PART THREE

Procurement, inventory and demand forecasting

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Procurement and supply

14

Introduction

Procurement and supply (or supply management) is one of the key links in the supply chain and as such can have a significant influence on the overall success of the organization. Ensuring that there are sufficient supplies of raw materials at the right price, of the required quality, in the right place and at the right time is obviously crucial to any manufacturing plant. So important is this process that over the years many organizations have developed large departments to deal with the sheer weight of supplier transactions. Recently, however, many companies have been reducing the number of suppliers they deal with in order to reduce the cost of these transactions.

In addition to supplier reduction programmes, many companies have tried to move away from the traditional adversarial relationship with suppliers and towards a more partnership-based approach. This style of relationship recognizes that both parties need to make a profit to survive but that there may be areas where, through cooperation, real cost may be removed from the supply chain and competitive advantage gained by working together.

Of course, procurement is not just about raw materials. The following may also need to be acquired:

- utilities – gas, water, electricity and telephones
- fuel – diesel, petrol and heating fuel
- capital assets – machinery, vehicles and buildings
- corporate travel and hotels
- stationery
- consultancy
- outsourced services – distribution contracts, IT services, etc
- IT equipment – hardware, software and support

Very large sums of money are involved in the above areas of purchasing, with different emphasis placed on different elements depending on the business of the organization concerned. For a transport company, fuel may represent as much as 35 per cent of the total operating budget, but for a manufacturing plant the major cost may be in the plant running costs. These costs need to be carefully managed, but the first step is to determine some purchasing objectives.

Managing suppliers is another crucial aspect of procurement. 'How many suppliers should we have?', 'How will we assess their performance?' and 'Should we make or buy this component?' are all key questions that need to be answered if a procurement strategy is to work to the benefit of the business.

Over the last decade many companies have invested in both hardware and software to facilitate the use of e-procurement, which may be defined as: the electronic integration and management of all procurement activities including purchase request, authorization, ordering, delivery and payment between a purchaser and a supplier.

Procurement is a very large subject. The objective in this chapter is only to highlight key areas.

The procurement cycle

A typical procurement cycle progresses sequentially through the list below:

1. The identification of the need to procure a good or service.
2. Production of a requisition document that needs to be approved and passed to the procurement department.
3. A request for quotation (RFQ) is sent to a selection of suppliers.
4. Suppliers respond with prices and a period of negotiation may be entered into.
5. A supplier is selected and a purchase order (PO) is raised, which records the details of agreed price, delivery terms and place, and items or services to be provided.
6. The PO is signed and authorized by a manager. It is then sent to the supplier.
7. The goods or services are delivered and inspected.
8. The supplier sends an invoice.
9. The invoice is approved and paid or held pending resolution of any discrepancies found.
10. The procurement department assesses the performance of the supplier based on quality, timeliness, price and the completeness of the order. This is known as post-contract review.

Different organizations may structure the cycle slightly differently or call the stages by different names. The scope and scale of the purchase will dictate how much attention it receives. Most of the steps listed above could be completed online, especially for routine and repeat orders. Large capital purchases would require some of the stages to be quite complex. It is important to understand that the technical specifications need to be approved by technical specialists. This is not a job for the procurement people.

Authorization of purchase orders and therefore expenditure should not be in the hands of the purchasers. To ensure integrity of the process these roles and responsibilities need to be separated. The purchasers will do the job of selection and negotiation but the final authority to spend company money should not be theirs. This separation of roles acts as a protection for all parties involved in the transaction.

The scope of procurement

Modern procurement departments aim to:

- align their objectives with those of the organization rather than simply optimizing the performance of the function
- exploit modern e-procurement techniques to reduce the cycle time for processing orders as well as reducing transaction costs
- use the internet to identify new sources of raw materials and suppliers of goods and services
- get involved early in the process of new product or service design
- source and organize globally if the scope and scale of the organization needs this
- build partnerships with crucial suppliers while utilizing online catalogues or purchase cards for routine purchases
- seek value-for-money deals rather than simply buying the cheapest
- reduce inventory carrying costs through intelligent acquisition such as vendor-managed inventory
- adhere to the 3 Es: economies – spending less; efficiencies – spending well; and effectiveness – spending wisely
- enhance the competitiveness of the company

Setting the procurement objectives

When setting procurement objectives, consideration should be given to the following:

- whether to make yourself or buy from a supplier (Make vs Buy decision)

- ensuring the continuing supply of raw materials and other supplies
- vendor-managed inventory (VMI)
- the quality and number of suppliers
- standardization and product specification
- the price
- the origin of the supplies
- the method of supply, e.g. JIT-style deliveries
- the mode of transport used
- a hierarchy of importance, e.g. key raw materials would have precedence over office stationery

Ensuring the supply of raw materials

Clearly, without an assured flow of raw materials into a manufacturing plant, serious problems will ensue. These could take the form of plant stoppages, which will be enormously expensive. If expensive plant, machinery and labour are standing idle then costs may be incurred at an alarming rate. Not only will cost be incurred, but customers may be let down, as goods are not available for delivery at the appropriate time.

