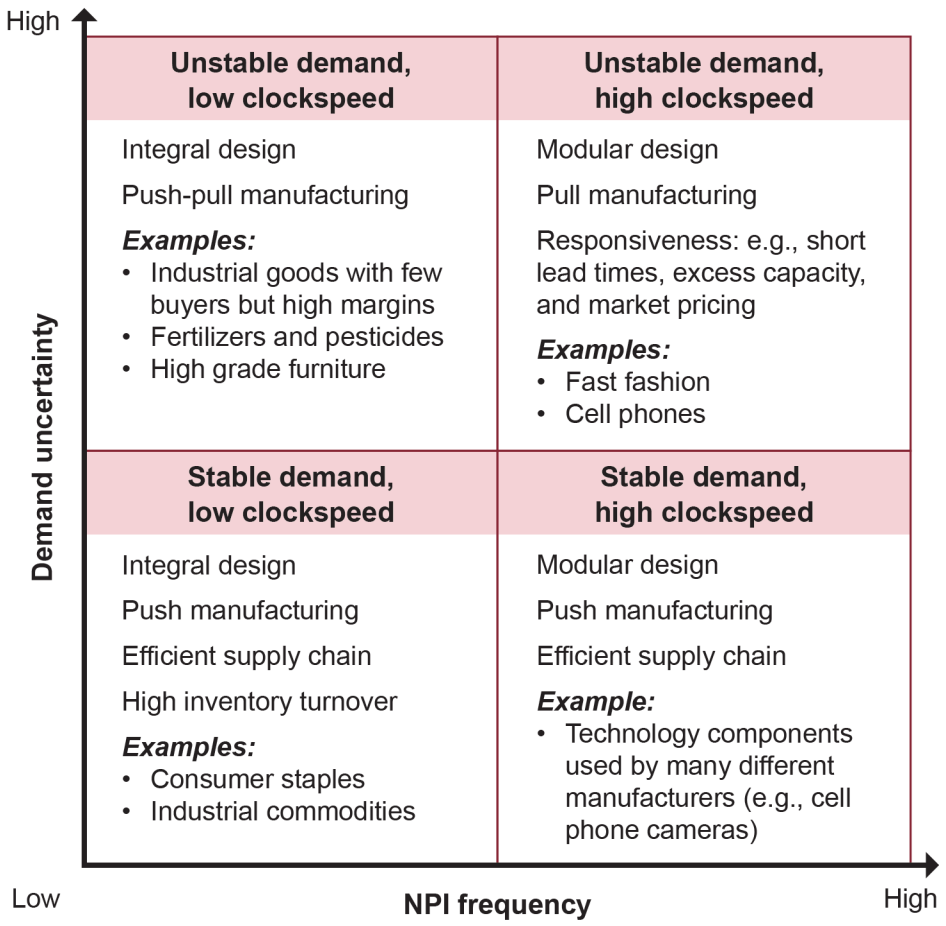
NPI Frequency versus Demand Uncertainty

New products occupy a spectrum from innovative products at one end to functional products at the other end. *Designing and Managing the Supply Chain* cites an article by Marshall Fisher, who coined the term technology clockspeed. Clockspeed is the rate of technology change for the given industry, market, or product. Clockspeed strongly influences the duration of the product life cycle. Innovative products have fast technology clockspeeds and life cycles, while functional products have slow technology clockspeeds and life cycles. Fast clockspeeds require compressed NPI schedules.

The product design strategy and the supply chain strategy need to align with the type of product being developed. For example, organizations that have a strategic focus on innovation as their basis of competition may have one supply chain specifically dedicated to new product introductions and a different supply chain for established products. They will also need to ensure that new products are designed for the supply chain (in part by collaborating with suppliers) so speed, dependability, or cost objectives can be met.

An important supply chain factor to consider is demand uncertainty. Items with low demand uncertainty can be pushed out to the market because there is steady demand. Items with high demand uncertainty should move more toward a pull model so that only what is demanded is produced. Exhibit 1-30 compares NPI frequency to demand uncertainty, which results in four quadrants of product types.

Exhibit 1-30: NPI Frequency Versus Demand Uncertainty



As shown in the graphic, the four categories of products are as follows:

- **Unstable demand, low clockspeed**. The life cycle for the products is long, and the products can have an integral design (not modular). The products can be pushed to a certain point (e.g., components produced based on a demand forecast), and then demand-pull can take over (e.g., final assembly in response to actual customer orders). This could occur by centralizing inventory and drop-shipping, for example.

- **Unstable demand, high clockspeed**. Due to the high rate of change and short life cycles, manufacturing uses pull manufacturing (e.g., make-to-order) and highlights responsiveness over cost. Modular designs, short lead times, maintaining excess capacity, and dynamic market pricing can help ensure that supply can quickly respond to changing demands.

- **Stable demand, low clockspeed**. These are staple items that have low margins and need to be produced economically and create high turnover to ensure profitability. Since these are make-to-stock items, they can have an integral design.
- **Stable demand, high clockspeed**. There are few finished goods in this category, but many types of components fit in this area if enough buyers exist to keep demand stable. Due to the short product life cycles, modular designs enable variations on products, and, as NPI occurs, portions of the product or component that don’t need to change might be able to be used in the new version. Push manufacturing and supply chain efficiency help ensure profitability.

Section D: Forecasting

This section is designed to

- Describe the principles of demand forecasting
- Describe qualitative forecasting methods, including judgmental/expert judgment forecasting and the Delphi method
- Describe quantitative forecasting methods, including time-series and associative forecasting
- Use a forecasting process to select the right forecasting model, including by visualizing forecast data in charts to see trends
- Differentiate time-series methods, including naive forecasting, the simple moving average, the weighted moving average, and exponential smoothing
- Understand that forecasts with seasonality need to be deseasonalized prior to forecasting, after which the seasonality is added back in
- Describe how simple regression (an associative forecasting method) uses an independent variable such as a leading indicator to predict a dependent variable such as future sales
- Describe how service industries may forecast demand by the hour
- Discuss the basic concepts in measuring forecast error
- Understand the features of mean absolute deviation, the tracking signal, standard deviation, mean squared error, and mean absolute percentage error.

Marketing or sales typically conducts forecasting, but supply chain managers rely on these predictions for multiple decisions related to synchronizing supply and demand, ensuring that the right amount of warehouse space or transportation services are available, and so on. Supply chain managers need to know how forecasts are created and what can go wrong with them, because a forecast that is biased or has too much error can directly result in numerous incorrect decisions being made in the supply chain, all with a significant cost.

Topic 1: Forecasting Principles and Process

There are numerous techniques available to use when developing a forecasting process. Whatever the process, however, it needs to be formulated with the following basic forecasting principles in mind. After that, a generic forecasting process is provided to show the big picture.

Principles of Forecasting

According to the *APICS Dictionary,* 16th edition, **forecasting** is

> the business function that attempts to predict sales and use of products so they can be purchased or manufactured in appropriate quantities in advance.

The purpose of forecasting is to engage in demand planning. The *Dictionary* defines **demand planning** as

> the process of combining statistical forecasting techniques and judgment to construct demand estimates for products or services (both high and low volume; lumpy and continuous) across the supply chain from the suppliers' raw materials to the consumer's needs. Items can be aggregated by product family, geographical location, product life cycle, and so forth, to determine an estimate of consumer demand for finished products, service parts, and services. Numerous forecasting models are tested and combined with judgment from marketing, sales, distributors, warehousing, service parts, and other functions. Actual sales are compared with forecasts provided by various models and judgments to determine the best integration of techniques and judgment to minimize forecast error.

Everything in the supply network depends upon the number of customers that make purchases from the wholesaler, retailer, or direct sales/website offering your product: manufacturing, capacity, warehousing, transportation, location and type of retail outlets, amounts of raw material to extract—everything. If production outstrips demand, you suffer financial losses or worse. If orders exceed supply, your frustrated customers may go instead to your competitor.

Forecasting demand is a necessary part of business planning. You have to have some guidelines when deciding how much product you're likely to sell and how much, therefore, you need to produce. **Demand forecasting** is "forecasting the demand for a particular good, component, or service" (*Dictionary*). Even make-to-order business models need to have sufficient capacity and components prepared prior to receiving customer orders.

A number of principles of forecasting follow that, if understood, help people know how to best conduct forecasting and how much to rely on the results.

Forecasts Should Be Based on Demand Rather than Orders.

Forecasting needs to be based on an estimate of actual demand rather than on customer orders, which can differ from actual demand in important ways. Customer orders are often the starting point for estimating demand, but they should not be the ending point. Orders from intermediate customers such as distribution centers, distributors, and retailers can include quantities ordered not due to actual demand but instead due to other decisions, such as in anticipation of a shortage. Given stockouts, an

estimation should be made of the sales that would have occurred if there had not been a stockout. Similarly, customer orders need to be modified to account for returns.

Forecasts Are (Almost) Always Wrong.

No matter how sophisticated the statistical technique, no matter how wise and experienced the experts, a forecast is at best an estimate of what may happen in the future—if there are no surprises. Even if the sales force were able to poll every potential customer for a new product or service, there would be some degree of error in the forecast for individual selling or shipping locations. Circumstances and minds can change. For this reason, forecasts require regular review. Forecasting techniques should be reviewed if forecast errors grow too large.

Forecast uncertainty is one potential contributor to the bullwhip effect, the observation that demand fluctuations at the retail level tend to be magnified in orders placed further up the supply chain. The more forecasts miss their target, the more orders vary, with that variation expanding up the supply chain.

Conventional “forecasting” all too often assumes that each sales period should yield an increase of some arbitrary percentage of the volume from the prior year, but this is a business goal, not a forecast. The forecast needs to avoid bias by being data-driven rather than goal-driven.

Forecasts Should Include an Estimate of Error.

Just as opinion polls often specify a margin of error (e.g., 40 percent favorable rating plus or minus three percent), demand forecasts should include an estimate of how large the forecast error is likely to be. Statistical analysis of the variability of demand around the average demand provides the basis for this error estimate. If your forecast error grows unacceptably large over time, you know that you need to either improve the forecasting process or arrange your supply chain to accommodate a large amount of uncertainty. Error estimates should also be given in terms of the monetary value of the error so that the errors with the most dollars at risk can be addressed first.

Forecasts Are More Accurate for Groups than for Single Items.

Accuracy generally increases with the size of a product group, assuming that forecasts for each item in the group are as likely to be too high as too low. The low forecasts tend to balance out the high forecasts, at least in sizable groups.

The general principle at work in these cases is risk pooling—taking individual risks and aggregating them into a pool. The overall risk for the pool tends to be less than the average of all the risks that flow into the pool. Risk pooling can also refer to centralization of inventory.

For instance, a retailer will have better luck forecasting demand for all blue jeans than for loose-fit Levi brand jeans. A hospital will be better able to forecast numbers of surgeries than numbers of quadruple heart bypass procedures.

In a similar fashion, a manufacturer can improve production forecasting accuracy by pooling the demand forecasts for all customers who order the same product—all wholesalers who order the same brand or style of blue jeans, for example. The manufacturer uses the improved forecast to its advantage if it can send large orders of the trousers to a distributor who serves multiple customers. Any errors on the low side for individual customers may balance errors on the high side for others, and they will all be drawing from the same supply. (This is the other meaning of risk pooling.)

Forecasting at more detailed levels is still needed, but the detailed levels are reserved for the shorter-term forecasts. For example, an overall product family forecast may still require a mix forecast later in the process. **Mix forecast ,** as defined by the *APICS Dictionary,* 16th edition, is a

> forecast of the proportion of products that will be sold within a given product family, or the proportion of options offered within a product line…Even though the appropriate level of units is forecasted for a given product line, an inaccurate mix forecast can create material shortages and inventory problems.

Forecasting at more detailed levels for shorter-term forecasts is acceptable due to the principle to be discussed next.

Forecasts for the Near Term are More Accurate than for the Long Term.

The further you extend a forecast into the future, the more likely that chance and change will derail your estimates. (For similar reasons, lenders generally charge more interest for long-term loans than for short-term loans.) While an item-level forecast would be very likely to have significant error if conducted for a long horizon, when a very short horizon is used, the potential for significant error is much lower.

Forecast accuracy review against actual results also can be tied to an appropriate time horizon. Long-term forecasts are generally reviewed on an annual or quarterly basis, medium-term forecasts on a monthly basis, and short-term forecasts on a weekly basis. In addition to regular reviews, taking steps to shorten the required lead time for items can shorten the forecasting horizon and thus improve the accuracy of forecasts.

Forecasting Process

Here are the steps in the forecasting process:

1. **Determine the purpose of the forecast.** For example, to determine manufacturing or purchasing targets, capacity, or service staffing.
2. **Determine the level of aggregation and what will be forecasted.** Specify units of measure and total sales, product family, product, or stock keeping unit (SKU).
3. **Determine the time horizon.** Specify a short-, medium-, or long-term forecast and the planning bucket (e.g., by week, month).
4. **Visualize the data.** Map any available historical data on a graph to see if they have obvious trends or seasonality. This will help when selecting the forecasting method.
5. **Choose the forecasting method or model.** You can choose qualitative or quantitative methods or both. For quantitative methods, decide if a time-series forecast or an associative forecast would work better, and choose a subtype. If historical data are available and the trend appears to be relatively steady, a time-series forecast is a good choice. If no data are available or the trend changes frequently, it may be best to develop an associative forecast based on elements that appear to be driving the changes in the trend.
6. **Prepare the data.** Gather data to be used as forecast inputs. If the visualization showed strong seasonality, remove this temporarily using deseasonalization.
7. **Test the forecast using historical data.** If historical data are available, prepare a forecast for a few periods back from the present and compare the forecast results to the actual historical results. Forecast using multiple methods to find the most accurate one.
8. **Forecast.** After making any necessary adjustments, use the model. If seasonality was removed from the data, add it back in. Any qualitative adjustments would be made at this point.
9. **Perform sales and operations planning.** The result is that demand-side, supply-side, and financial professionals arrive at a single demand forecast that everyone agrees to use. This is called a one-number system (one forecast).
10. **Periodically review and improve models for accuracy.** Monitor and control error levels and continually improve models.

Topic 2: Forecasting Methods

Forecasting methods can be qualitative (based on experience and judgment), or they can be quantitative (based on historical or publicly available data and calculated). Quantitative methods can be a projection of historical data over time, which is called time-series forecasting, or be based on trend indicators such as government data on leading indicators, which is called associative forecasting. Various methods can also be combined.

Qualitative and Combination Methods

Qualitative forecasts rely on judgment rather than math. These methods lack scientific precision but can be used on their own in volatile situations or when there are no historical data available, such as for a new product. Sometimes a similar product might be used as a proxy, and this possibility should be explored prior to resorting to a pure qualitative forecast. Qualitative forecasts depend on the experience level of the forecasters, so results can vary widely. This can be true even when a qualitative method is used to adjust a quantitative method.

Bias is a real risk when using qualitative forecasting on its own or after quantitative forecasting. Estimators may be motivated to estimate too high or too low depending on their incentives. For example, a salesperson could estimate too low to make a sales target easy to reach, while a culture of optimism might lead to aggressive sales goals. One way to mitigate bias is to ask estimators to provide a pessimistic estimate, a most likely estimate, and an optimistic estimate. The three estimates can be combined and divided by three (the simple average), or the most likely estimate can be given more weight. A common way is to multiply the most likely result by four (putting four times more weight on this estimate) and then divide the total result by six:

$$\frac{\text{Optimistic} + (4 \times \text{Most Likely}) + \text{Pessimistic}}{6}$$

Two common types of qualitative forecasting are judgmental/expert judgment forecasting and the Delphi method.

Judgmental/Expert Judgment Forecasting

Executives, salespersons, market analysts, and others can use their detailed knowledge of their products and their customers, along with their memory of the differences between prior forecasts and actual results, to generate a forecast or, more often, to adjust a quantitative forecast. Tracking these adjustments separately from any quantitative component will help in determining whether these modifications are increasing or decreasing accuracy and in showing whether they are introducing bias by being consistently high or low.