With this in mind, procurement management can adopt several policies to ensure that supplies are always in the right place at the right time:

- The manufacturer could purchase the supplying company. This used to be common in vertically integrated organizations.
- Sufficient safety stocks may be held at the manufacturing plant to cover such eventualities. These stocks would attract inventory carrying costs, but the alternative may justify this investment.
- A manufacturer may insist on the co-location of the supplier next to or close to the plant itself.
- Where commodities such as wheat or crude oil are concerned, then options to buy certain quantities may be negotiated in advance.
- A manufacturer may develop very close relationships with suppliers, for example through a system of quality-assured suppliers or vendor-managed inventory.
- Take advantage of opportunities to purchase supplies at unusually low prices. However, such purchases must be weighed in the light of the additional inventory carrying costs that may be incurred. Such additional costs could exceed the savings accrued from the opportunity purchase.

Vendor-managed inventory (VMI)

Where VMI is used, the vendor takes responsibility for the inventory held in the client's premises. The vendor monitors inventory levels and organizes replenishment. Ownership of the inventory passes to the client when the inventory is utilized. For VMI to be effective, the management of information is crucial. Vendor and client will have linked computer systems, often using electronic data interchange (EDI). This allows the vendor to monitor inventory levels and for purchase orders and invoices to be effectively transmitted between the partners.

The main advantage of VMI is that the overall level of inventory in the client's warehouse can be reduced. The vendor is able to schedule deliveries efficiently, as it has better visibility of the client's requirements, and can incorporate these requirements at an early stage into production schedules. For the process to work, there needs to be high levels of trust between the two partners. This is often derived from the cultural compatibility of the companies involved. The partners' IT systems also need to be compatible.

Where the client retains an element of involvement in managing the vendor's inventory, this is referred to as co-managed inventory (CMI).

The quality of supplies

Ensuring that the goods and services purchased are of the right quality is important in that substandard supplies cause waste and a variety of problems:

- If the goods are unusable then their presence has created a shortage in the required quantity, which in JIT environments may be crucial.
- Substandard goods will need to be stored awaiting collection. This could be a problem if storage at the receipt stage is restricted.
- They will incur transaction costs, as paperwork and time will be involved in rectifying the error.
- They will undermine confidence in the supplier and the supply process.

Insisting on suppliers having quality management systems in place can help avoid these problems, as can extrinsic audits of suppliers' premises. These audits may be carried out by the company's quality auditors. Supplier assessment programmes will help highlight the main offenders.

The cost of poor quality may be broadly divided into two categories: the cost of conformance and the cost of non-conformance. The cost of conformance may be further subdivided into the cost of appraisal and the cost of prevention. Examples of appraisal costs include the costs of inspection and testing. Examples of prevention costs include training, right-first-time campaigns and product design costs. The cost of non-conformance may also be further subdivided into the internal costs and external costs of non-conformance. Internal costs of non-conformance include scrap and rework as well as lost production time. External costs of quality failure include lost customer confidence and therefore future sales, returned goods and product liability costs.

The ideal situation would be for a five-star supplier to ship-to-stock. This would save a lot of inspection costs but could only be predicated on a superb quality record of the supplier in question. Such a supplier is likely to have achieved a 'partnership' status with the company.

Product specification

An important method of avoiding purchasing substandard supplies is the development of product specifications. If vendors are given very clear and precise instructions about what is being ordered, this will go a long way to avoiding costly misunderstandings. This is especially true where there are many different options associated with components of a product. For example, when purchasing a car the same model may be offered for sale with different types of engine, gearbox, paintwork and interior trim. It is important that the choices made are clearly communicated in writing to the vendor in the form of a request for quotation (RFQ). Product specifications should also be included in the purchase order when it is issued to the supplier.

One extremely effective method of both reducing suppliers and ensuring consistent accurate specifications is to adopt a system of standardization for certain products. It should also contribute to a reduction in the procurement transaction costs as buyers will simply access standard specifications and signal to the supplier that a repeat order is required. If the process of standardization is widespread then it will also have the beneficial effect of reducing the inventory of spare parts required.

The price

This is the area that most people associate with the purchasing process. The price will be determined by certain factors:

- The relative negotiating skills of the purchasing and selling team.
- The relative power of the supplier or buyer in the marketplace. Where there are many suppliers, the buyer's position will be strong. The converse is also true in that where there are many buyers and few suppliers then it follows that the supplier will have a strong negotiating position.
- The quality of the goods in question.

- Detailed knowledge of the product being purchased. For example, when multiple retailers purchase commodities such as flour they will have familiarized themselves with the costs of wheat and production before entering any negotiation.
- How much of the product is generally available for purchase. In other words, if the product is scarce then prices tend to be higher as purchasers pay higher and higher prices for the goods. The opposite is true when the product is plentiful.
- The distance the goods have to travel from their point of origin to the delivery point. Associated with this is the mode of transport used. The cost of transporting the raw materials may represent a large part of the purchase price.
- If the goods are being purchased by a buying group, then prices should be lower. A buying group is a number of companies grouped together in order to pool their buying power.

If the product specification can be defined precisely, then prices can be assessed on a like-for-like basis between suppliers. Discounts may be obtained from suppliers in various ways:

- by offering prompt payment
- increasing the quantity ordered – as a general rule, the unit price of the item will go down as the quantity ordered increases
- through the fact that your company may be a crucial company to the supplier
- through special or promotional offers, e.g. if the goods being supplied are at the end of their product life cycle
- the origin of the supplies

In recent years many large organizations have decided to source their supplies offshore. The logic for this trend is that in some parts of the world, such as China and India, the costs of labour and production are very low. However, labour costs in both China and India have been rising as a consequence of this trend, which has allowed some other countries and continents to emerge as competitors in the low-cost labour market. For example, Bangladesh, Vietnam and Sri Lanka in Asia and Egypt, Ghana and Kenya in Africa, not forgetting Central and South America. Many companies based in the United States of America are outsourcing to Mexico in a process called near-shoring due to the proximity. Companies can potentially gain a significant competitive advantage by offshore sourcing. However, a number of factors need to be taken into account. If the goods have to travel halfway around the globe then not only will the transport costs be high but the lead times to delivery may be unacceptably long. The price paid for the goods at origin may be low but the landed cost will include a proportion of the transport costs, any duties or taxes paid and handling charges. It will be the landed cost of the item that will be recorded in the company's inventory as the finance department seek to correctly apportion the full cost of acquisition.

In addition, pipeline inventory will be increased if sea transport is used. This can have the effect of impeding market responsiveness due to the long replenishment lead times. There are inherent problems with regard to dealing with different country's cultures. Further to this, the documentation associated with international sourcing is diverse and complicated. Dealing with different cultures and international documentation requires specialist knowledge and expertise (see Chapter 33).

It is also the case that not all parts of the world enjoy political stability. If supplies are interrupted for unspecified periods of time by political strife then a company could be in dire trouble if it does not have an alternative source of raw materials. The global Covid-19 pandemic during 2020–21 has highlighted the fragility of long supply chains and the consequences of interruption (see Chapter 41). Important decisions must be made with these factors in mind.

The method of supply

Smaller, more frequent deliveries typify a JIT system of supply. Inventory carrying of raw materials may be measured in hours only, and deliveries may even be made directly to the production line itself. As more and more companies seek to reduce inventory carrying costs then these types of arrangement have become more common.

The speed of processing goods received in a warehouse can be significantly improved if suppliers provide the goods in the right quantities, at the allotted time, correctly labelled and barcoded where necessary. How the raw materials are to be supplied needs to be determined and then discussed in advance with suppliers because they may not be able to meet the necessary criteria. It will be no good insisting on barcoded products if a supplier is unable to comply and, if a supplier cannot comply, a buyer's receiving operation may be severely compromised.

The mode of transport used by suppliers

Many transport and delivery requirements need to be discussed prior to agreeing to deal with a supplier. In the past, company procurement managers have in some instances been guilty of making spot purchases of goods on the basis of price alone, only to discover that the consequential handling costs were unreasonably high. Typical questions that need to be answered include:

- Will the goods be shipped by road, sea, rail or air?
- What sort of unitization is used?
- Will the goods be on pallets?

- What size are the pallets?
- Will the goods be stuffed loose inside containers and require considerable time and labour cost to unload?
- Should a railway siding be built to accommodate rail traffic?
- Who is responsible for customs fees and duties?

The hierarchy of importance

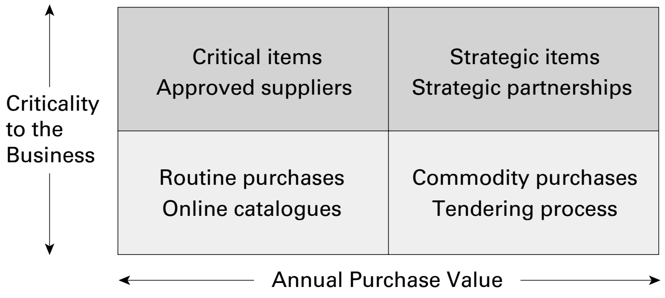
> In our visits to firms, it never ceases to amaze us how most purchasing departments still treat a critical microchip in the firm's key product much the same as a paperclip purchase.
>
> Jack Berry, Arthur D Little Inc

This quotation says it all really. It is vital that appropriate amounts of time and effort are spent on the purchases that most matter to the organization. Therefore, procurement management must ensure that purchasing is segmented accordingly. Products and services need to be classified according to their criticality to the business and the value of annual purchases. The four categories usually used are:

1. routine purchases
2. commodities
3. critical items
4. strategic items

Figure 14.1 demonstrates how purchases may be easily categorized by assessing how critical an item may be to the organization and by calculating the annual value of purchases. A strategic item is one that is both very critical to the business and has a high annual purchase value. At the other end of the scale, a routine purchase is one that has a low annual purchase value and is not critical to the business.