Delphi Method

A more involved and sophisticated qualitative forecast can be created by surveying experts and collating their responses into a document that keeps the responses anonymous. The compiler continues to work toward consensus in successive rounds by highlighting areas where there is disagreement and allowing responders to change their responses after reading the current group opinion. Anonymity is used for two reasons. First, it helps prevent dominant personalities or emotions from influencing the group opinion, called the “groupthink” effect. When the groupthink effect is in play, otherwise independent thinkers might become emotionally committed to an unrealistic forecast. The other problem anonymity prevents is a “stake in the ground” mentality. This is when a person has

already publicly committed to a forecast result and doesn't want to lose face by changing his or her declared position. Since the position is anonymous, it is easier to change given more information. This method has had good success at arriving at reliable forecasts, but it is time-consuming and labor-intensive. It is often used only for strategic-level estimation.

Combination Methods

Good forecasting is best done with a combination of quantitative and qualitative considerations. For example, a forecaster for an electronics company might use a mathematical model to estimate demand for future periods. The forecaster should then modify the projection with all pertinent and available intelligence. This could include knowledge of competitor sales promotions or product launches, the state of the economy, trends in discretionary spending, and so on. The assumptions used need to be openly discussed so that everyone can arrive at a shared set of assumptions. Documenting the assumptions is important for post mortems.

When using combination methods, both the quantitative forecast and the qualitatively adjusted forecast can be measured separately for error to determine the degree to which qualitative methods are helping or hindering forecasting.

Quantitative Methods: Time-Series Forecasting

Quantitative forecasting uses mathematical formulas to predict future results based on past trends. Two basic categories are time-series and associative. Time-series forecasting is more commonly used because the methods are less complex mathematically and thus easier to explain to decision makers. Time-series methods assume that the factors that influenced the past will continue on into the future. When that trend is unlikely to be stable, associative forecasting may be needed.

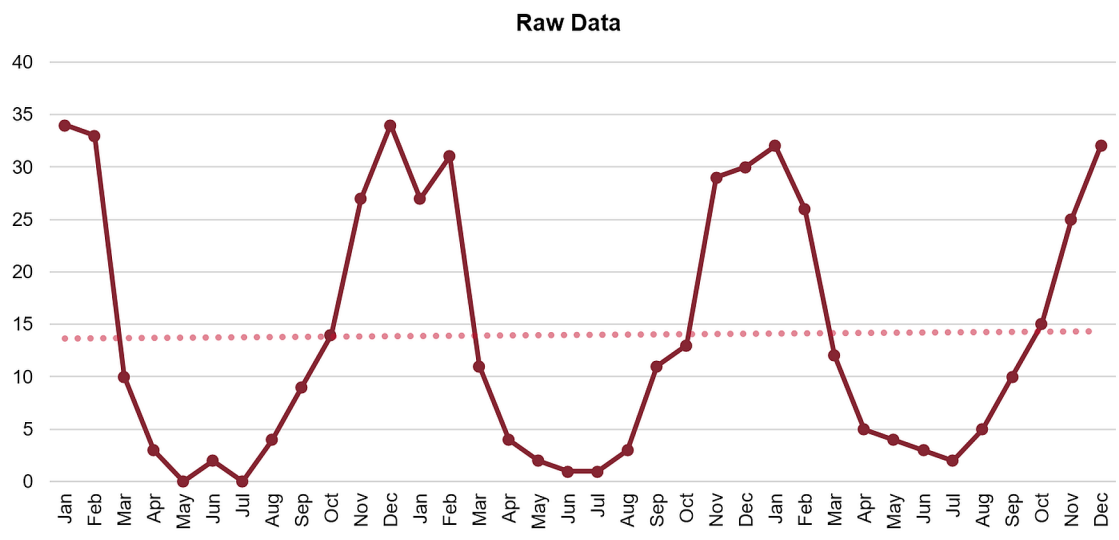
There are a number of types of time-series forecasting, ranging from the very simple to the relatively complex. Naive forecasting is the simplest; it assumes that the last period's demand will be this period's forecast. It can be cost-effective but does not account for trends, and any random spike or trough in demand would be carried forward. The naive method is not discussed further in this text.

Other time-series methods include the simple moving average, the weighted moving average, and exponential smoothing. We'll examine these in a moment, but first we'll look at some of the steps in time-series forecasting.

Visualizing

Visualizing the data is an important part of forecasting because you can often spot seasonality or other trend or cycle information very quickly and decide how best to forecast. Exhibit 1-31 shows some visualized raw data for a product with strong demand in the winter months and very low demand in the summer months.

Exhibit 1-31: Visualize the Raw Data



In this case, the data for three years were placed in Microsoft Excel™ and one of the features was used to generate a chart automatically. An additional option was selected to automatically calculate the linear trend, shown as the dotted line. It is slightly upward-sloping. However, the waves are very strong, showing strong seasonality. A time-series forecast done during a seasonal upswing would predict this upswing to keep on going upward, while your visual review clearly shows that the upswing will very likely go to a downswing in a predictable manner. The seasonality needs to be removed (deseasonalizing) or the results will be of little use.

Deseasonalizing

The process of deseasonalizing data involves generating a seasonal index. Calculating a seasonal index requires several years' worth of data (for seasonality that occurs over an annual period). The data used to create the chart in Exhibit 1-31 are shown in Exhibit 1-32 below along with the calculations required to find the seasonal index.

Exhibit 1-32: Creating a Seasonal Index

	A	B	C	D	E	I
1		Raw Data				
2	**Month**	**Year 1**	**Year 2**	**Year 3**	**Month Average**	**Seasonal Index**
3	Jan	34	27	32	31.00	2.214
4	Feb	33	31	26	30.00	2.143
5	Mar	10	11	12	11.00	0.786
6	Apr	3	4	5	4.00	0.286
7	May	0	2	4	2.00	0.143
8	Jun	2	1	3	2.00	0.143
9	Jul	0	1	2	1.00	0.071
10	Aug	4	3	5	4.00	0.286
11	Sep	9	11	10	10.00	0.714
12	Oct	14	13	15	14.00	1.000
13	Nov	27	29	25	27.00	1.929
14	Dec	34	30	32	32.00	2.286
15	**SUM**	170	163	171	168	
16	**Year Average**	14.17	13.58	14.25	14.00	

If you would like to experiment with an interactive version of the worksheet used as a running example for both time-series forecasting and error calculations, download the "Forecasting Model" spreadsheet from the Resource Center.

The index is calculated as follows, using monthly time buckets with three years of data. (Other time periods and buckets could be used instead.)

1. **Calculate the month average for each month.** The month average is the sum of each year's results for a given month divided by the number of years. For example, January results for year 1, year 2, and year 3 are summed and divided by 3 to find the month average of 31 units. This is then done for each of the other months.
2. **Calculate the year average.** Sum the 12 month averages and divide by 12. In the example, this is 168/12 = 14 units. This year average is deseasonalized because it averages out the rise and fall in sales.
3. **Calculate the seasonal index.** Divide each month average by the year average. In Exhibit 1-32, the seasonal index for January is 31/14 = 2.214. This is repeated for each other month. Note how the months with higher-than-average demand have an index over 1.0 while months with lower-than-average demand have an index of less than 1.0.

The general formula for calculating the seasonal index is

$$\text{Seasonal Index} = \frac{\text{Average Demand for Period (e.g., Month)}}{\text{Average Demand for all Periods (e.g., Year)}}$$

The next step in the deseasonalization process is to apply the seasonal index to the raw data, which will result in deseasonalized data.

Deseasonalizing data involves dividing the raw data by the seasonal index for the given month. Exhibit 1-33 shows this for the year 1, year 2, and year 3 data. For example, the January year 1 data of 34 units was divided by 2.214, resulting in 15.35 units. The process is repeated for each of the 36 data points.

Exhibit 1-33: Generating Deseasonalized Data

	A	B	C	D	E	I	J	K	L
1		Raw Data					Deseasonalized Data		
2	**Month**	**Year 1**	**Year 2**	**Year 3**	**Month Average**	**Seasonal Index**	**Year 1**	**Year 2**	**Year 3**
3	Jan	34	27	32	31.00	2.214	15.35	12.19	14.45
4	Feb	33	31	26	30.00	2.143	15.40	14.47	12.13
5	Mar	10	11	12	11.00	0.786	12.73	14.00	15.27
6	Apr	3	4	5	4.00	0.286	10.50	14.00	17.50
7	May	0	2	4	2.00	0.143	0.00	14.00	28.00
8	Jun	2	1	3	2.00	0.143	14.00	7.00	21.00
9	Jul	0	1	2	1.00	0.071	0.00	14.00	28.00
10	Aug	4	3	5	4.00	0.286	14.00	10.50	17.50
11	Sep	9	11	10	10.00	0.714	12.60	15.40	14.00
12	Oct	14	13	15	14.00	1.000	14.00	13.00	15.00
13	Nov	27	29	25	27.00	1.929	14.00	15.04	12.96
14	Dec	34	30	32	32.00	2.286	14.88	13.13	14.00
15	**SUM**	170	163	171	168				
16	**Year Average**	14.17	13.58	14.25	14.00				

Simple and Weighted Moving Averages, Exponential Smoothing

Once the data are deseasonalized, they are ready for use in forecasting with the simple and weighted moving averages and exponential smoothing.

- The **simple moving average** is the average of demand from several preceding periods. Three- and six-month periods are commonly used. For example, a three-month moving average would be calculated as follows, where M1, M2, and M3 are the three most recent months:

$$\text{3-Month Moving Average} = \frac{(M1 + M2 + M3)}{3}$$

This is a moving average because it is recalculated using the most recent set of months (or other periods), dropping the oldest month and adding the just-ended month to the list.

The simple moving average can be useful when demand is relatively constant from period to period. The method can be used to prevent an overreaction to a random or irregular spike or dip in a given month because it smooths out these variations. However, if there is a change in a trend, this method would be slow to respond to it. It would lag the trend, in other words, so is best used when a trend is relatively flat. Using more periods. such as a six-month moving average, will make the method even less sensitive to random variation by smoothing more, but it would also make it lag a trend more.

One disadvantage of averaging multiple periods is that data collection and organization can be complex when multiple products in a product family need to be forecasted.

- The **weighted moving average** (or weighted average) forecasting method places weights on the periods being averaged, usually to put greater emphasis on the more recent periods and relatively less emphasis on the more distant periods. Thus it allows trends to have more of an impact on the forecast. The weights are usually selected using expert judgment and trial and error. While any weighting system can be used, only testing against historical data can prove whether a given set of weights is a better predictor than another set.

  When calculating the average, you divide by the sum of the weights rather than the number of periods. For example, if the third month out is given a weight of 1, the second month out a weight of 2, and the most recent month a weight of 3, you would divide this three-month weighted moving average by (1 + 2 + 3) = 6, for example:

$$\text{3-Month Weighted Moving Average} = \frac{(1 \times M1) + (2 \times M2) + (3 \times M3)}{6}$$

- **Exponential smoothing** uses three inputs in its equation: the last period's forecast, the last period's demand, and a smoothing constant, a number greater than 0 and less than 1 represented by the Greek letter alpha (α), which is basically a percentage weighting where 1 = 100 percent. One way to calculate exponential smoothing is

$$\text{New Forecast} = (\alpha \times \text{Last Period's Demand}) + [(1 - \alpha) \times \text{Last Period's Forecast}]$$

  Using this equation produces a weighted average of previous results. As you increase α closer to 1.0 or 100 percent, you get closer and closer to a naive forecast, with 1.0 being a naive forecast since it is 100 percent weighted on last period's demand and 0 percent weighted on the prior period's forecast. A constant of 0.3, on the other hand, would put 30 percent of the weight on the last period's demand and 70 percent on the last period's forecast. This constant smooths out random or irregular spikes or dips in actual demand by placing more weight on the prior forecast. Most organizations select a smoothing constant between 0.05 and 0.5. A constant of 0.05 would give minimal weight to the preceding period's actual demand, while 0.5 would equally weight the actual and forecast results. The constant value is selected by experience, trial and error, and testing against historical data.

  This method is often used when you want to minimize the lag that exists when trends shift, but, like all time-series models, it cannot eliminate this lag.

Exhibit 1-34 shows how the simple and weighted moving averages and exponential smoothing would be calculated in a worksheet. All of the data shown in the exhibit are still deseasonalized. The data would be entered in columns, and formulas would be entered (or dragged down) wherever the numbers are bold. The last column in the left-side version shows deseasonalized actual results. Also in this

version, each month's forecast would be created as soon as the actuals for the necessary number of periods become available.

Exhibit 1-34: Comparison of Forecasts (Deseasonalized Data)

$$\text{Exponential Forecast} = (\alpha \times \text{Last Period's Demand}) + [(1 - \alpha) \times \text{Last Period's Forecast}]$$

$$16.87 = (0.3 \times 14.92) + [(0.7) \times 17.71]$$

	A	C	D	E	I
19		Deseasonalized			
20		**Moving Average**	**Weighted Average**	**Exponential**	**Actual Demand**
45	Jan	14.45	14.45	**13.43**	14.45
46	Feb	12.13	12.13	**13.74**	12.13
47	Mar	15.27	15.27	**13.26**	15.27
48	Apr	17.50	17.50	**13.86**	17.50
49	May	28.00	28.00	**14.95**	28.00
50	Jun	21.00	21.00	**18.87**	21.00
51	Jul	28.00	28.00	**19.51**	28.00
52	Aug	17.50	17.50	**22.05**	17.50
53	Sep	14.00	14.00	**20.69**	14.00
54	Oct	15.00	15.00	**18.68**	15.00
55	Nov	12.96	12.96	**17.58**	12.96
56	Dec	14.00	14.00	**16.19**	14.00
57	Jan	**13.99**	**13.82**	**15.54**	15.87
58	Feb	**14.28**	**14.76**	**15.64**	14.64
59	Mar	**14.84**	**14.94**	**15.34**	15.68
60	Apr	**15.40**	**15.36**	**15.44**	15.51
61	May	**15.27**	**15.42**	**15.46**	19.73
62	Jun	**16.97**	**17.65**	**16.74**	18.61
63	Jul	**17.95**	**18.47**	**17.30**	17.37
64	Aug	**18.57**	**18.17**	**17.32**	18.61
65	Sep	**18.19**	**18.19**	**17.71**	14.92
66	Oct	**16.97**	**16.56**	**16.87**	15.79
67	Nov	**16.44**	**15.97**	**16.55**	15.51
68	Dec	**15.41**	**15.50**	**16.23**	15.08

		Moving Average	Weighted Average
20			
45	Jan	14.45	14.45
46	Feb	12.13	12.13
47	Mar	15.27	15.27
48	Apr	17.50	17.50
49	May	28.00	28.00
50	Jun	21.00	21.00
51	Jul	28.00	28.00
52	Aug	17.50	17.50
53	Sep	14.00	14.00
54	Oct	15.00	15.00
55	Nov	12.96	12.96
56	Dec	14.00	14.00
57	Jan	**13.99**	**13.82**
58	Feb	**13.65**	**13.74**
59	Mar	**13.88**	**13.81**
60	Apr	**13.84**	**13.79**
61	May	**13.79**	**13.79**
62	Jun	**13.84**	**13.79**
63	Jul	**13.82**	**13.79**
64	Aug	**13.82**	**13.79**
65	Sep	**13.82**	**13.79**
66	Oct	**13.82**	**13.79**
67	Nov	**13.82**	**13.79**
68	Dec	**13.82**	**13.79**

$$\text{3-Month Moving Average} = \frac{M1 + M2 + M3}{3}$$

$$14.84 = \frac{14.00 + 15.87 + 14.64}{3}$$

$$13.88 = \frac{14.00 + 13.99 + 13.65}{3}$$

$$\text{3-Month Weighted Average} = \frac{(1 \times M1) + (2 \times M2) + (3 \times M3)}{6}$$

$$18.47 = \frac{(15.51) + (2 \times 19.73) + (3 \times 18.61)}{6}$$

$$13.79 = \frac{(13.79) + (2 \times 13.79) + (3 \times 13.79)}{6}$$

The smoothing constant selected for exponential smoothing in this example is 0.3. Exponential smoothing cannot be calculated unless the prior period's actuals are known, but you can use the other forecasting methods to project further into the future. To do this, you would substitute forecast data for demand data for those future periods, as is shown in the right-hand version.

Note, however, how the forecast quickly becomes repetitive when forecast data are used in place of actual results; after a few periods, everything is based on forecast data and an average or weighted average of the same three numbers results in the same number. It shows how these methods are less useful the further you go into the future.