Figure 14.1 Categories of purchase with the appropriate buying process



SOURCE Adapted from Kraljic (1983)

Table 14.1

Risk

Bottleneck Items (Low profit impact, High supply risk) Typical products: proprietary spare parts, niche materials Relationship focus: Collaborative or single sourcing to secure supply Tactics: Supplier relationship building, inventory buffers, alternative sourcing plans	Strategic Items (High profit impact, High supply risk) Typical products: core technology modules, IP-sensitive components Relationship focus: Strategic alliances with long-term mutual commitment Tactics: Joint development, co-investment, shared R&D, supplier development
Non-Critical Items (Low profit impact, Low supply risk) Typical products: office supplies, MRO consumables Relationship focus: Transactional, automated procurement, e-auctions Tactics: Reduce administrative burden, focus on cost and efficiency	Leverage Items (High profit impact, Low supply risk) Typical products: standardized raw materials with high spend Relationship focus: Preferred supplier, competitive bidding to leverage volume Tactics: Aggregate demand, negotiate aggressively, exploit buying power

Profit

SOURCE Adapted from Kraljic (1983)

Once purchases have been categorized in this way, the process by which they are to be purchased may be decided upon. Buying processes include:

- online catalogues or purchase credit cards
- tendering
- a system of approved suppliers
- strategic partnerships

Peter Kraljic's (1983) Portfolio Purchasing Model provides a structured way to align supply strategy with product characteristics (Table 14.1). It classifies products based on profit impact (value contribution) and supply risk (market complexity, availability).

Figure 14.1 also shows how the appropriate buying process may be matched with a purchase category. Online catalogues available to employees will allow them to purchase routine items quickly and easily. This speeds up the process and limits the cost of these transactions. The same is true for purchase credit cards.

The tendering process for high annual purchase value commodities will be appropriate where obtaining the best price is important. A network of approved suppliers and a formal system for approving suppliers are most appropriate where items are critical to the business but have a low annual purchase value. Suppliers will have been able to satisfy the purchasing department that they are able to meet certain criteria satisfactorily on a consistent basis. The criteria used may include delivery reliability, quality of goods supplied and value for money.

Strategic partnership (see the section on partnerships later in this chapter) will be most appropriate where the purchase has high annual value and is critical to the business. In these cases, it is in the interest of both purchaser and vendor to develop a strong working relationship.

Make or buy?

The decision to make goods or provide a service as opposed to buying it is one that is rarely straightforward. It is not always simply a question of cost. Other issues such as the company's reputation or production capacity may be included in the mix. The following is a list of some of the factors often considered:

- Cost: if the goods or services are to be provided in-house, then it is not simply the direct costs involved that need to be considered but the wider costs, such as the opportunity cost of the capital employed. In other words, could the capital tied up in this exercise produce a better return if invested in another activity? If the activity is to be provided by a supplier, then the costs associated with managing the supplier and the transaction costs (e.g. for processing invoices) should be included in the analysis.
- Ensuring supply: as mentioned above, if goods or services are not available when required then significant extra costs may be incurred. The reliability of the supplier and the quality of its offering is another crucial part of the decision-making process.
- Production capacity: some parts of an operation may be provided by subcontractors because a company does not have sufficient capacity within its operation to do the job itself. This may be a very sensible approach to take in certain circumstances. A vehicle fleet, for example, should be kept working full-time. Therefore, it is better to have sufficient vehicles to achieve this end and subcontract any further work created by short-term increases in demand. Of course, the opposite is true in that if a production plant has spare capacity then it may be correct to use it rather than have it stand idle.
- Competitive advantage: there may be certain products, components or processes that the company wishes to keep secret and so it will not allow any other company to gain information about them. A revolutionary new product may fit this situation.

Managing the suppliers

Key areas for managing suppliers include:

- the choice of supplier
- supplier numbers
- supplier management – adversarial or partnership approach
- supplier appraisal and performance

Choosing the suppliers

Choosing your suppliers will involve all the elements already discussed, but there are one or two further points that have to be considered. Of course, this only applies in a situation where there is a choice. There are certain situations where no choice exists at all and one is forced to deal with a monopoly situation.

If a partnership approach is desired, then suppliers need to be able to respond to this type of situation. They must also be companies that are sufficiently well established. Company accounts are public information and are easily obtained. A check should be made to establish that a company is financially stable. It would be very unfortunate to spend time developing a partnership only to see a new partner going into liquidation.

Another consideration is whether or not a supplier wishes to become closely involved with a major customer. It will be necessary to share information, and the supplier may also deal with competitors. This could place a supplier in a difficult position and it may decline the offer of closer ties. Another fear may be that the customer could become so close that it gets taken over.

How many suppliers?

This will obviously vary from industry to industry. The high costs associated with transactions are driving companies into supplier reduction programmes. The suppliers who remain will hopefully be the ones who perform best on supplier appraisals. They will also be the ones who have been prepared to share information and get involved in EDI to reduce the cost of purchasing and who have the geographical coverage to match the client company. Increasingly, global companies are seeking to do business with global suppliers.

Supplier onboarding

Supplier onboarding is a critical process in supply management that integrates new suppliers into a company's procurement system while ensuring they meet required standards for quality, compliance and reliability. A well-structured onboarding process helps build strong relationships, reduces risks and improves overall supply chain performance.

The necessary steps in supplier onboarding typically include:

1. Post-evaluation supplier identification and documentation management: Thoroughly assess qualified suppliers based on detailed metrics. Gather contracts, tax forms, compliance certificates and insurance details.
2. Verification and approval: Verify the authenticity of submitted documents and approve suppliers accordingly.
3. Training and orientation: Introduce suppliers to company policies, quality requirements, reporting methods, and delivery schedules. Thorough training on compliance policies.
4. System integration: Set up suppliers in procurement and payment systems for seamless transactions.
5. Performance monitoring set-up: Establish key performance indicators (KPIs) to track ongoing supplier performance.

Key questions to ask during onboarding include:

- What certifications and compliance standards does the supplier hold?
- What is the criticality of those compliance requirements that the potential supplier is missing?
- Can they meet the required quality and delivery timelines?
- How do they manage risk and ensure sustainability?
- What are their payment terms and pricing structures, including clarifying any potential grey areas?
- Are they able to provide necessary documentation and reporting?
- Are they able (and willing) to be audited?

Asking these questions and following these steps ensures a smooth onboarding process that supports long-term, reliable supplier partnerships:

Particular attention needs to be given to training and orientation, which are essential parts of onboarding, familiarizing suppliers with the company's policies, quality requirements, and reporting procedures. This phase may include sharing technical specifications, delivery schedules and performance metrics. Proper onboarding reduces errors, delays and costs, enhancing collaboration and long-term partnership success.

Supplier management: a partnership or adversarial approach

In a traditional adversarial relationship between buyer and seller each party sees itself as being in competition with the other. The inevitable result of this kind of relationship is that one or other party inevitably 'wins' in any negotiation. This is often referred to as a 'win–lose' situation. Who and why one party is successful in this sort of relationship has much to do with the relative power that resides in one camp or the other. For example, a vendor with a rare product that is absolutely crucial to the process of the buyer would tend to be in a more powerful position. This would be especially true if the item on sale could not be substituted by another. The problem with this type of association is that, because both parties are secretive and defensive, inefficiencies in the supply chain are the result. These usually take the form of excess buffer stocks held by both parties, stockouts and a lower level of customer service.

The idea of seeing a supplier as a partner makes a great deal of sense from a logistics point of view. The Toyota organization, like many other Japanese companies, has long seen its suppliers as co-makers of the product. The Japanese system of *keiretsu* (literally 'headless combine') epitomizes the approach. A network of suppliers is intimately bound to the client company in a complex web of interdependence. This type of association should be seen as a 'win–win' situation in which both parties gain more from the relationship than from the adversarial style.

It is worth introducing a word of caution at this point. Toyota reduced its supplier base to such an extent and was so reliant on JIT deliveries that when a fire occurred at the premises of one of its suppliers it was forced to stop its production lines in Japan for a week. At the time, Toyota owned 22.6 per cent of the supplier, Aisin Seiki, a manufacturer of vital brake components. The fire occurred early in 1997 and brought Toyota to a standstill. This was not an isolated incident either, because in 1995, after the Hanshin earthquake in western Japan, car manufacturers were cut off from some of their suppliers by the disaster. By contrast, Honda does not have such a closely knit *keiretsu* and has a policy of dual supply for all raw materials as a hedge against just such a situation.

This was a lesson learned, as after the devastating earthquake and tsunami in March 2011 in east Japan as well as the loss of electrical power due to the problems with the nuclear power plant at Fukushima, many manufacturers experienced substantial disruption to their supply chains. Toyota estimated that along with Lexus it lost 220,000 units of production globally in the first 20 days after the earthquake happened. Subsequently, the total loss of production units reached 670,000 globally.

These are extreme examples and should in no way inhibit companies from building closer ties for mutual benefit. As with all partnerships, the partner has to be selected with care, as not all suppliers will wish either to engage in this sort of relationship or be suitable. In practice it is usually the partner with the greater power that dictates the terms of the partnership. It is very difficult for a small company to approach a larger company with a view to instigating such a partnership. A lack of equality in the partnership will lead to the more dominant partner dictating terms regarding many aspects of the relationship. This phenomenon has led some commentators to question whether a true partnership can ever exist between two commercial parties when one partner holds most of the power. Nevertheless, clear advantages have been documented where two companies work more on a collaborative basis than an adversarial one.

Some prerequisites for a successful partnership will include:

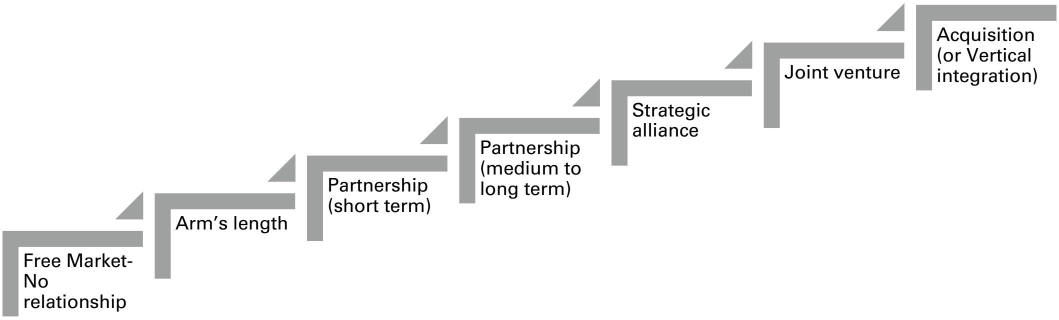
- compatible cultures
- high levels of trust already in place
- compatible computer systems to aid the electronic sharing of information
- the financial stability of both parties
- a willing attitude to exploring the advantages of partnership

In a partnership, members of equivalent departments in both organizations will meet regularly to discuss areas of mutual interest. For example, new product development people from both organizations will sit down together to see how products may be produced in such a way as to avoid causing problems for each other. In a similar way, logistics personnel will associate more freely. Traditionally, in the old adversarial way, only buyer and seller would meet.