Note that the three methods produce fairly accurate results, but there is some variance from the actual results for all three methods. The exponential method seems to do better in most periods, but the actual results of 14.64 units (cell I58) is lower than the predicted 15.64 units (cell E58), which will have an impact on the error for that period. However, it bounces back to being more accurate in March because of the 70 percent weight placed on the last period's forecast.

Reseasonalizing

Reseasonalizing involves multiplying the deseasonalized data by the given period's seasonal index to find the seasonalized forecast values. In Exhibit 1-35, the deseasonalized data for the moving average (the "Moving Year 4" column) is multiplied by the seasonal index and the resulting forecast in units is shown in the "Moving Average" column (column R). For example, the seasonal index of 2.214 for January is multiplied by the moving average January forecast of 13.99, resulting in 30.97 units (which would be rounded up to a forecast of 31 units). The weighted average and exponential columns are similarly calculated.

Exhibit 1-35: Comparison of Forecasts (Reseasonalized Data)

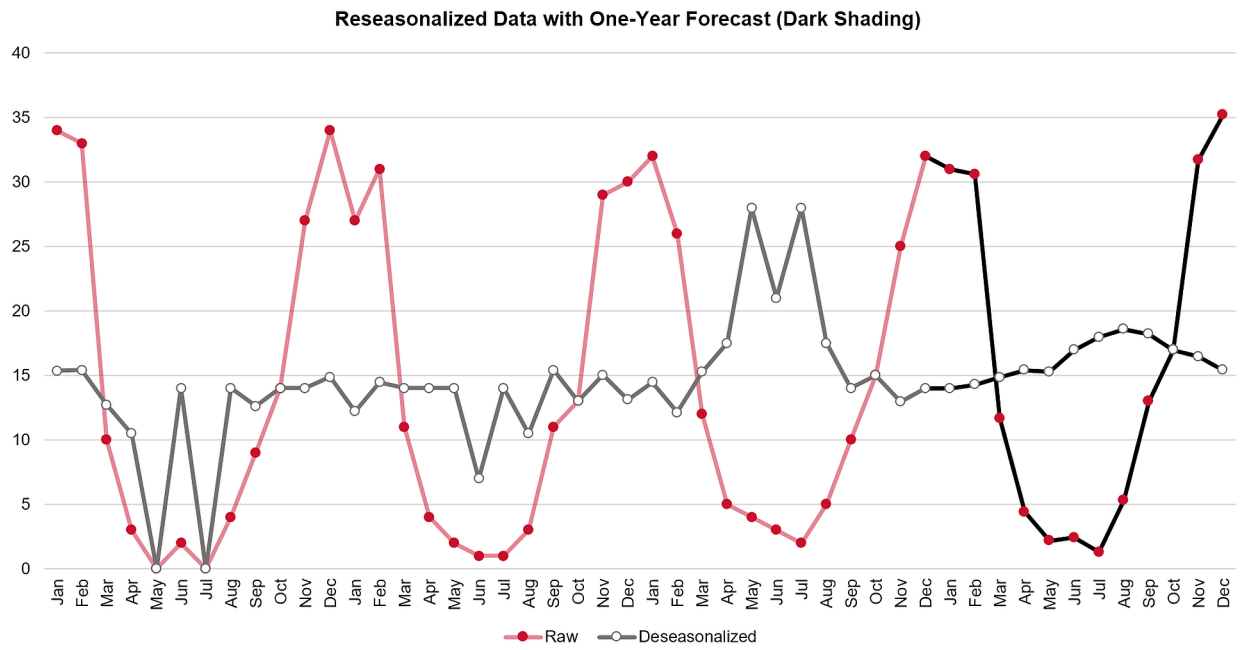
	A	I	O	P	Q	R	S	T	U
1			Deseasonalized			Year 4 Reseasonalized Forecasts			
2	Month	Seasonal Index	Moving Year 4	Weighted Year 4	Expon. Year 4	Moving Average	Weighted Average	Exponential	Year 4 Raw Actuals
3	Jan	2.214	13.99	13.82	15.54	30.97	30.60	34.40	34
4	Feb	2.143	14.28	14.76	15.64	30.60	31.64	33.51	29
5	Mar	0.786	14.84	14.94	15.34	11.66	11.74	12.05	13
6	Apr	0.286	15.40	15.36	15.44	4.40	4.39	4.41	5
7	May	0.143	15.27	15.42	15.46	2.18	2.20	2.21	5
8	Jun	0.143	16.97	17.65	16.74	2.42	2.52	2.39	3
9	Jul	0.071	17.95	18.47	17.30	1.28	1.32	1.24	2
10	Aug	0.286	18.57	18.17	17.32	5.31	5.19	4.95	6
11	Sep	0.714	18.19	18.19	17.71	13.00	13.00	12.65	11
12	Oct	1.000	16.97	16.56	16.87	16.97	16.56	16.87	16
13	Nov	1.929	16.44	15.97	16.55	31.71	30.80	31.91	30
14	Dec	2.286	15.41	15.50	16.23	35.21	35.44	37.11	33

Note the February year 4 actual results—only 29 units were sold. While all of the forecasts were high, the exponential forecast was off by the most. On the other hand, it returns to low amounts of variance right after that month of irregular demand and otherwise has lower error rates.

When you are done creating a forecast, it is generally useful to finish by visualizing the data again in chart form. You can also use charts to present the forecast to decision makers since they can make your forecast easier to digest. Exhibit 1-36 shows a chart with both the raw data and the deseasonalized data and uses dark shading to show a one-year forecast of demand using the three-month moving average method applied to the deseasonalized actual demand (which would become

available month by month). The resulting forecast is then reseasonalized. Note that the deseasonalized data would normally not be shown in a chart at all since it is not useful for making decisions in and of itself. It is simply used to produce the reseasonalized forecast for demand planning.

Exhibit 1-36: Deseasonalized and Reseasonalized Data with Forecast



When trends vary too much for these time-series methods to be useful in predicting demand (or anything else being forecasted), associative forecasting can be used.

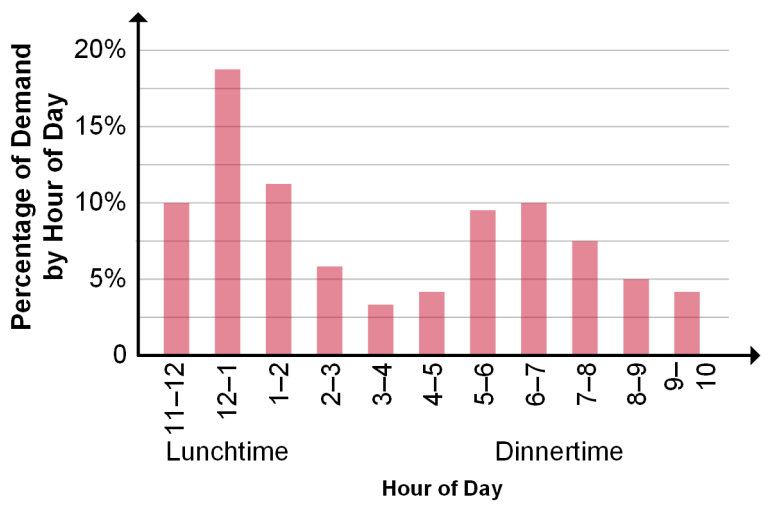
Service-Sector Forecasting

Some service businesses present special forecasting challenges, since their demand may fluctuate hour by hour rather than on a monthly basis. These rapid changes in demand have significant implications for scheduling and ordering.

Restaurants, for instance, must take into account variations in amount and type of demand by hour of the day, day of the week, and season of the year. They require sophisticated demand planning in more ways than one, since they have to guess right about not only the level of aggregate demand but also the amount of demand for each of the menu items. Running out of an item means disappointing some customers; stocking too much of a perishable item means financial losses and waste.

Computers can be invaluable in tracking point-of-sale data as they occur. Before automation, detailed tracking meant keeping a manual log during the day or sorting through receipts. Exhibit 1-37 illustrates the forecast for a fast-food restaurant's demand requirements from lunchtime through dinner.

Exhibit 1-37: Restaurant Demand by Hour of Day



These projections are useful in determining all the capacity requirements of a restaurant—numbers of workers to put on each shift, number of registers to maintain, number of tables, space requirements, and so on—as well as in making decisions about food items to stock.

Quantitative Methods: Associative Forecasting

Associative forecasting (also called causal, correlation, explanatory, or extrinsic forecasting) uses data gathered from one or more internal or external sources as a predictor of something that is presumed to be correlated. The predictor is called the independent variable. The element being predicted is called the dependent variable, and it could be demand for a product family or for total organizational sales.

While the time-series method is best for short- or medium-term forecasting, the associative method is best for long-term forecasting, especially at the aggregate level. Part of the reason for this is that these models require larger data sets and generally have higher costs; they use information with predictive value to form a forecast rather than just looking at past results.

Prior to discussing specific associative methods, let's look at the distinction between correlation and causation. We'll also examine leading versus lagging indicators, since they are often the predictors used in an associative forecast. After that, simple and multiple regression are covered.

Correlation Versus Causation

Correlation is an observation that the change in an independent variable has a measurable effect on a dependent variable. However, just because the effect can be reliably observed over time does not mean that the one thing caused the other thing. It could be that some third force is affecting both of them, or the correlation could be a coincidence that would be proven incorrect after a longer period of study.

Leading and Lagging Indicators

According to the *APICS Dictionary,* 16th edition, a **leading indicator** is "a specific business activity index that indicates future trends." Leading indicators provide information that enables organizations to anticipate or predict micro- or macroeconomic changes. Acknowledging trends allows a company to prepare to take action to achieve a certain outcome and avoid undesirable circumstances. For instance, if a residential hardware manufacturer researches the residential home market and sees that building permits are down and a recession is near, it may decide that it should order more inexpensive components from its suppliers for its faucet products, since consumers will probably be more interested in making repairs to existing hardware rather than buying brand-new faucets.

The following are some leading economic indicators:

- Building permits issued for new production facilities, housing, warehouses, utilities (Building permits imply future construction, and construction leads to other types of production.)
- Initial unemployment insurance claims (Initial claims for unemployment are more dependent upon business conditions than other unemployment metrics.)
- Orders for plant equipment or manufacturers' orders for durable goods and materials (New orders indicate increased production, which decreases inventory and increases unfilled orders.)

- Changes to the total amount of money in an economy that is available at a specific point in time—the money supply adjusted for inflation (Bank lending typically declines when inflation rises faster than the money supply, and this harms economic expansion.)
- Standard & Poor's 500 stock index (Investors' expectations about the economy and interest rates are reflected by changes in the stock prices of the 500 largest U.S. companies.)
- The difference between long- and short-term interest rates (The line that results from plotting, at a certain time, the market interest rates of a financial instrument— for instance, a bond—over a range of maturity dates is called a yield curve. An inverted yield curve indicates that shorter-term yields are higher than longer-term yields, a possible sign of an upcoming recession. Changes to the yield curve usually accurately predict economic swings.)
- The level of consumer optimism about the economy (Consumer expectations often indicate future changes in spending.)

Lagging indicators are the economic and financial factors that reflect the changes that have already occurred in the economy. They usually confirm a pattern and often provide data or actionable information about six months after the fact and therefore are more reactionary. For example, the unemployment rate is one of the most widely used lagging indicators. Generally, the unemployment rate will fall after a few months of economic growth. If a leading indicator of hours worked is increasing, after a few months the lagging indicator of unemployment should fall.

Some other lagging economic indicators include the following:

- Outstanding business and commercial loans (Demand for loans generally peaks about a year after a peak in the overall economy.)
- Comparison of inventory to sales (Increases in inventory usually mean that sales goals were missed, indicating a slowing economy.)
- Changes in company profits (Decreases in profitability have a domino effect often felt by many members of a supply chain.)
- Spending by businesses (Decreases in customer spending, particularly manufacturers' customers, ultimately result in a downturn in the manufacturers' business, too.)
- Consumer price index (CPI) (Increases in the prices of consumer-related service products usually occur within the first few months of a recession and taper off at the start of a recovery.)
- Average duration of unemployment (This is the average number of weeks an unemployed person has been out of work.)

By paying attention to both leading and lagging indicators, a company can reinforce that it is on the right track.

It is important to apply common sense when selecting indicators to use as independent variables (predictors). The indicators selected should be easy to measure, objective, pertinent to the strategy, cost-efficient, and embraced by the group whose processes are being analyzed. For example, a roofing

shingle company might predict sales of its roofing materials using data on the prior month's housing starts, total marketing spend, or extreme weather events like hurricanes. These make sense. However, even if data on recent college graduation rates correlate with roofing material sales, they are less likely to be a good predictor. Remember that chosen predictors need to make sense to decision makers, too.

Simple Regression

Simple regression (also called linear regression) uses a formula to make an association between the dependent variable y (the element being predicted) and the independent variable x (the predictor), with two other elements, alpha and beta. Beta (β) is the slope, which is a value used as a multiplier to find the correct placement of the forecast result. Alpha (α) is the intercept, which is where the slope intercepts 0 on a chart. In the case of the housing starts to roofing sales example, if there were 0 housing starts the prior month, what would roofing sales be? That is the intercept. These two values can be calculated manually for a data set, but often forecasters calculate them quickly using the free add-on data analysis toolset for Microsoft Excel.

Once you know these values, it is a simple matter of plugging the value for x (e.g., housing starts) into the formula below to find the forecast, *y.* Exhibit 1-38 shows the prior month's housing starts against the organization's total roofing sales and helps to explain how those two variables work.

$$y = \alpha + \beta x$$

$$\text{Roofing Sales} = \alpha + (\beta \times \text{Prior Month's Housing Starts})$$

Exhibit 1-38: Simple Regression Slope and Intercept Defined for Roofing Sales Example

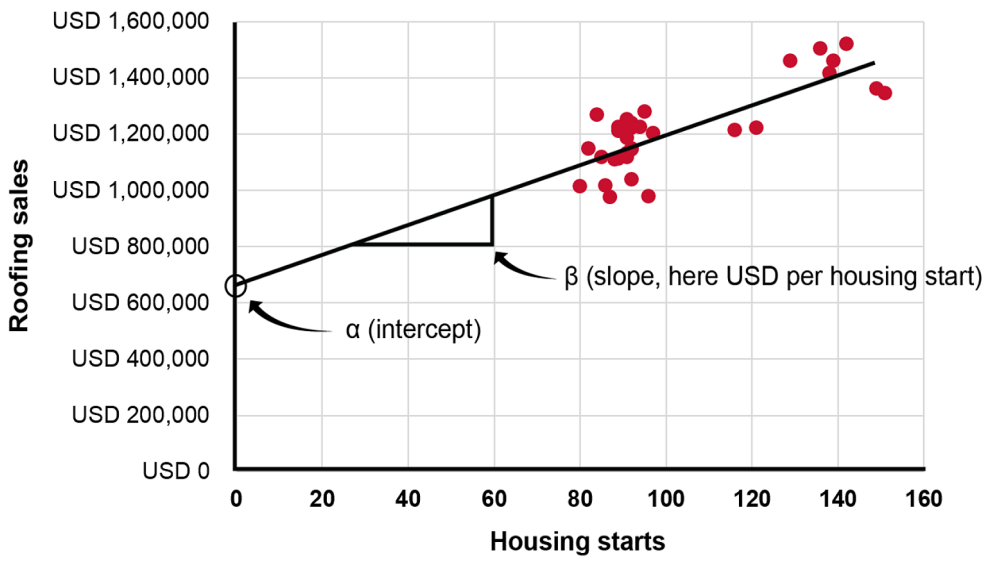
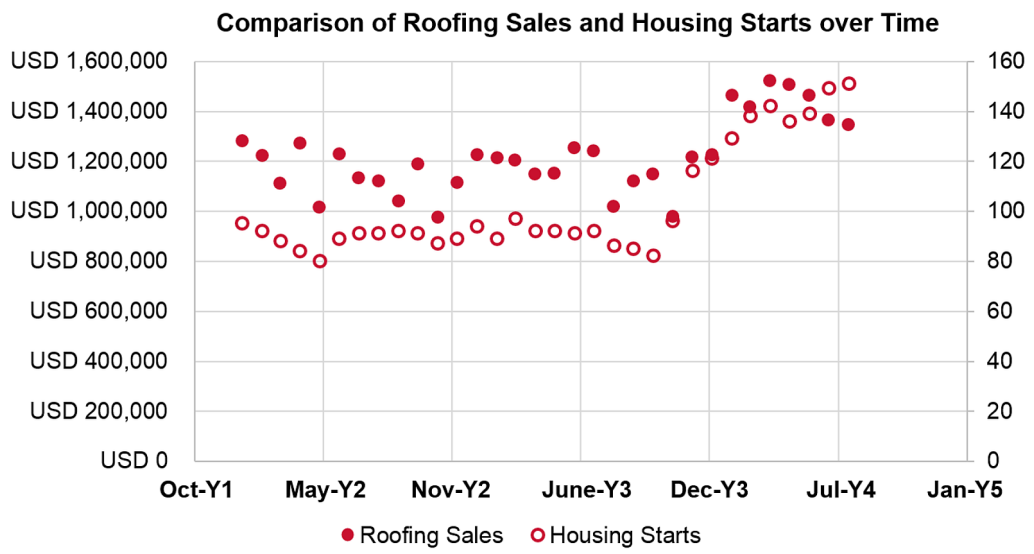


Exhibit 1-39 shows the same data, but now both housing starts and roofing sales are shown over time. This visualization shows that there is some correlation, so further analysis is worthwhile.

Exhibit 1-39: Simple Regression Slope and Intercept Defined for Roofing Sales Example



So, how do we tell whether there is enough correlation to use this predictor in our sales forecast? The statistical term that defines the strength of correlation is called the coefficient of correlation (r).

Basically, it is a number between –1.0 and +1.0 where

- –1.0 is perfect negative correlation: An increase in the predictor causes an equal decrease in the predicted element.
- +1.0 is perfect positive correlation: An increase in the predictor causes an equal increase in the predicted element, and a decrease in the predictor causes an equal decrease in the predicted element. (They rise and fall together.)
- 0.0 is not correlated at all.

In this example, the value is +0.79, which means that the element is positively correlated at about 79 percent, which is a strong positive correlation worth pursuing. Another way of stating this is that this predictor explains about 79 percent of the change in roofing sales, with the remaining factors being other causes. Weaker values would indicate that you should find some other predictor.

Multiple Regression

Multiple regression is an extension of simple regression; there are multiple predictive variables rather than just one. For example, one could add marketing spend as another predictor to the roofing sales analysis to see if this increases or decreases the predictive value of the model.

Topic 3: Measures of Forecast Error

Here we look at forecast error and accuracy and the effect of bias and random variation along with several error-tracking methods: mean absolute deviation, the tracking signal, standard deviation, mean squared error, and mean absolute percentage error.

Forecast Error and Accuracy

Since the first principle of forecasting is that forecasts are (almost) always wrong, organizations need to track forecasts against actual demand results and find ways to measure the size and type of error. Note that the size of an error can be measured in units or percentages, but often finding a way to put a monetary value on the error can help in focusing on the most expensive errors. (Being off by 1,000 on an item that costs US$1 will differ significantly from the same amount of error for an item that costs US$100.) Forecasters can use error measurements to modify forecasts to reduce the amount (and costliness) of error. If software does your calculations, the program can select the smoothing constant that will reduce your historical forecast errors to a minimum.

Forecast error is “the difference between actual and forecast demand” (*APICS Dictionary,* 16th edition).

The formula for forecast error as an absolute value follows. (Assume a time-series forecasting result with actual demand of 29 units and forecast demand of 33.51 units.)

$$\begin{aligned}\text{Forecast Error} &= |A - F| \\ &= |29\ \text{Units} - 33.51\ \text{Units}| \\ &= |-4.51\ \text{Units}| = 4.51\ \text{Units}\end{aligned}$$

Where
A = Actual demand
F = Forecast demand

An absolute value is a number that is stated without regard to positive or negative signs, so the absolutes of +4.51 and –4.51 are both 4.51. The equation above expresses the absolute value mathematically using vertical bars, e.g., $|-4.51| = 4.51$. Absolute values of forecast error are used in some of the error tracking methods discussed elsewhere, such as mean absolute deviation.

When expressing forecast error as a percentage (also known as absolute percentage error [APE]), the equation is as follows (with a continuation of the prior example):

$$\begin{aligned}\text{Forecast Error as a Percentage} &= \frac{|A - F|}{A} \\ &= \frac{|29\ \text{Units} - 33.51\ \text{Units}|}{29\ \text{Units}} \\ &= \frac{4.51\ \text{Units}}{29\ \text{Units}} \\ &= 0.155 = 15.5\,\%\ \text{Error}\end{aligned}$$

Forecast accuracy is simply the complement of the forecast error as a percentage, expressed as follows (with a continuation of the prior example):

$$\begin{aligned}\text{Forecast Accuracy} &= 1 - \text{Forecast Error as Percentage} \\ &= 1 - 0.155 = 0.845 = 84.5\,\%\ \text{Accuracy}\end{aligned}$$

Bias and Random Variation

Forecast error can be the result of bias or random variation.

- **Bias .** Bias is defined in the *APICS Dictionary,* 16th edition, as

  > a consistent deviation from the mean in one direction (high or low). A normal property of a good forecast is that it is not biased.

  Bias exists when the cumulative actual demand differs from the cumulative actual forecast. For example, if actual demand is 34, 29, and 13, cumulative actual demand adds these amounts to arrive at 76. If the forecast demand is 34.4, 33.51, and 12.05, the cumulative forecast demand is 79.96. Calculating bias can use a variation on the forecast error calculation, but it doesn't use absolute amounts because the plus or minus sign can show the direction of the bias:

  Cumulative Forecast Error
  = Cumulative Actual Demand – Cumulative Forecast Demand
  = 76 – 79.98
  = –3.96

  Any answer that does not result in zero reflects a bias. The size of the number reflects the relative amount of bias that is present. A negative result shows that actual demand was consistently less than the forecast, while a positive result shows that actual demand was greater than forecast demand.

  Bias could be the result of a temporary situation or an unaccounted-for change in a trend or seasonal effect. Tracking the circumstances surrounding each significant bias can help distinguish between the two. For example, bias caused by a one-time bulk sales order would not require modifying the forecasting model, but a significant shift in a trend or seasonal effect (or shifts in the timing of these effects to earlier or later periods) requires changes to the forecasting model (e.g., seasonal index or smoothing constant) or process (e.g., could be a result of overly optimistic qualitative adjustments).

- **Random variation.** In terms of measuring errors, random variation is any amount of variation in which the cumulative actual demand equals the cumulative forecast demand. For example, if actual demand is 100 for three periods, cumulative actual demand is 300, and if forecast demand is 90, 110, and 100, the cumulative forecast demand is 300. Because of the zero net difference, the error over this period can be said to be the result of random variation. Note that wide swings in either direction that just happen to balance out would still be difficult to plan around.

Mean Absolute Deviation (MAD)

A common way of tracking the extent of forecast error is to add the absolute period errors for a series of periods and divide by the number of periods. This gives you the mean absolute deviation (MAD). Note: In the formula below, the Greek uppercase letter ∑ stands for “the sum of.”

$$MAD = \frac{\Sigma|A-F|}{n}$$

where:
$\Sigma\,|\,A-F\,|$ = Total of absolute forecast errors for the periods
n = Number of periods

The *APICS Dictionary,* 16th edition, defines **MAD** as

> the average of the absolute values of the deviations of observed values from some expected value. It can be calculated based on observations and the arithmetic mean of those observations. An alternative is to calculate absolute deviations of actual sales data minus forecast data. These data can be averaged in the usual arithmetic way or with exponential smoothing.

With absolute values, whether the forecast falls short of demand or exceeds demand doesn’t matter; only the magnitude of the deviation counts in MAD.

We can see how this works using the time-series demand and smoothing forecast example shown in Exhibit 1-40. Note that error rates for all three methods are shown, but we will focus on the exponential smoothing method primarily.

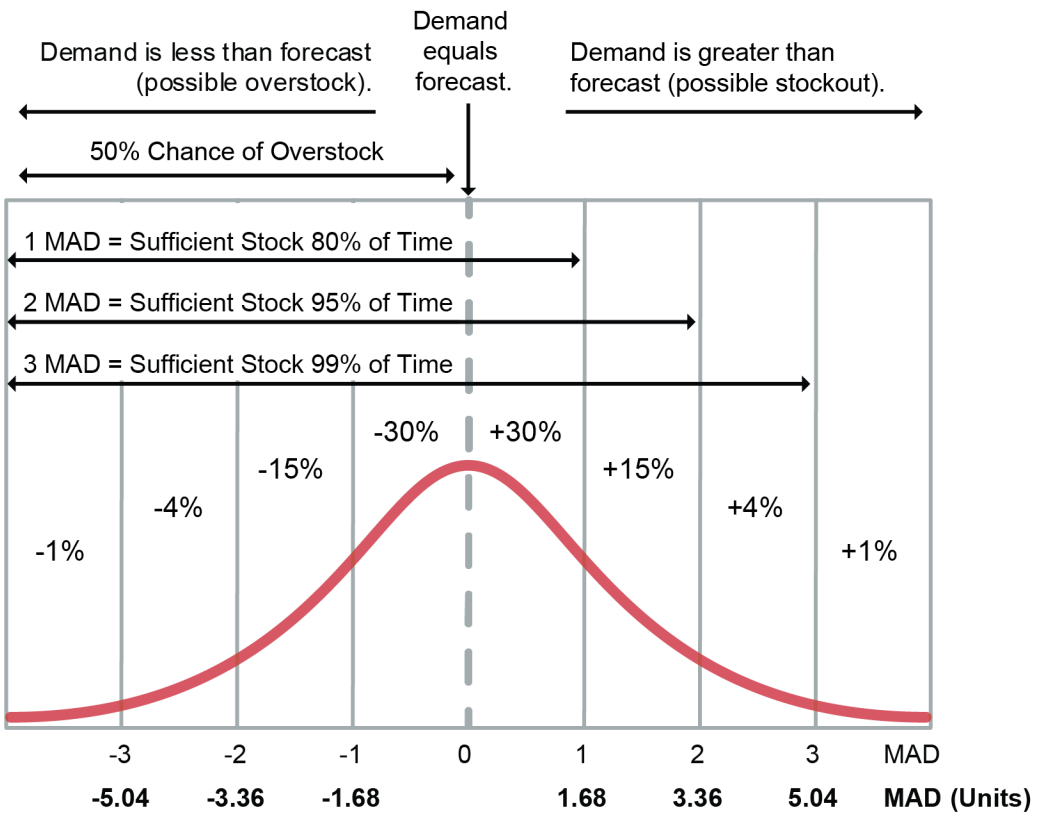
Exhibit 1-40: Mean Absolute Deviation with Smoothing

	R	S	T	U	V	W	X
1	**Year 4 Reseasonalized Forecasts**				Absolute Errors		
2	**Moving Average**	**Weighted Average**	**Exponential**	**Year 4 Raw Actuals**	**Moving Error**	**Weighted Error**	**Expon. Error**
3	30.97	30.60	34.40	34	3.03	3.40	0.40
4	30.60	31.64	33.51	29	1.60	2.64	4.51
5	11.66	11.74	12.05	13	1.34	1.26	0.95
6	4.40	4.39	4.41	5	0.60	0.61	0.59
7	2.18	2.20	2.21	5	2.82	2.80	2.79
8	2.42	2.52	2.39	3	0.58	0.48	0.61
9	1.28	1.32	1.24	2	0.72	0.68	0.76
10	5.31	5.19	4.95	6	0.69	0.81	1.05
11	13.00	13.00	12.65	11	2.00	2.00	1.65
12	16.97	16.56	16.87	16	0.97	0.56	0.87
13	31.71	30.80	31.91	30	1.71	0.80	1.91
14	35.21	35.44	37.11	33	2.21	2.44	4.11
15				**SUM**	18.25	18.45	20.20
16				**MAD**	**1.52**	**1.54**	**1.68**

$$MAD = \frac{\Sigma \text{ Absolute Errors}}{\text{Number of Periods}}$$
$$= \frac{0.40+4.51+0.95+0.59+2.79+0.61+0.76+1.05+1.65+0.87+1.91+4.11}{12}$$
$$= \frac{20.20}{12} = 1.68 \text{ Units}$$

A MAD of 1.68 units implies that forecasts are off on average for the review period by about plus or minus 1.68 units. Exhibit 1-41 shows MAD from Exhibit 1-40.

Exhibit 1-41: Normal Distribution Curve for MAD of 1.68 Units



MAD may be used as the basis for safety stock calculations. This is because when a forecast is in error and lower demand is planned for than the actual demand that occurs, stockouts could result. Higher levels of safety stock will be needed to safeguard against those less probable events at the stockout end of the normal distribution curve.

In Exhibit 1-41, the center is the average or central tendency, which would be a forecast matching actual demand in this example. The left-hand side of the curve is the likelihood that demand will be less than the forecast, which means that 50 percent of the time there will be sufficient inventory or possibly an overstock situation. The right-hand side of the curve is the likelihood that demand will be greater than the forecast, or a potential stockout situation if not enough safety stock is held.

Note that this is a normal MAD distribution curve. In the exhibit, ±1 MAD, or up to ±1.68 units in error, should be experienced 60 percent of the time (plus or minus 30 percent from the mean). For a stockout probability, 1 MAD adds the 50 percent overstock probability to the 30 percent zone for 1 MAD for an 80 percent probability that there will still be sufficient stock if 1.68 units are held as safety stock (two units if rounded up). Moving further out in the curve, ±2 MAD means that in some instances the error will be up to two mean absolute deviations, and adding the two 15 percent zones means that 90 percent of results should be within ±2 MAD, or ±3.36 units (1.68 × 2). Again, for a stockout probability, 2 MAD adds the 50 percent overstock probability to the 30 percent zone for 1 MAD and the 15 percent zone for 2 MAD, to equal a 95 percent probability that sufficient inventory will be in stock if at least 3.36 units are held as safety stock (four units rounded up). Similarly, 98 percent of all results should fall within ±3 MAD, or ±5.04 units (1.68 × 3), which equates to about a 99 percent probability that there will

be no stockouts if at least 5.04 units (six units rounded up) of safety stock are held. The chance of a stockout is calculated as one minus the percent chance of sufficient inventory. For 2 MAD, this is 1 − 0.95 = 0.05 = 5 percent chance of stockout.

Note that an analyst would provide actual MADs for a given service level. If a specific service level is desired, such as 98 percent of orders with no stockouts, analysts can calculate the exact MAD to use as the multiplier in the calculation of units of safety stock. This multiplier is called a safety factor. The *APICS Dictionary,* 16th edition, defines **safety factor** in part as follows.

> The numerical value used in the service function (based on the standard deviation or mean absolute deviation of the forecast) to provide a given level of customer service. For example, if the item's mean absolute deviation is 100 and a .95 customer service level (safety factor of 2.06) is desired, then a safety stock of 206 units should be carried. This safety stock must be adjusted if the forecast interval and item lead times differ.

Exhibit 1-42 shows a safety factor table.

For the purposes of the following example, note how a 98 percent service level has a safety factor of 2.56 MAD (or 2.05 if standard deviation in units is known).

1.68 MAD in Units × 2.56 Safety Factor = 4.3 Units of Safety Stock
(or 5 units if rounding up is the rule the organization decides to follow)

Exhibit 1-42: Safety Factor Table

Percentile Customer Service Level	Standard Deviation Units x Factor Below	MAD Units x Factor Below
50.00	0.00	0.00
75.00	0.67	0.84
80.00	0.84	1.05
84.13	1.00	1.25
85.00	1.04	1.30
89.44	1.25	1.56
90.00	1.28	1.60
93.32	1.50	1.88
94.00	1.56	1.95
94.52	1.60	2.00
95.00	1.65	2.06
96.00	1.75	2.19
97.00	1.88	2.35
97.72	2.00	2.50
98.00	2.05	2.56
98.61	2.20	2.75
99.00	2.33	2.91
99.18	2.40	3.00
99.38	2.50	3.13
99.50	2.57	3.20

Percentile Customer Service Level	Standard Deviation Units x Factor Below	MAD Units x Factor Below
99.60	2.65	3.31
99.70	2.75	3.44
99.80	2.88	3.60
99.86	3.00	3.75
99.90	3.09	3.85
99.93	3.20	4.00
99.99	4.00	5.00

Source: www.supplychainchannel.org

Note also the relationship between standard deviation and MAD. Look at the 84.13 percentile customer service level row. When standard deviation is 1.0, MAD is 1.25. In fact this relationship continues throughout. A rule of thumb is that multiplying MAD times 1.25 results in an approximation of standard deviation.