Through this closer liaison, information sharing occurs for mutual benefit. Real benefits have been achieved by linking together computer information systems. In this way, a retailer with an electronic point-of-sale (EPOS) system can provide the supplier with real-time data about the current level of demand for a given product. This information can lead to real reductions of inventory carrying in the supply chain and a reduction in stockouts. As the relationship matures then initiatives such as VMI may be introduced. Ordering and invoicing may be carried out via EDI, thus reducing transaction costs by the removal of expensive paper-based systems.

Notably, the same supplier relationship model will not fit in every situation. Standard products benefit from competition and market leverage, whereas transactional or preferred supplier models maximize efficiency. On the other hand, innovative, high-tech or critical components require trust, joint problem-solving, and aligned investment horizons, where strategic alliances mitigate supply risk and foster innovation. Similarly, unstable or capacity-limited markets may require a blend of approaches including such as multi-sourcing for redundancy while deepening ties with key players.

Figure 14.2 The Supplier Relationship Continuum showing transactional to strategic collaboration



SOURCE Adapted from Cooper and Gardner, 1993

The Supplier Relationship Continuum (Figure 14.2) illustrates how relationships with suppliers range from purely transactional to deeply strategic, depending on the nature of the product, the market context, and the business objectives. At the transactional end, interactions are short-term, price-focused and low in trust or information sharing. This is suitable for standard, low-risk items where switching costs are minimal. As we move along the continuum, relationships become more collaborative, involving shared planning, joint process improvements and greater integration, often seen in preferred supplier and partnership models. At the strategic end, alliances are characterized by mutual investment, shared risks and rewards, joint innovation and long-term strategic alignment. This is typical for high-value, high-risk or innovation-critical items. The continuum helps procurement professionals avoid a ‘one size fits all’ approach by aligning relationship depth and complexity with the strategic importance and risk profile of each supply category.

A few tips on successfully managing supplier relationships include the following ideas:

- mapping the supply base before deciding relationship types
- avoiding over-investing in partnerships for low-value, low-risk products
- focusing relationship-building efforts where they can deliver the most strategic benefit
- regularly reassessing product criticality and market risk
- balancing dependence and creating mutual value without locking one party into unfavourable conditions

Supplier appraisal and performance

The poor performance of suppliers will adversely affect the satisfactory delivery of goods and services to the final customers by the purchasing company. Therefore, supplier performance must be continually monitored and poor performance communicated to them effectively and in a timely manner. The old computer adage of 'garbage in, garbage out' applies equally as well to suppliers and their performance as it does to computers. If your suppliers provide low-quality goods for inclusion in your products then it is logical to assume that your products will also be of a lower quality. By the same token, if they provide their products late then this will impact your ability to deliver to the final customer on time. This could be reflected in higher levels of raw material inventory needing to be carried against the uncertainty of supplier's delivery or, worse still, very unhappy customers due to missed delivery deadlines.

There are many ways to assess supplier performance and whatever methods are used they will reflect the detailed nature of the relationship between the two organizations. The quality of the goods or services delivered, the completeness of the delivery and its timeliness form a useful base, but much more detailed evaluations may be necessary. The basic performance measure of 'full loads (complete orders) on time' is used by many.

Expediting

Unfortunately, expediting is an uncomfortable fact of life for procurement departments. The job of an expeditor is to chase suppliers to ensure that goods are delivered on time or that the remnants of a part-order are delivered.

It goes without saying that if there is a high level of expediting required then something is wrong with the procurement process. Either the suppliers have been poorly selected or are performing badly. The level of expediting is a bellwether for the health of the procurement operation in general.

Procurement performance measures

As with all areas of management it is important to measure performance. Some key performance measures are listed below:

- the speed of converting a requisition into a purchase order
- the number of purchase orders processed in a day per person

- full loads (complete orders) delivered on time
- the number of stockouts
- the total cost of raising a purchase order
- prices paid against market standards
- the level of expediting
- the number of complaints from internal customers
- the number of complaints from suppliers

Of course there are many more and some that are specific to certain industries. The above is a representative selection.

Collaborative planning, forecasting and replenishment

As the name implies, collaborative planning, forecasting and replenishment (CPFR) is a collaborative business process where two companies work closely together to improve the efficiency of their supply chains. The client and the supplier will link their computer systems to the extent that the supplier has visibility of the inventory held by the client as well as the latest sales and forecasts for the line items involved. Information regarding promotional activity will also be shared with the supplier.

Despite the compelling logic for adopting such an approach to efficient replenishment, take-up has been slow. Some of the reasons for this relate to the difficulties in aligning the two parties' IT systems as well as their business processes. Fears about the security of sensitive market information have also hampered progress. A further reason has been the practical difficulties of agreeing how to share the overall benefits, particularly where higher costs may be incurred by one party in the supply chain. However, some large organizations such as Procter & Gamble have found success using this process.