Tracking Signal

According to the *APICS Dictionary,* 16th edition, the **tracking signal** is “the ratio of the cumulative algebraic sum of the deviations between the forecasts and the actual values to the mean absolute deviation.”

The tracking signal can be calculated as shown in Exhibit 1-43 (Note that the example uses data from column AF.)

Exhibit 1-43: Tracking Signal

	R	S	T	U	V	W	X	AD	AE	AF
1	**Year 4 Reseasonalized Forecasts**				Absolute Errors					
2	**Moving Average**	**Weighted Average**	**Exponential**	**Year 4 Raw Actuals**	**Moving Error**	**Weighted Error**	**Expon. Error**	**Moving Error +/-**	**Weighted Error +/-**	**Expon. Error +/-**
3	30.97	30.60	34.40	34	3.03	3.40	0.40	3.03	3.40	-0.40
4	30.60	31.64	33.51	29	1.60	2.64	4.51	-1.60	-2.64	-4.51
5	11.66	11.74	12.05	13	1.34	1.26	0.95	1.34	1.26	0.95
6	4.40	4.39	4.41	5	0.60	0.61	0.59	0.60	0.61	0.59
7	2.18	2.20	2.21	5	2.82	2.80	2.79	2.82	2.80	2.79
8	2.42	2.52	2.39	3	0.58	0.48	0.61	0.58	0.48	0.61
9	1.28	1.32	1.24	2	0.72	0.68	0.76	0.72	0.68	0.76
10	5.31	5.19	4.95	6	0.69	0.81	1.05	0.69	0.81	1.05
11	13.00	13.00	12.65	11	2.00	2.00	1.65	-2.00	-2.00	-1.65
12	16.97	16.56	16.87	16	0.97	0.56	0.87	-0.97	-0.56	-0.87
13	31.71	30.80	31.91	30	1.71	0.80	1.91	-1.71	-0.80	-1.91
14	35.21	35.44	37.11	33	2.21	2.44	4.11	-2.21	-2.44	-4.11
15				**SUM**	18.25	18.45	20.20	1.30	1.60	-6.69
16				**MAD**	**1.52**	**1.54**	**1.68**			
19				**Tracking Signal**	**0.85**	**1.04**	**-3.98**			

$$\text{Tracking Signal} = \frac{\text{Algebraic Sum of Forecast Errors}}{\text{Mean Absolute Deviation (MAD)}}$$

$$= \frac{(-0.40)+(-4.51)+(0.95)+(0.59)+(2.79)+(0.61)+(0.76)+(1.05)+(-1.65)+(-0.87)+(-1.91)+(-4.11)}{1.68}$$

$$= \frac{-6.69}{1.68} = -3.98$$

The algebraic sum of forecast errors is a cumulative sum that does not use absolute values for the errors. Therefore the tracking signal could be either positive or negative to show the direction of the bias.

Organizations use a tracking signal by setting a target value for each period, such as ±4. If the tracking signal exceeds this target value, a forecast review would be triggered.

Many organizations calculate and track each stock keeping unit (SKU) on a monthly basis. This helps measure two aspects of the forecast:

- **Forecast bias.** If the tracking signal is continually negative, we are consistently over-forecasting. If it is consistently positive, we are under-forecasting. Ideally, the tracking signal should oscillate between positive and negative values. If not, it should be the first thing to work to eliminate.

- **Suitability of the forecasting method.** If the tracking signal remains in a range of +4 to −4, then, as a rule of thumb, the method being used to forecast the SKU should be considered to be working correctly. If it is outside this range, review the forecasting methodology to find something more suitable.

Standard Deviation

Another way to estimate forecast error would be to use standard deviation. The *APICS Dictionary,* 16th edition, defines **standard deviation** as follows:

> A measurement of dispersion of data or of a variable. The standard deviation is computed by finding the differences between the average and actual observations, squaring each difference, adding the squared differences, [and] dividing by n.

A formula for standard deviation is commonly available in most forecasting or spreadsheet software programs. Note that standard deviation measures the amount of variation in actual results from the central tendency (the peak of the bell curve) and does not use forecast error as an input but rather assesses the relative level of variability of actual results as a proxy for how much error in a forecast is likely. It can also be used to determine how much safety stock to use using a safety factor table. (There is a variant called root mean squared error that does use forecast error as an input.)

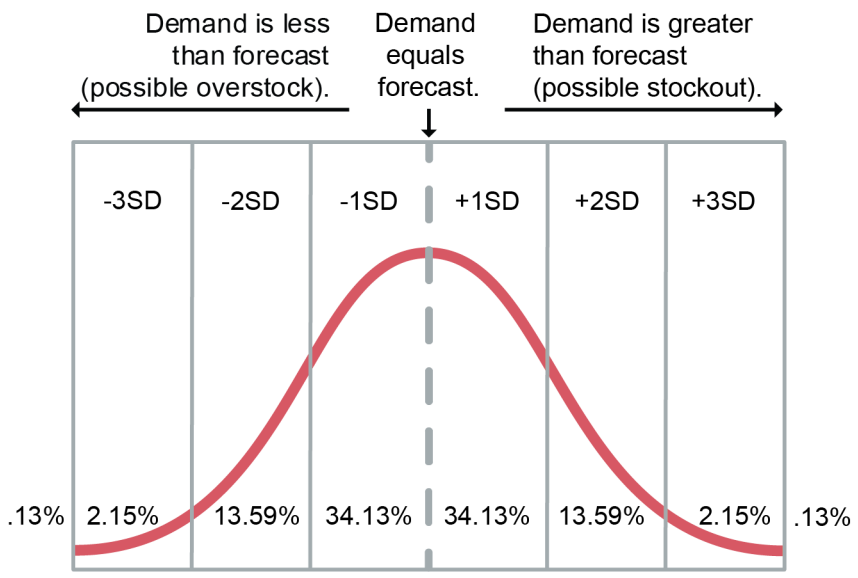
The final part of the standard deviation formula is to take the mean of the squared differences (that is, after dividing by *n [n* = number of data points]) and apply a square root to it. Note also that a variation on standard deviation instead divides by *n* – 1. This formula is used in the more common situation when this is a sample of data that you want to extrapolate to the whole population; *n* is used when you are using the entire set of data and don't need to extrapolate. Alternatively, some practitioners use *n*– 1 when there are 30 or fewer samples from the population and *n* when there are more samples than these, since the effect being corrected for is not as important when more samples than these are used.

The more common formula for standard deviation follows. (Note: In the formula below, the Greek uppercase letter ∑ stands for "the sum of.")

$$\text{Standard Deviation} = \sqrt{\frac{\Sigma(\text{Sample} - \text{Sample Mean})^2}{n-1}}$$

Exhibit 1-44 shows a bell curve for standard deviation along with the percentage probabilities of a result being in a particular number of standard deviations from the mean (center dotted line). For example, 1 SD is 34.13 percent and 2 SD adds 13.59 percent more probability, so the chance of a stockout at 2 SD is the sum of these amounts, or 47.72 percent. However, since there is also a 50 percent chance of an overstock (left side of the bell curve), this is also added, which results in a 97.72 percent chance of an item being in stock at 2 SD.

Exhibit 1-44: Normal Distribution Curve for Standard Deviation



If standard deviation is the information you have at your disposal, you can use a safety factor table to calculate the safety stock at a given service level.

Let’s assume SD of 2.1 units. Also assume a desired 98 percent service level, which is a safety factor of 2.05. This results in a need to hold about five units of safety stock:

2.1 SD in Units × 2.05 Safety Factor = 4.3 Units of Safety Stock
(or 5 units if rounding up is the rule the organization decides to follow)

Mean Squared Error (MSE)

Another method of calculating error rates, the mean squared error (MSE), magnifies the errors by squaring each one before adding them up and dividing by the number of forecast periods. Squaring errors effectively makes them absolute, since multiplying two negative numbers always results in a positive number.

Note that the errors are squared before being summed, which requires new columns in the worksheet, as shown in Exhibit 1-45. The formula for mean squared error follows (with an example from the exhibit below):

$$\text{MSE} = \frac{\text{Sum of (Errors for Each Period)}^2}{\text{Number of Forecast Periods}} = \frac{55.57}{12} = 4.63$$

MSE and MAD Comparison

Note in Exhibit 1-45 how the process of squaring each error using the MSE method gives you a much wider range of numbers than when the mean absolute deviation (MAD) is used. For example, in row 4 of the spreadsheet, the MAD for the exponential smoothing method is –4.51 while with MSE it is the 20.31. In addition to the large results being much larger, fractional results become smaller. This is seen in row 3 of the spreadsheet, where the MAD is –0.40 but squaring this for MSE results in 0.16.

The greater range gives you a more sensitive measure of the error rate, which is especially useful if the absolute error numbers are relatively close together and reduction of errors is important.

Exhibit 1-45: Mean Squared Error and MAD Compared

	U	V	W	X	AD	AE	AF	AG	AH	AI
1		Absolute Errors								
2	**Year 4 Raw Actuals**	**Moving Error**	**Weighted Error**	**Expon. Error**	**Moving Error +/-**	**Weighted Error +/-**	**Expon. Error +/-**	**Squared Moving Error**	**Squared Weighted Error**	**Squared Expon. Error**
3	34	3.03	3.40	0.40	3.03	3.40	-0.40	9.16	11.54	0.16
4	29	1.60	2.64	4.51	-1.60	-2.64	-4.51	2.55	6.95	20.31
5	13	1.34	1.26	0.95	1.34	1.26	0.95	1.80	1.58	0.90
6	5	0.60	0.61	0.59	0.60	0.61	0.59	0.36	0.37	0.35
7	5	2.82	2.80	2.79	2.82	2.80	2.79	7.94	7.82	7.79
8	3	0.58	0.48	0.61	0.58	0.48	0.61	0.33	0.23	0.37
9	2	0.72	0.68	0.76	0.72	0.68	0.76	0.52	0.46	0.58
10	6	0.69	0.81	1.05	0.69	0.81	1.05	0.48	0.65	1.10
11	11	2.00	2.00	1.65	-2.00	-2.00	-1.65	3.98	3.98	2.72
12	16	0.97	0.56	0.87	-0.97	-0.56	-0.87	0.93	0.31	0.76
13	30	1.71	0.80	1.91	-1.71	-0.80	-1.91	2.91	0.64	3.66
14	33	2.21	2.44	4.11	-2.21	-2.44	-4.11	4.90	5.93	16.87
15	**SUM**	18.25	18.45	20.20	1.30	1.60	-6.69	35.87	40.47	55.57
16	**MAD**	**1.52**	**1.54**	**1.68**						
17	**MSE**	**2.99**	**3.37**	**4.63**						
19	**Tracking Signal**	**0.85**	**1.04**	**-3.98**						

Measuring the extent of deviation helps determine the need to improve forecasting or rely on safety stock to meet customer service objectives.

Mean Absolute Percentage Error (MAPE)

There is a drawback to the MAD calculation in that it is an absolute number that is not meaningful unless compared to the forecast. Mean absolute percentage error (MAPE) is a useful variant of the MAD calculation because it shows the ratio, or percentage, of the absolute errors to the actual demand for a given number of periods. The example continues the study of the exponential forecast error in Exhibit 1-46.

$$\text{MAPE} = \frac{\Sigma\left(\frac{|A-F|}{A}\right)[\%]}{n} = \frac{206.8\,\%}{12} = 17.2\,\%$$

Exhibit 1-46: Mean Absolute Percentage Error (MAPE)

	R	S	T	U	V	W	X	Y	Z	AA
1	Year 4 Reseasonalized Forecasts				Absolute Errors					
2	Moving Average	Weighted Average	Exponential	Year 4 Raw Actuals	Moving Error	Weighted Error	Expon. Error	Moving APE	Weighted APE	Expon. APE
3	30.97	30.60	34.40	34	3.03	3.40	0.40	8.9%	10.0%	1.2%
4	30.60	31.64	33.51	29	1.60	2.64	4.51	5.5%	9.1%	15.5%
5	11.66	11.74	12.05	13	1.34	1.26	0.95	10.3%	9.7%	7.3%
6	4.40	4.39	4.41	5	0.60	0.61	0.59	12.0%	12.2%	11.8%
7	2.18	2.20	2.21	5	2.82	2.80	2.79	56.4%	55.9%	55.8%
8	2.42	2.52	2.39	3	0.58	0.48	0.61	19.2%	16.0%	20.3%
9	1.28	1.32	1.24	2	0.72	0.68	0.76	35.9%	34.0%	38.2%
10	5.31	5.19	4.95	6	0.69	0.81	1.05	11.6%	13.5%	17.5%
11	13.00	13.00	12.65	11	2.00	2.00	1.65	18.1%	18.1%	15.0%
12	16.97	16.56	16.87	16	0.97	0.56	0.87	6.0%	3.5%	5.5%
13	31.71	30.80	31.91	30	1.71	0.80	1.91	5.7%	2.7%	6.4%
14	35.21	35.44	37.11	33	2.21	2.44	4.11	6.7%	7.4%	12.4%
15				SUM	18.25	18.45	20.20	196.3%	192.0%	206.9%
16				MAD	1.52	1.54	1.68			
18				MAPE	16.4%	16.0%	17.2%			

Exhibit 1-46 shows how the absolute percentage error (APE) is first determined for each period by taking the absolute error divided by the actual demand. This is done for each month in a new set of columns. Then, the sum of the APE (percentage) for periods 1 through 12, which is 206.9 percent for the exponential method (see column AA), is divided by the number of periods, 12 in the example, to calculate the MAPE. On average, MAPE is 17.2 percent.

Note that the result is expressed as a percentage. Exception rules for review can be applied to any stock keeping unit or product family that has a MAPE above a certain percentage value.

Percentage-based error measurements such as MAPE allow the magnitude of error to be clearly seen without needing detailed knowledge of the product or family, whereas an absolute error in units (or an error in dollar amounts) requires knowing what is considered normal for the product or product family.

Section E: Supply and Demand Alignment

This section is designed to

- Describe operations planning and control, master planning, sales and operations planning (S&OP), the demand plan, and the production plan
- Review the role of strategy in operations planning and control and its overall process
- Identify the purpose and elements of S&OP
- Describe what occurs in the meetings and steps of the S&OP process
- Explain how to use a demand plan dashboard
- Explain that S&OP reconciles the requirements of multiple areas: demand, supply, and financial plans
- Describe ways to promote and implement S&OP at an organization
- Describe how demand management and prioritization are achieved using a process of reconciliation and analysis
- Describe the demand management functional responsibilities and interfaces with product development, marketing, sales, and operations.

This section covers the operations planning and control concepts that help supply chain managers enable long- and short-term demand, supply, and financial planning so that sourcing, acquisition, manufacturing control, delivery, invoicing, and payment form a smooth and fast cycle.