With the benefit of experience some commentators have questioned the overall efficacy of CPFR relationships. Reservations centre on the fact that successful CPFR is highly dependent on accurate retailer forecasts. If the forecasts are inaccurate, and very often this is the case, then CPFR may not deliver the expected outcomes.

Factory gate pricing

This is sometimes also referred to as purchasing on an 'ex works' basis. This is very often one area associated with the buying process that is overlooked, although in recent years it has been more widely discussed. The cost of transporting the goods to the buyer's facilities may hide some extra cost that the buying company could avoid. Often companies show a remarkable lack of interest in this area, preferring to see it as somebody else's problem. The reality is that some costs could be eliminated and a higher level of control over the inbound supplies may be achieved.

If raw materials are being sourced from a variety of locations, whether it is on a national, continental or global scale, then there may be a possibility of removing some of the associated transport costs by employing a third party to coordinate this process. Large freight-forwarding companies may be able to pool one company's transport requirements with others so that a better price is obtained.

Another way of removing cost from the inbound side of a business is to use the vehicles delivering finished goods to collect from suppliers. This will allow a company to buy raw materials at ex works prices and utilize its delivery fleet more effectively as well. It may be possible to have the same organization that handles final deliveries coordinating inbound raw material transport needs as well (see also Chapter 5).

E-procurement

E-procurement may be defined as: the electronic integration and management of all procurement activities including purchase request, authorization, ordering, delivery and payment between a purchaser and a supplier.

Procurement professionals have seen the benefits of the widespread use of the internet and IT systems in general. The internet has opened up a global marketplace for both consumers and professional buyers alike. Web-based companies such as Amazon, eBay and more recently Alibaba.com have created vast trading sites that connect buyers and sellers all over the world. Some industries have created industry-specific portals that facilitate the connection of suppliers and buyers. The internet can be used not only for the purchase of certain goods but the delivery as well. For example, software, music and films may all be delivered in this way.

Other manifestations of e-procurement include:

- online auctions where pre-qualified bidders compete to win contracts or buy assets
- sending and receiving of documents such as purchase orders, bills of lading, RFQs, invoices and delivery confirmations
- the use of online catalogues

Portals may also be used earlier in the process for facilitating collaborative product design.

Costs saved in procurement are transferred immediately to the bottom line of a company's profit-and-loss account.

Corruption

There are many opportunities for corruption to rear its ugly head in the field of procurement, such as contracts awarded to friends or family; payments made to procurement staff to ensure preferential treatment; invoices passed for payment when no goods or services have been supplied; and many more.

It is important that proper checks are made when recruiting staff to procurement positions. There should be a system of oversight for all purchasers' work. Roles and responsibilities need to be separated in order to preclude corrupt practices from taking place. Managers need to be observant about employees who seem to have some newfound wealth and about the people who come and go in the offices.

There will always be corruption, but good systems and processes – with clearly delineated roles and responsibilities – will help. Managers and senior managers need to be ever vigilant and closely question staff about the who, what and where of certain purchases. A good discipline for a manager is to take a selection of POs at random on a regular basis, then ask questions and examine them in detail. This sends a simple but powerful message that the process is being closely monitored.

Ethical supply chain management

Ethical supply chain management has evolved into a strategic imperative, driven by consumer expectations, technological advancements, and a robust regulatory framework. Current approaches and the regulatory landscape shaping this domain are evolving rapidly, and companies are putting a lot of effort into ensuring ethical practices. Some of the practices in ethical supply chain management include:

1. Enhanced due diligence and risk assessment: Companies are adopting comprehensive due diligence processes to identify and mitigate human rights and environmental risks within their supply chains. This includes evaluating suppliers' compliance with ethical standards and implementing corrective actions when necessary.
2. Enhanced technology-driven transparency: The use of AI and blockchain enhances supply chain traceability and transparency. AI maps complex supply chains and identifies potential violations (for example, human rights), while blockchain ensures secure and immutable records of transactions.

3. Commitment to fair labour practices: Organizations are adhering to fair labour practices, including prohibition of child and forced labour, ensuring fair wages and providing safe working conditions. These practices contribute to building resilient and ethical supply chains.
4. Sustainable sourcing and environmental responsibility: Companies prioritize sustainable sourcing by selecting suppliers that adhere to environmental standards, reduce carbon footprints and minimize waste.

These practices are also aligned to a regulatory that becomes stricter and more accountable. Some key directives include:

1. The EU Corporate Sustainability Due Diligence Directive (CSDDD): Adopted in June 2024, the CSDDD requires EU and certain non-EU companies with significant EU operations to identify and prevent human rights abuses, including modern slavery, in their supply chains. This directive mandates due diligence across a company's value chain and is set to take effect in 2027.
2. The German Supply Chain Due Diligence Act (LkSG): Effective from 2023, the LkSG mandates companies operating in Germany with over 1,000 employees to establish a risk management system to identify, prevent or minimize risks to human rights and the environment in their supply chains.
3. The Corporate Sustainability Reporting Directive (CSRD): The CSRD, which came into force in December 2022, requires companies to disclose non-financial information, including environmental, social and governance (ESG) factors. This directive aims to provide stakeholders with consistent and comparable sustainability information.
4. International standards and frameworks: Standards such as ISO 20400 provide guidance on integrating sustainability within procurement processes. Organizations are encouraged to adhere to frameworks like the Ethical Trading Initiative (ETI) Base Code, which sets minimum ethical standards for labour practices in global supply chains.
5. The European Union Deforestation Regulation (EUDR) which was adopted in June 2023 (partially replacing the previous EUTR – EU Timber Regulation) is a regulation designed to prevent deforestation and forest degradation linked to products entering the EU market. It mandates that companies importing or selling certain commodities and derived products in the EU must demonstrate that these products are deforestation-free and produced in compliance with the laws of the country of origin. This regulation aims to reduce the EU's contribution to global deforestation and promote sustainable supply chains.