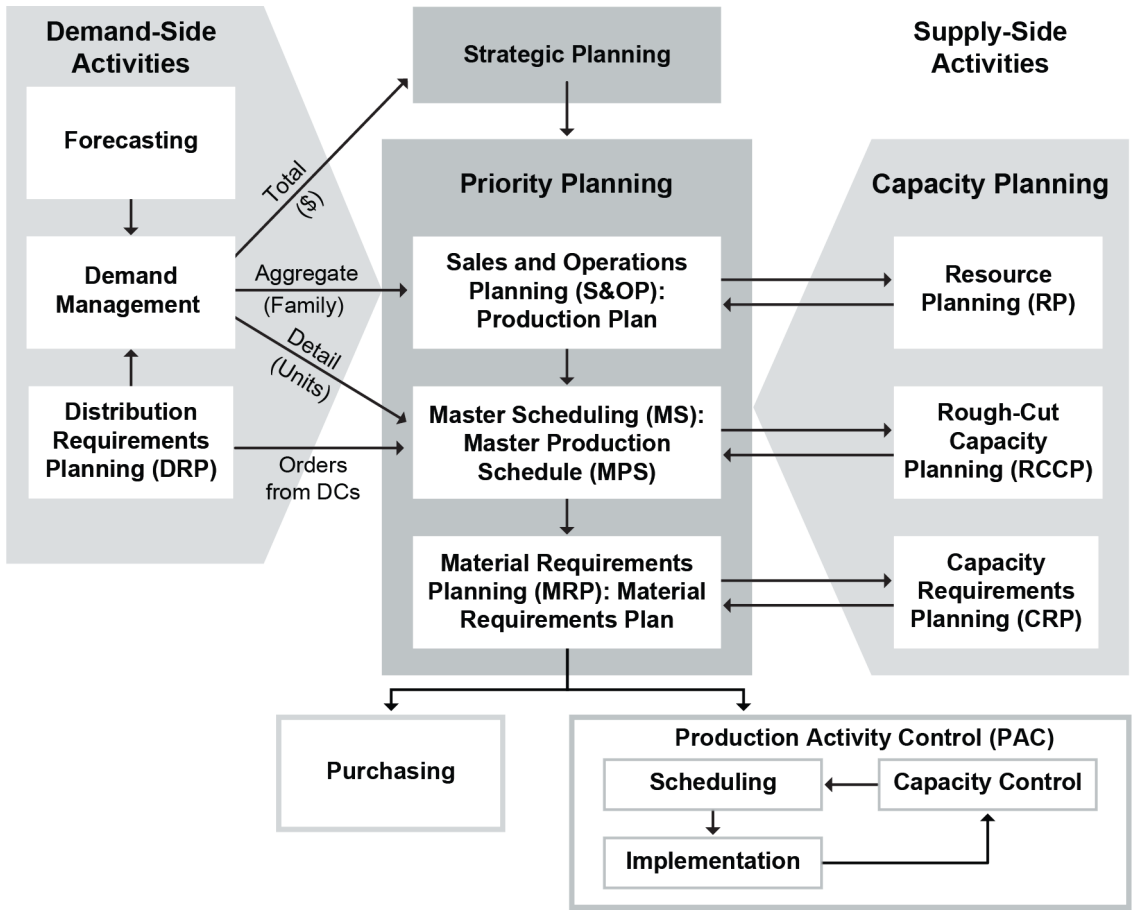
Topic 1: Supply and Demand Alignment

Here we set the stage for the sales and operations planning process by providing an overview of the supply and demand alignment process called operations planning and control. After that, strategic planning, master planning, and resource planning are addressed more.

Supply and Demand Alignment Road Map

Exhibit 1-47 provides an overview of how supply and demand are aligned using a process called operations planning and control.

Exhibit 1-47: Operations Planning and Control



The core functions in this process are called master planning. The *APICS Dictionary,* 16th edition, defines **master planning** as

> a group of business processes that includes the following activities: demand management (which includes forecasting and order servicing); production and resource planning; and master scheduling (which includes the master schedule and the rough-cut capacity plan).

Note how master planning uses strategic planning (and business planning) as a key input, plus information from the demand and supply sides of the organization that is brought together using sales and operations planning to produce a consensus demand plan and production plan.

The center column shows the supply-side outputs. The production plan, based on a consensus demand plan from sales and operations planning, is developed to guide master scheduling, which produces a master production schedule and plans for the necessary raw materials in material requirements planning. This in turn is used for controlling production and scheduling assembly (production activity control and final assembly scheduling). The exhibit shows how both the demand and supply organizations have continuing input as plans grow more and more detailed and time horizons grow shorter and shorter.

The high-level demand-side activities of forecasting and demand management involve demand sensing and creation activities and result in a demand plan. The distribution requirements planning process involves determining the inventory replenishment needs at distribution centers.

The supply-side activities start with resource planning, which determines the need for capital investments or capacity modifications. The remaining activities in the right-hand column of the exhibit address whether evolving plans are feasible from an operations capacity standpoint.

To expand upon Exhibit 1-47, the basic steps in operations planning and control can be summarized as follows.

- Demand history data are gathered and cleansed. A statistical forecast is run and analyzed for events or outliers that are not expected to repeat in the future.
- The statistical forecast with associated errors is reviewed with the product and brand management, marketing, and sales teams. The teams add information to the demand plan that will improve forecast accuracy.
- The demand plan is finalized with the demand-side teams and passed on to supply.
- The supply team reviews the demand plan and constrains it based on capacity and material availability.
- Both supply and demand review the constrained plan with the finance team and executive management.
- When the executive S&OP meeting is held, the result is the communication of a single plan: Sales sells to the plan and supply produces to the plan.
- One of the outputs of S&OP is the production plan, which provides the rate of production at the product family level. Resource requirements are evaluated with the resource plan.
- The production plan is the input to master scheduling, and its output is the master production schedule (MPS). The MPS is typically a weekly plan at the item level with an evaluation of capacity using rough-cut capacity planning.
- Then material requirements planning uses bill-of-material data, inventory data, and the MPS to calculate requirements for materials, resulting in planned production and purchase orders.
- Production activity control receives the output of material requirements planning and detail planning, and shop floor scheduling is done.

Strategic, Master, and Resource Planning

Strategic and business planning, master planning, and resource planning are addressed next.

Strategic and Business Planning

The organization’s strategic and business plans are the foundation for the organization’s master planning, sales and operations planning, and resulting production plan.

The strategic plan is a long-term plan, extending over five to ten years or more, that focuses on how to marshal resources and determine actions to support the mission and goals of the organization. It clearly identifies the mission, goals, and objectives and sets the high-level direction of the organization, including broad goals for market share, revenue, profits, and growth.

The objectives of organizational strategy indicate what value the organization will provide to customers or constituents in terms of products/services and what value operations should generate for the owners. While organizational strategy is set for the long term, it is updated periodically in response to the organization’s strengths and weaknesses and the opportunities and threats in the current operating environment.

An organization’s business plan states organizational strategy in more specific terms and sets goals for achieving the strategy over the next one to three years or more. The business plan specifies how value will be created for both customers and owners and what the results should be in terms of market share, revenue, cash flow, profits, and measurements such as customer satisfaction.

The business plan is typically stated in dollars and grouped by product family. There may be overly optimistic projections from marketing at some points, but the numbers are there for later review as well as to specify projected revenues, costs, profits, and objectives for the product families—all to support the long-range strategy proposed for entering the marketplace. Key inputs to the business plan include the demand plan and its long-term forecasts. Budgets and projected financial statements are key outputs. A business plan should

- Clarify strategy by stating an explicit vision for the business—a reason for being
- Provide a point of reference for the sales and operations plan
- Describe long-term strategies that will be used to guide shorter-term tactical plans for producing and selling the product.

As the organization begins spending the lender’s or stockholders’ money and the market heats up (or doesn’t heat up), the plan sometimes disappears into a file and becomes part of history. It shouldn’t. An objective for business planning is to update the business plan annually to reflect changes in strategy and to use the disciplined sales and operations planning process on a monthly basis to evaluate progress against the plan and make adjustments as needed. Thus the business plan is the parent of every operations planning and control activity described here.

Master Planning

The next step after the business plan is development of a master plan. This is a long-term resource plan and a near-medium-term sales and operations plan based on the longer-term views of the business plan. Master planning starts by taking the forecast and determining what production can accomplish using available capacity (S&OP) and by directing investments in capacity (resource planning). The overarching goal is always to satisfy the organization's stakeholders. In a for-profit organization, this means providing the lenders and investors with the return on investment they anticipated when they signed on as financial partners in the enterprise.

Resource Planning

Resource planning (RP), or resource requirements planning (RRP), takes the longest view of the system's capacity, typically going out 15 to 18 months but sometimes requiring much longer planning horizons for capital investments.

Resource planning is defined as follows according to the *APICS Dictionary,* 16th edition:

> Capacity planning conducted at the business plan level. The process of establishing, measuring, and adjusting limits or levels of long-range capacity. Resource planning is normally based on the production plan but may be driven by higher level plans beyond the time horizon for the production plan (e.g., the business plan). It addresses those resources that take long periods of time to acquire. Resource planning decisions always require top management approval.

The duration of the planning horizon depends on the lead time of the needed resources, which may be a machine to produce the planned product. The total lead time needed would include not only order lead time and installation time but also the lead time needed to conduct operations. Equipment or facility construction with long development lead times may be driven primarily by the business plan, while realigning existing facilities and the workforce to change capacity is more likely to be based on the production plan generated during the S&OP process. Note that capital expenditures in facilities or expensive equipment is an executive-level decision, while the resource planning that is based on the production plan is more likely to be a supply chain management decision. In this latter case, resource planning may be used to plan for materials with very long lead times.

Topic 2: Sales and Operations Planning

Sales and operations planning (S&OP) is an important process for supply chain managers because it is how the organization comes to consensus on what is needed and what is capable of being purchased or produced. Here we present the big-picture overview of S&OP, followed by a discussion of the important inputs to and outputs of the process. Reconciliation is the final step in the S&OP process, where supply, demand, and financial plans are reconciled with each other. A discussion of how to implement S&OP is also provided. Finally, we address demand management and prioritization, which is the final component of the demand management process.

S&OP Process

The *APICS Dictionary,* 16th edition, defines **sales and operations planning (S&OP)** as follows:

> A process to develop tactical plans that provide management the ability to strategically direct its businesses to achieve competitive advantage on a continuous basis by integrating customer-focused marketing plans for new and existing products with the management of the supply chain. The process brings together all the plans for the business (sales, marketing, development, manufacturing, sourcing, and financial) into one integrated set of plans. It is performed at least once a month and is reviewed by management at an aggregate (product family) level. The process must reconcile all supply, demand, and new-product plans at both the detail and aggregate levels and tie to the business plan. It is the definitive statement of the company's plans for the near to intermediate term, covering a horizon sufficient to plan for resources and to support the annual business planning process. Executed properly, the sales and operation planning process links the strategic plans for the business with its execution and reviews performance measurements for continuous improvement.

S&OP stands both for the sales and operations plan and sales and operations planning. It is both a plan and the process that creates, implements, monitors, and continuously improves the plan.

The S&OP process involves a series of meetings to arrive at consensus demand and production plans that reflect the results of demand-side sensing and influencing activities and supply- and finance-side capabilities and constraints.

Wallace and Stahl, authors of *Sales and Operations Planning: The How-to Handbook,* list the following meetings in S&OP:

- Data gathering
- Demand planning
- Supply planning
- Pre-meeting
- Executive meeting

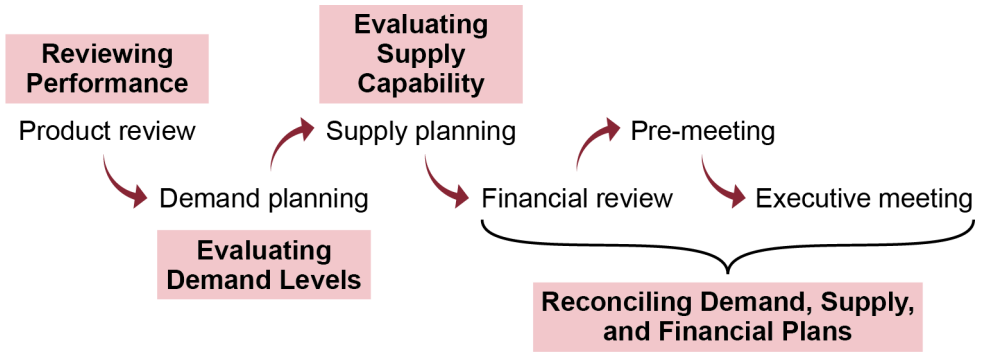
Crum and Palmatier, in *Demand Management Best Practices,* discuss two additional meetings. The first is a product review after the data-gathering step, and the second is a financial review after the supply planning step.

These meetings map to an overall S&OP process. The steps in this process are

- Reviewing performance
- Evaluating demand levels
- Evaluating supply capability
- Reconciling demand, supply, and financial plans.

The sequence of processes and activities is shown in Exhibit 1-48.

Exhibit 1-48: S&OP Process and Meetings



S&OP culminates in a monthly executive meeting to gain agreement on a plan to balance supply with demand, but it requires two weeks or more of team member preparations and preliminary meetings. S&OP can be run on a different timetable, but monthly data collection, analysis, and meetings are typical.

The results of the prior month's meetings are used as the basis for the current month's meetings; replanning is used in each review meeting as well as in the overall process.

The purpose of these meetings is to give each area of the organization sufficient time to prepare tactical plans and study the plans submitted to them so they can assess what impact the plans would have on their area of concern. In this way, the S&OP process ensures that detailed reviews are occurring, that decision makers from each part of the organization get a reliable understanding of the organization's current needs and capabilities, and that checks and balances are in place to give executives understanding of and control over the direction of the organization.

Reviewing Performance

The product review meeting involves updating the status of new product developments, product changes, or other organizational process change initiatives that could affect supply or demand. This meeting involves product and brand management, but other managers involved in process change initiatives could also attend as needed, such as involving an IT professional if the organization is implementing a new enterprise resources planning (ERP) system. Since a product or product feature's time to market strongly impacts demand management activities, this meeting provides demand-side professionals with vital information on which to base their assumptions. The quality of this review rests on the quality of the data gathering that is done.

Shortly after the end of the month, all the files necessary to develop the new statistical forecast should be updated. This needs to be done quickly to keep the process moving ahead on time. Timing the S&OP process to begin after the best data are available each month is a best practice.

Evaluating Demand Levels

The demand planning phase includes a demand review meeting (or demand consensus review meeting), which is a meeting held between product and brand management, marketing, and sales professionals to agree to a single set of demand numbers and to document the assumptions used to make the decisions.

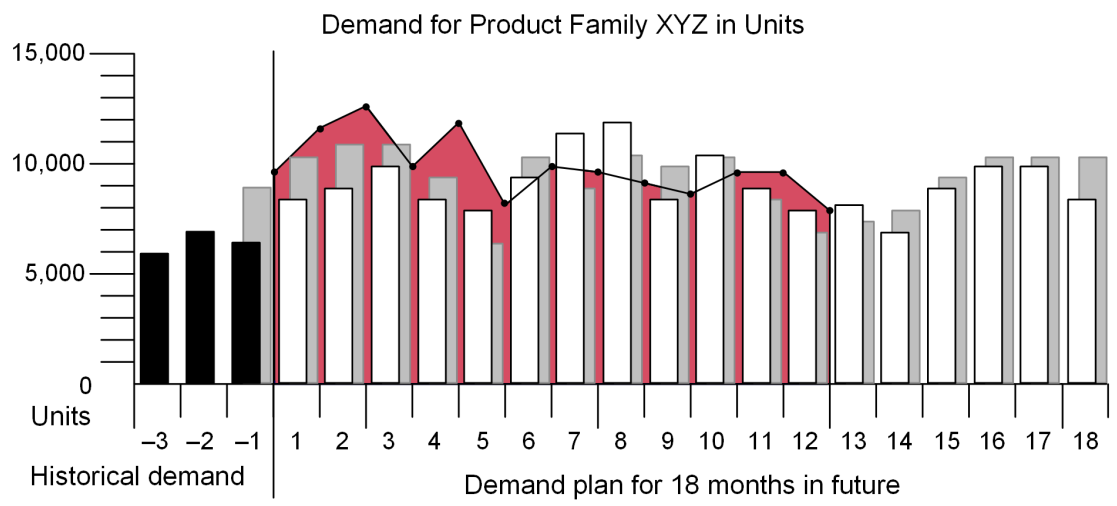
The highest ranking demand-side professional, such as the vice president of sales or marketing, not the demand manager, typically chairs this small, brief meeting between representatives of each department. The demand manager serves more as a facilitator in this meeting, such as by combining the individual plans of product and brand management, marketing, and sales into a single document prior to the meeting with recommended consensus numbers and areas with differences of opinion listed in the notes.

The meeting is not intended to be a lengthy detailed review (this should have occurred prior to the meeting) but a way for the responsible and accountable leaders of each demand-side area to review the big picture and commit to a consensus view of demand that can be passed down to their subordinates and to the financial and supply sides of the organization.

To keep the meeting brief, review is at the product family level; subfamilies are reviewed only on an exception basis. Other methods to promote brevity include reviewing only what has changed since the last meeting, focusing on validating assumptions, and reviewing only significant performance metric results. The rest of the meeting should be spent on what strategies can be employed to close any gaps between the demand plan and business plan revenue goals. The demand manager can facilitate these meetings by preparing demand plan dashboards that consolidate the various departments' plans, highlighting where significant disagreements exist.

Exhibit 1-49 shows an example of such a dashboard for an 18-month demand plan in units. Note that the dashboard also lists examples of key performance metrics, assumptions, events, opportunities, risks, and decisions. Note also that a separate dashboard in monetary units would be provided to show the results of the unit plan in terms of its impact on organizational revenue.

Exhibit 1-49: Example of a Demand Plan Dashboard—Units



Key: Actual demand; Annual business plan; Prior demand plan; Current demand plan

Product family XYZ:
Lead time = 2 weeks
Inventory turnover = 2 weeks

Metrics (excerpt)		Historical Month		
Goal	Metric	–3	–2	–1
Delivery promises	On time in full	88%	86%	80%
Improve cash flow	Cash-to-cash	16d	13d	14d
Plan accuracy	Plan vs. actual	75%	80%	68%

Key assumptions
- Internal: Period 6 TV ad buy, results seen in Periods 6–8
- External: Competitor X will mimic Product XYZ feature ABC by Period 14 at lower price

Key events
- Internal: Period 1 deliveries delayed due to Machine 123 breakdown, will continue to delay in Period 1.
- External: Economic growth will continue to be flat for next 12 periods.

Risks/Opportunities
- Risk: Customer Z is vulnerable.
- Opportunity: Breakthrough in product development can reduce product replacement time by 3 months.

Decisions
- Rapid development of Product Family XYZ replacement for release in Period 14.

A key aspect of this and other review meetings is replanning. Since the plan is reviewed each month, replanning promotes consensus building. For example, referring to Exhibit 1-49, if there is significant disagreement over the amount or timing of the demand increase from the Period 6 TV ad buy, the demand-side leaders can agree to a number but also agree to revisit it the next month when new information may be available to help clarify the issue. Participants could be assigned research tasks or be asked to communicate with others during the month so that they have better information for the next meeting. The success of the demand plan depends on the quality of the communication process.

Finally, the demand review meeting is a place to review performance metrics in relation to demand and forecast accuracy. Organizations might set rules for exception review of performance metrics. For example, if the demand plan differs from actual demand for a particular product family for three months running, a detailed strategy review should occur to determine what can be done to improve results. Individual metrics could also be color-coded in the dashboard to show exceptions.

Achieving consensus on what to produce can be contentious even between just the demand-side professionals. Setting the tone that disagreement between plan numbers should be an expected occurrence can keep participants from becoming frustrated with the process. Failure to acknowledge these differences or allowing each department to plan and act using its own set of numbers will generate far more conflict down the line because the supply organization will not know which set of numbers to use. This situation is far from rare, especially in an extended supply chain. According to Oliver Wight colleague Ron Ireland, most supply chains operate with between 14 and 25 individual

demand forecasts. Those that do use a single set of demand numbers typically have adopted the S&OP process.

This step in the S&OP process results in product and brand management, marketing, and sales representatives issuing an updated medium-term demand plan for current and new products. The demand plan should be reviewed by a senior sales and marketing executive before being entered in the S&OP files. Sometimes this process is called a marketing/sales handshake, because it requires coming to an agreement on a request for product and coordinated demand-influencing activities. The consensus plan arrived at by the demand-side managers is used as the basis in both the supply planning phase and the financial reviews.

Evaluating Supply Capability

The supply planning phase includes a supply review meeting, which uses the consensus demand plan to generate a production plan. The role of the supply management team is to identify any constraints that would prevent operations from being able to satisfy the demand plan. This process is sometimes called the operations handshake, because it requires operations professionals to agree on production plan recommendations that could best fulfill the demand plan while keeping operations profitable. The supply review meeting is used to finalize supply plan recommendations.

During this meeting, the feasibility of meeting the demand plan is discussed related to capacity and profitability constraints. If the demand plan can be met, the production plan will match the demand plan. The supply management team may need to alter the production plan and revise the S&OP data to meet the demand plan as closely as possible. If supply cannot match demand in total units or in product mix, then the meeting involves generating one or more alternative plans that propose solutions to the supply and demand mismatch, such as the following:

- Produce above demand for certain periods to meet later spikes in demand.
- Increase capacity by hiring, adding shifts, planning overtime, leasing new equipment, or outsourcing (or proposing the opposite to reduce capacity).
- Reduce the demand plan (as a last resort).

Supply-side professionals should highlight any significant risks or costs involved with each alternative that is proposed.

S&OP Inputs and Outputs

Demand management has functional responsibilities and interfaces with other areas in the organization. For example, demand management serves as an intermediary between product development and brand management, marketing, sales, and operations so that all of these functions' plans, communications, influences, and priorities are coordinated to maximize and satisfy demand.

Let's take a closer look at how demand management works with each of these functions.

Product Development and Brand Management

Product development or design and brand management are typically long-term strategic tasks that can benefit from integration with demand management because it promotes the balanced needs of the supply chain. When demand management is allowed to influence product and brand management, products and services can be designed and branded to reflect what is valuable to the customer. Elements that are not perceived as a value to the customer should be eliminated from the design of the product/service package. (This is a principle of lean thinking.)

Demand management can influence product development and brand management to consider each of the following:

- Satisfying customer requirements on the basis of demand and eliminating features not sufficiently in demand
- Meeting customer requirements for product/service package quality (especially reliability and service responsiveness) and effectiveness of delivery (e.g., timing, convenience, and consistency)
- Meeting customer requirements for price by designing in organizational efficiencies (e.g., acceptable cost and profit)
- Designing production processes and equipment that can accommodate a certain level of increase/decrease in capacity or custom work without loss of profitability
- Creating a brand that expresses the value that the customer places on the product/service package

Demand management can influence product and brand management to consider the processes throughout the whole supply chain, such as the ease and expense of a product's sourcing (of raw materials), manufacturing, warehousing, transporting, displaying, servicing, repairing, returning, and reusing or recycling at the end of its life.

Demand management can provide a collaborative venue for multiple departments or supply chain stakeholders to provide input, consider the feasibility of options or strategies, and, after some amount of iteration, arrive at the product/service package and brand design with the highest potential for mutual profit.

Marketing

Demand management relies on marketing because marketing must provide input to the demand plan. This input is necessary because marketing and sales are the people who are closest to prospects and customers. At some organizations, marketing and sales are considered to “own” the demand plan, while at others this is the role of the demand manager. At the very least, marketing and sales are typically considered responsible and accountable for forecasting. There is sometimes resistance on the part of marketing and sales to either own the plan or to provide detailed input because this takes away from the time that could otherwise be spent executing marketing and sales activities. The organization must define what inputs are really necessary from marketing and sales and also find ways to make the required inputs more efficient and less time-consuming.

Marketing staff are responsible for finding potential customers and identifying needs the company can solve, creating and maintaining customer demand with communications and promotions, helping to refine product design and packaging to meet customer needs, forecasting demand throughout a product’s life cycle, and pricing products and services to be affordable and profitable at the same time.

Marketing traditionally has had little understanding of the processes and requirements surrounding operations management. This lack of understanding works both ways and is the product of the traditional “silo” mentality of departments. Providing a formal demand management function at an organization can provide marketing with expertise on operations and vice versa. Because demand management fits into neither traditional “silo,” it is an ideal representative for both interests.

Demand management interfaces with marketing in the medium and short term to tailor demand to meet available capacity. Tailoring demand from a marketing perspective includes setting existing and potential customers’ expectations regarding the types of demand that the organization will accept or consider. That is, if customers know the rules of the game, they will be more likely to happily work within those rules. This helps avoid situations such as frustrating a potential customer by having to reject an unprofitable customization request that likely took some time to prepare.

Another way demand can be tailored is by raising or lowering prices either semi-permanently or through promotions. Price reductions can stimulate demand in times of excess capacity, and returns to regular pricing can help when there is insufficient capacity.

Sales

Sales departments work with customers on a daily basis and make delivery promises. The primary interface demand management has with sales is to implement the demand plan commitments regarding influencing or prioritizing demand. Another interface is to ensure that the demand plan supports the organizational strategy. For example, if the organizational strategy is to develop lifetime customers by maintaining excess capacity, it could be the role of sales staff to identify customers on the basis of potential for loyalty and make offers that may not be initially profitable while up-selling to existing loyal customers.

Salespersons desire to eliminate order backlogs, which means sales staff is not typically interested in minimizing inventories. Their priority is to increase sales by providing the right quantity of supplies at the right place. For similar reasons, a high priority for sales is time to market, especially if the product or service must be ready for a particular selling season, be presented at a tradeshow or convention, or beat the competition to the market. Demand management can champion these requirements with product development, marketing, and operations.

Demand management can work with sales to manage demand in such ways as convincing product and brand management to raise or lower prices for ordering in bulk or for accepting delayed shipments (within the parameters set by marketing). Another role for demand management is to educate sales staff on the limitations of product development, marketing, and operations, for example, not promising to perform custom work without approval or to supply products in excess of maximum production capacity.

Operations

Interfacing between the demand side of the organization and manufacturing planning and control is a vital task for demand management, because most operations professionals are highly specialized. According to research by Showalter and White, operations management literature “exhibits a pronounced lack of marketing perspective.” They also state that when the marketing perspective is included it is treated “simply as a complicating constraint on the production planning process.” A formal demand management function and/or a demand manager can represent product and brand management, marketing, and sales interests in operations-specific technical terms.

Demand management can also facilitate the understanding between operations and the other parties at S&OP meetings, such as by accommodating the requirements of profitable customer segments in production plans. It also plays a stronger role now than in the past due to the emphasis on replacing safety stocks of inventories with shorter lead times and manufacturing flexibility.

Reconciliation

Here we discuss the process of reconciling demand, supply, and financial plans. This involves three final meetings: the financial review meeting, the pre-meeting, and the executive meeting.

Financial Review Meeting

The financial review meeting analyzes the demand plan in dollars as well as any alternative production (supply) plans for their financial impact and feasibility. The key question that financial professionals will ask is to what degree the plan will achieve or fail to achieve the organization's business and financial goals as stated in the business plan. The financial review meeting will also finalize projections on the revenues, profits, cash flow, or need for capital investments for each alternative and provide a recommendation for the plan that best meets financial goals as well as financial constraints such as budgets, cash flow, or capital expenditure limits.

Pre-Meeting

The pre-meeting, or pre-S&OP meeting, is a meeting between people from prior steps, at least one person from the finance area, the S&OP process owner, and the demand manager. Other pre-S&OP team members might include a number of key supply chain managers and other area managers, such as the plant manager, the logistics manager, the product and brand manager, the customer service manager, and the accounting manager. The team reviews the data and sets the agenda for the S&OP executive meeting. The purpose of the pre-meeting is to identify areas where consensus can be reached without needing executive input and to add the more contentious items to the executive review agenda.

Executive Meeting

The monthly S&OP executive meeting involves the chief executive officer (CEO); the demand (sales and marketing), supply (operations), and financial executives; and other direct reports to the CEO. **Executive sales and operations planning** has its own definition in the *APICS Dictionary,* 16th edition:

> The portion of sales and operations planning that defines executive decision-making processes to balance supply and demand at the volume level in families, fully integrates financial planning and operational planning, and that provides a forum for establishing and linking high-level strategic plans with day-to-day operations.

The purpose of this meeting and its related processes is to provide executives with a broad understanding of supply and demand issues and to allow them to exercise control over the organization's direction if it is not in line with business plan goals.

The attendees review the plans from the prior meetings with the goal of arriving at a consensus demand plan that meets organizational revenue goals to the extent possible and that everyone agrees to support. To accomplish this goal, the meeting may involve reviewing performance metrics or

scorecards, changes since the last meeting, new risks and opportunities, and other events. Executives will want to know whether plans are staying on budget, on schedule, and on scope; how well product mixes are performing; whether current strategies need modifying; whether capacity will be sufficient for the level of demand (at the resource planning level, such as hiring new staff if new products are experiencing high demand); and what decisions will need to be made and when. Decisions that need to be made during the current period are discussed and then finalized, and responsibilities are assigned to ensure execution.

The assembled executives may accept the decisions and the numbers forwarded from the pre-S&OP meeting, or they may take another path. They will make decisions pertaining to each product family, authorize any decisions with significant financial implications, and compare the demand plan to the business plan to see if actions need to be taken to bring them in line with each other (e.g., additional marketing activities).

Communication of the agreed-upon S&OP plan is critical to all internal participants. For instance, it is critical for sales account managers to understand when material they have requested in the demand plan will not be supplied and therefore they should not make commitments to deliver the product to customers. If supply is available to meet demand, the sales account managers still need to be informed that their sales forecast has been accepted and they can sell against it. Remember, the success of the demand plan depends on the quality of the internal communication process.

Implementing S&OP

Like supply chain management, sales and operations planning rests on the assumption that companies wishing to compete in the expanding global marketplace can and must break down the silo walls between functions and break through the barriers separating supply chain partners. In fact, S&OP is intended to be a planning and controlling tool not just for manufacturing but also for the entire enterprise. Breaking down those barriers, however, doesn't happen quickly and easily.

The most important consideration is the understanding that the plan to generate enough capacity to match supply with aggregate demand must be created, executed, and monitored in collaboration with sales and other functional areas, not in isolation.

We'll look at three aspects of implementing S&OP:

- Getting buy-in on S&OP's coordinating function
- Emphasizing what each party contributes to S&OP
- Building enthusiasm for S&OP among supply chain managers

Getting Buy-In on S&OP's Coordinating Function

Functional areas within a company and supply chain partners on the outside are accustomed to developing their own plans, controlling their own information, and determining their own actions. S&OP can't function if those assumptions, and those barriers, remain in place.

The basic premise of S&OP is that there should be one plan to unite all the major functions—sales, operations, and finance. Further, S&OP assumes that key players, including executives, will agree to the unified plan, carry it out tactically, and continuously monitor and adjust it in monthly S&OP meetings. The key to getting buy-in to S&OP is to emphasize that it is all about improving communications. As S&OP consultant and author Thomas F. Wallace puts it, "S&OP is as much about institutionalizing communications throughout the organization as it is anything else." If, as Wallace states, you "get all the facts on one sheet of paper" reviewed jointly by the key players monthly, communication has to happen, facts have to be recognized, even if they are negative, and decisions have to made, debated, and acted upon—before the next meeting.

S&OP provides the following organizational benefits:

- **Link between business planning and tactics.** S&OP forms a link between the vision in the strategic and business plans on the sales side and the practical details of the tactical plans on the operations side. The executives of the company are responsible to investors and to one another for making the projections in the business plan a reality. S&OP brings the executives directly into the planning process.

- **Opportunities to be proactive rather than reactive.** The monthly meeting is a chance for executives to respond to changes in economic trends and market conditions as they are occurring.
- **Definitive short- to medium-term plan.** The sales and operations plan is the definitive statement of company plans for the near to intermediate term—typically 12 to 18 months or more. It covers enough time to enable planning for resources and to support the annual long-range business planning process.
- **Unified, cross-functional plan and process.** S&OP brings together a planning team that reconciles all of the functional business plans—not just sales plans and marketing plans, but engineering and development, manufacturing, sourcing, and financing plans—into one unified plan and one unified process.
- **Bridge between customer value and supply chain efficiency.** The S&OP process integrates the tactical focus of the operations side with the customer orientation of the marketing and sales side. There is an inherent tension between the needs of the customer and the evolving quality standards of the supply chain. Reducing cycle times, squeezing out unnecessary inventory, paring down the number of partners, practicing lean manufacturing, and focusing relentlessly on quality may result in a swifter, more agile supply chain, but that can come at the expense of the end customer if marketing isn't there to keep a close eye on the final product. In common terms, cheaper and faster are not always better from the customer's perspective. After all, **quality** is "conformance to requirements or fitness for use" (*APICS Dictionary,* 16th edition). On the other hand, the perfect product is not always affordable from an operational standpoint. S&OP integrates the sales and marketing perspective with the operational perspective so the inherent tension between the two can become a creative force that drives the business.
- **Incentive to engage in continuous improvement.** S&OP is not a static plan. S&OP's (usually) monthly meetings incorporate replanning from prior months. This continuous review and improvement should incorporate appropriate metrics for evaluating results against plans.

All functional areas involved in the sales and operations planning process should submit annual budgets for review by finance. The final plan should merge and reconcile all functional area plans and be reviewed by senior management. Budgeting is part of the annual update of the business plan.

Emphasizing Each Party's Contributions to S&OP

The specific contributions to S&OP represent the demand side, where sales and marketing take responsibility, the supply side, where operations does the capacity research, and finance, which does the financial goals analysis. The results are merged and reconciled so that aggregate demand and supply are in balance and meet business and financial goals to the extent possible.

Product and Brand Management, Marketing, and Sales Contributions

The following contributions go into the planning process from the demand organization for review by the full team:

- **Demand forecasts.** S&OP receives time-phased (e.g., demand per month) forecasts of expected demand (customer orders) arranged by product family.
- **Demand plan commitments.** Product and brand management, marketing, and sales are responsible for developing and implementing realistic strategies and tactics to achieve the goals and revenue objectives stated in the business plan—for the near and medium term. For example, product and brand management may plan new product launches and determine the life cycle impact of events. Marketing sets pricing strategies and performs competitive analysis. Sales strategy includes number and type of salespeople, sales territories (by geography, product, customer type, etc.), and sales and marketing approaches.
- **Demand plan numbers and assumptions.** Along with customer order forecasts and commitments to action, the demand organization contributes estimates of the results of their efforts expressed both in units (e.g., volume, numbers, weights) and the revenue dollar equivalents, along with all underlying assumptions. shows how various audiences will use one or more of these reports.

Exhibit 1-50: Demand Plan Estimates

Product and Brand Management	Unit of Measure
Marketing and sales	Units and dollars
Logistics	Units
Customer service	Units
Finance	Dollars

- **Market analysis.** Marketing contributes research and analysis of market opportunities; selection of target market segments; development of strategies for capturing a share of those markets; and development, management, execution, and control of marketing plans, programs, and projects.

Operations Contributions

The organization’s sales and operations plan is implemented on the supply side of the organization through a production plan. The production plan is a high-level view of future production requirements over a planning horizon of 12 to 18 months.

Sales and operations planning approaches tactics at the level of aggregate supply and demand. It deals with overall capacity in the system, gross volumes, and product families. According to the *APICS Dictionary,* 16th edition, a **product family** is

> a group of end items whose similarity of design and manufacture facilitates their being planned in aggregate, whose sales performance is monitored together, and, occasionally, whose cost is aggregated at this level.

Thus this level of planning is at a higher level than individual products and specific work centers. The mission of S&OP is to balance supply with demand, and this balancing act starts at the level of product families.

Operations makes the following contributions to the plan, to be reconciled with the numbers and strategies from the sales and marketing side.

- **Product families.** For purposes of the S&OP, product families need to be established on the basis of similar operations capacity requirements. “Like-capacity” items are grouped together so that the resulting production plan can be used directly by operations. While each part of the organization may create its own product families for internal department planning purposes, such as sales creating families based on similar market appeal, the integrated nature of the S&OP process requires that everyone use the same product families.

- **Output and resources.** Specific output targets are identified for each product family during the planning horizon. These targets include
  - Overall level of manufacturing output and other activities to meet planned sales levels (The projections are generally stated as a rate of production, such as units per period of time.)
  - Inventory levels
  - Backlog levels (The *APICS Dictionary,* 16th edition, defines **backlog** as “all the customer orders received but not yet shipped; sometimes referred to as open orders or the order board.”)
  - Required plant, equipment, labor, and material resources for each period in the plan.

- **Operations constraints.** Given a request for product in the form of a demand plan, a primary input from operations involves evaluating whether there is sufficient capacity over the planning horizon to meet the plan for each product family. Information on site and work center bottlenecks is provided as needed to support recommendations. Constraints can sometimes be alleviated by operating above or below optimal capacity or by altering operations strategies or supply-demand strategies. Operations and supply-demand strategies are discussed next.

- **Operations strategies.** The level of output for periods in the plan can be determined according to a level production strategy, a chase production method (also called a chase strategy or chase-demand matching), or a hybrid of the two.

  - According to the *APICS Dictionary,* 16th edition, a **level production method** is “a production planning method that maintains a stable production rate while varying inventory levels to meet demand.” This method aims for the same output in each period (e.g., each month). The level amount is based on the average of demand forecasts for each period with some modifications for desired inventory levels. For example, Porta Potty, a portable outhouse manufacturer, has seasonal demand spikes but produces the same number of units all year round. Leveling offers the benefits of simplicity and, from an operations viewpoint, predictability (no last-minute hiring of

temps or layoffs). The tradeoff is the potential for inventory to pile up during periods of low demand or for stockouts if demand spikes upward.

- The *Dictionary* defines a **chase production method** as “a production planning method that maintains a stable inventory level while varying production to meet demand.” This results in demand matching, which aims to match production to demand for each period. For example, restaurants often use chase methods by maintaining a part-time workforce that can be scheduled as needed and altering purchases based on projected demand. Manufacturers sometimes pursue this method by producing different goods for different seasons (e.g., K2 produces skis and in-line skates).

  The benefit, if the strategy succeeds in producing only what is demanded, is a reduction of inventory costs. On the negative side, resources must be ramped up during periods when demand is high, with increases in costs for overtime, additional hiring, training, etc. Layoffs may be necessary when demand falls, resulting in loss of competent, trained workers who may not be available for rehiring when demand picks up again. Finally, plant capacity has to be built up to produce at the highest level of demand rather than at an average level.

- A **hybrid strategy** combines elements of level and chase production. The plant runs near full capacity for part of the cycle, allowing inventory to build up, and then slows or shuts down to allow the inventory to shrink as customers buy the product. A large number of organizations use hybrid strategies. For example, Lego manufactures toy building blocks using one shift for the first half of the year and adds another shift in the second half of the year for holiday season demand.

- **Supply-demand strategies.** For each product family there should be an operational approach for determining when to produce the product in relationship to customer orders (that is, before or after the order). Three strategies are make-to-stock, make-to-order, and assemble-to-order:

  - The **make-to-stock** approach is defined by the *Dictionary* as

    > a production environment where products can be and usually are finished before receipt of a customer order. Customer orders are typically filled from existing stocks, and production orders are used to replenish those stocks.

The schedule for make-to-stock production is based on finished goods, which will be manufactured and sent to inventory. A make-to-stock product family usually contains a small number of items made from a large number of components. Consumer electronics, such as televisions, radios, and audio systems, are examples of this situation. Most make-to-stock environments represent high-volume, low-variety products.

Make-to-stock is essentially a mass-market strategy that works well when demand is stable and products turn over rapidly. For slower-moving products or products with unstable demand, the risk

here is inventory build-up and, in some cases, product obsolescence. In the computer industry, for instance, components age rapidly toward obsolescence.

- The **make-to-order** approach is defined by the *Dictionary* as

  > [a] production environment where a good or service can be made after receipt of a customer's order. The final product is usually a combination of standard items and items custom-designed to meet the special needs of the customer.

  Make-to-order product families are at the opposite extreme from make-to-stock families, with a very large number of products made from a smaller number of components. Custom clothing provides a common example. In a custom business, each product is unique to the individual who orders it. If delivery lead time is not an issue, the product can be made to the customer's exact specifications. Most make-to-order environments represent low-volume, high-variety products. It is dependent on the individual company strategy whether raw materials are kept in inventory in anticipation of customer orders.

  A similar approach to make-to-order is engineer-to-order (or design-to-order). **Engineer-to-order** products are defined by the *Dictionary* as

  > products [that] require unique engineering design, significant customization, or new purchased materials, depending on customer specifications. Each customer order results in a unique set of part numbers, bills of material, and routings.

- **Assemble-to-order** (or finish-to-order) is "a production environment where a good or service can be assembled after receipt of a customer's order" (*Dictionary*). Assemble-to-order products are partially manufactured and inventoried to await orders. This allows mass customization of products without long lead times and works well with products that can be tailored to customer taste by exchanging a limited number of modular components. The focus of master scheduling in assemble-to-order is on scheduling the manufacture of the modules or components and on final assembly.

  Like make-to-order products, assemble-to-order product families include a large number of end items, but in this case the number of components may be limited. Computers can be assembled to order. (Their components may be complex, but the final assembly of the computer itself uses a few basic components—hard drives, RAM chips, audio and video subsystems, case, power supply, etc.). Instead of being finished in all hues for delivery to stock, paint colors are "assembled-to-order" behind the counter at hardware and home stores. The shelves are stocked with tint base, and a limited number of tints are combined by a computerized mixer for an exact match to hundreds of colors. In such cases, the efficient basis for the master production schedule is to schedule the limited number of components.

One of the challenges of the assemble-to-order approach is the need to have “reasonably skilled” labor to do the assembly. Distribution centers are not always eager to train or hire workers to do assembly.

A related concept, **package to order ,** is “a production environment in which a good or service can be packaged after receipt of a customer order” (*Dictionary*). Package-to-order can be used to accommodate different numbers of units per package or customer language differences.

- **Actual results and other data for performance metrics.** Operations also provides data on actual production amounts per product family and other historical data such as information on actual capacity limits versus planned limits. Operations may provide other data for planning and feedback purposes such as changes to inventory metrics.

Finance Contributions

Finance reviews the demand plan and the proposed production plan for financial feasibility and fit with business plan goals (especially financial goals) and may make a recommendation on the plan that makes the most financial sense if competing alternatives exist.

Building Enthusiasm for S&OP Among Supply Chain Managers

With its focus on breaking through functional barriers, the S&OP approach to aggregate planning integrates perfectly with supply chain management thinking. Instead of the traditional practice of first developing a sales plan and then asking operations to develop tactics to implement it, S&OP brings together sales, marketing, operations, finance, and other key players to produce an integrated plan that incorporates and reconciles the views of all functional areas. For this reason, APICS considers S&OP to be a best practice.

Demand Management and Prioritization

Organizations must manage and prioritize demand because sales will differ on a regular basis from planned demand in total volume and/or in product mix and because supply often cannot produce products in the exact timing and mix specified by the demand plan.

Since supply is often constrained or lacking, demand needs to be managed and prioritized to guarantee that the supply chain as a whole is well served and the organization uses its resources wisely so that operations lead to profitable business results. Demand management and prioritization starts at the level of master scheduling and also occurs at the material requirements planning level.

Demand management and prioritization may include setting time fences to keep operations running on time and on budget once they are committed. A time fence restricts disruptive last-minute changes to a manufacturing production schedule by setting one or more change cutoff dates as one gets closer to the present. Each time fence has escalating levels of approval required to override the cutoff. Demand management and prioritization may also direct the allocation of supply, and this allocation process must be measured and managed to ensure that customer service levels are met.

Managing and prioritizing demand requires an organization- or supply chain-wide view. It involves optimizing demand across the system as measured by optimum organizational profit, demand volume, sales revenue, and customer service (including customer retention). This is a management activity because it involves setting and enforcing policies to promote this optimization process; it is a prioritization activity because it involves making judgment calls to decide what actions or customers are more important than others when capacity is limited.

Management and prioritization can be based on customer segmentation strategies, such as fulfilling orders to the most valuable customer segments first. Another example is rationing supply so that each warehouse or retailer receives a portion of the full demand but no entity goes without a certain minimum amount. Managing and prioritizing demand could also involve prioritizing production to increase supply of certain items or prioritizing items within distribution systems to better distribute supply to meet demand. For service industries or for customer service attached to products, prioritizing demand can involve queues (waiting in line or waiting on hold).

Exhibit 1-51 shows some situations in which managing and prioritizing demand is usually necessary.

Exhibit 1-51: Situations Requiring Managing and Prioritizing Demand, with Examples

Situation	Example

Situation	Example
When conducting sales and operations planning and the supply organization cannot meet the demand plan without changes	An organization with fixed capacity starts with high inventory demand for a hot-weather product. Rather than continuing to try to predict the weather far in advance, they prioritize how product is distributed so that only areas currently forecasting or experiencing hot weather are allocated more product, reducing capacity pressures and inventory.
When the demand plan overstates actual demand and plan changes will impact sales revenue and product costs	An organization resolves a situation of too much supply by establishing a series of decision points (time fences) for production activities such as purchasing so that some operations can be delayed until more accurate demand information is available. Demand that does not materialize prior to the decision points can be de-expedited (moved back in the production queue).
When the demand plan understates actual demand and plan changes will impact sales revenues and product costs	An organization resolves a situation of insufficient capacity by extending its planning horizon to give it more time to increase capacity. For current capacity issues, it provides incentives for substitute products and offers discounts for taking delayed delivery.
When a large, one-time sales opportunity arises that would impact regular orders, production costs, and profits	An organization prioritizes unusual demand by establishing a process of recognizing and reporting the demand as soon as possible to allow time for decision making. Both demand and supply organizations develop cost and profit margin projections for accepting and rejecting the order, including impact on customer service. Sales management determines how to prioritize other orders if the order is accepted.

Since demand management and prioritization often involve thinking beyond an internal department focus or beyond a single organizational focus, successful implementation can benefit significantly by setting a clear prioritization policy and implementing it using a structured process.

Demand Management and Prioritization Policy

A demand management and prioritization policy should clearly indicate who is allowed to manage and prioritize demand.

Responsibility may be restricted to appropriate management levels in the supply organization based on the level of risk involved in the decision. The highest prioritization decisions involving strategic risks may be made at the executive level, while supply managers may be responsible and held accountable for lower-level demand management and prioritization decisions. A key policy best practice is to retain responsibility for these lower-risk decisions at the management level rather than delegating this responsibility to individual salespersons. Delegating to individual salespersons tends to create organizational conflicts because each salesperson will naturally be motivated to act in his or her own customers' best interests rather than in the overall best interests of the organization. This policy should be documented and clearly communicated to the sales force.

Another possible policy is to retain the management and prioritization power in the demand side of the organization rather than delegating it to the supply organization. While the supply side will provide critical input to decisions regarding the cost of changing ongoing production activities, only the demand side has information on the most valuable customers and marketing and sales goals.

Demand Management and Prioritization Process

A demand management and prioritization process rests on several principles. One is that the organization's intent is to fulfill demand whenever it is feasible and will result in an increase in marginal profits, even when this demand comes from unexpected sources. The prioritization process involves finding ways to make the unexpected orders become profitable if they would not be otherwise. This may involve fulfilling the demand later than is requested, delaying other orders to meet the customer's request date, or offering a substitute product. An order is declined only if these measures are not acceptable to the customer or the sales manager. Sales and customer service must be trained in such an exception process so that these orders can be analyzed as soon as possible, while multiple options still exist.

Another principle is that when demand differs from supply within a time frame that allows for supply capacity or operations to be changed without impact on costs or other operations, prioritization is not necessary. It is the supply organization's responsibility to manage supply in this case. When there are cost implications to a supply and demand mismatch (such as when materials have already been purchased or work is in process), management and prioritization are necessary to match supply.

The process should involve determining ways to delay commitments until the last possible moment so that prioritization is necessary for as few operations as possible. This is done by delaying decisions until a necessary decision point is reached, such as when raw materials need to be ordered or a batch process must be started to keep operations running smoothly and at acceptable cost. These decision points when they relate to operations are time fences. Decision points such as time fences should be set in consultation with both the supply and demand sides of the organization so that they reflect the optimum balance between production costs and customer service. Strategic decision points may include questions such as whether to increase capacity. Delaying such a decision until it is absolutely necessary to start the related capital projects will allow the organization to have the most current information on projected demand.

Collaborative Demand Management and Prioritization

Tools for collaborative demand management and prioritization include sharing information on actual capacity or working with retailers well in advance of perceived shortage periods.

Customer Service Levels and Prioritization

Customer service represents the supply chain's role in fulfilling marketing objectives. A customer service strategy must identify and prioritize all activities required to fulfill customer logistical requirements as well as—or better than—the competition does.

When developing a customer service strategy, the key question to ask is "Does the cost associated with achieving specified service performance represent a sound investment?" Comprehensive

evaluation of competitive performance and customer response to service attributes can be used to formulate a basic strategy.

The fundamental measures of basic customer service are fill rates, lead time monitoring, order status monitoring, and customer satisfaction.

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