Ethical supply chain management is characterized by proactive risk management, technological integration, and adherence to a comprehensive regulatory framework.

Organizations are increasingly held accountable for their supply chain practices, necessitating a commitment to transparency, sustainability, and human rights. A supply manager plays a vital role in ensuring ethical standards throughout the supply chain. Here are key actions they can take:

1. Establish clear ethical policies: Develop and communicate a robust supplier code of conduct that outlines expectations regarding labour rights, environmental practices, anti-corruption and fair business conduct.
2. Conduct thorough supplier due diligence: Assess suppliers before onboarding by evaluating their compliance with ethical standards, including certifications, labour practices and regulatory adherence.
3. Implement regular audits and monitoring: Schedule periodic audits and performance reviews to verify suppliers adhere to agreed ethical standards. Use both on-site inspections and remote monitoring tools.
4. Foster transparency and communication: Maintain open communication channels with suppliers to encourage reporting of unethical behaviour and promote collaborative problem-solving.
5. Leverage technology: Use digital tools such as blockchain or supply chain management software to enhance traceability, transparency, and real-time monitoring of supplier activities.
6. Train and educate: Provide ongoing training for internal teams and suppliers about ethical requirements, anti-corruption laws, and sustainability practices.
7. Enforce accountability: Establish consequences for non-compliance, including corrective action plans or termination of contracts with unethical suppliers.
8. Promote a culture of integrity: Lead by example and encourage a company-wide culture that prioritizes ethical behaviour and social responsibility.

These areas can significantly contribute to maintaining ethical standards and building a trustworthy, sustainable supply chain.

Inventory: the basic concepts

15

Introduction

Decisions regarding the amount of inventory that a company should hold and its location within a company's logistics network are crucial in order to meet customer service requirements and expectations. Potentially, however, there is a large cost associated with holding inventory. It is vital to get the balance of cost and service right. This chapter sets out to explore the basic concepts behind the inventory-holding decision.

In the first part of the chapter, the main reasons for holding inventory are considered. The many different types of inventory are then described. These include raw material stocks and all of the different types of stock held throughout the supply chain up to finished goods stocks. The implications of inventory-holding policy on other logistics functions are highlighted, with particular emphasis on the need to provide the balance between cost and service that was indicated in previous chapters. The need to avoid the sub-optimization of logistics resources is also discussed.

The two main inventory replenishment systems are described. These are the periodic review and the fixed point reorder systems. The stock level reorder point is important, and must take account of the stock required to cover the lead time before the new stock is received as well as the safety stock required to cover for variations in demand and supply. The impact that end user demand changes have on requirements further up the supply chain is outlined. The means of identifying reorder quantities using the EOQ method is described, and it is noted that it is important to take other factors into account when determining order quantities in this way.

The need to hold stocks

There are a number of reasons why a company might choose or need to hold stocks of different products. In planning any distribution system, it is essential to be aware of these reasons. The aim is to ensure that stock levels are adequate and not excessively high. The most important reason for holding stock is to provide a buffer between supply and demand. This is because it is almost impossible to synchronize or balance the varying requirements of demand with the vagaries of supply. These and other important reasons are summarized, as follows:

- To keep down production costs. Often it is costly to set up machines, so production runs need to be as long as possible to achieve low unit costs. It is essential, however, to balance these costs with the costs of holding stock.
- To accommodate variations in demand. The demand for a product is never wholly regular so it will vary in the short term, by season, etc. To avoid stockouts, therefore, some level of safety stock must be held.
- To take account of variable supply (lead) times. Additional safety stock is held to cover any delivery delays from suppliers.
- Buying costs. There is an administrative cost associated with raising every order. To minimize this cost, it is necessary to hold additional inventory so that orders do not have to be repeated too frequently. It is essential to balance these elements of administration and stockholding, and for this the economic order quantity (EOQ) is used.
- To take advantage of quantity discounts. Some products are offered at a cheaper unit cost if they are bought in bulk.
- To account for seasonal fluctuations. These may be for demand reasons whereby products are popular at peak times only. To cater for this while maintaining an even level of production, stocks need to be built up through the rest of the year. Supply variations may also occur because goods are produced only at a certain time of the year. This often applies to primary food production where, for example, large stocks result at harvest time.
- To allow for price fluctuations/speculation. The price of primary products can fluctuate for a variety of reasons, so some companies buy in large quantities to cater for this.
- To help the production and distribution operations run more smoothly. Here, stock is held to 'decouple' the two different activities.
- To provide customers with immediate service. It is essential in some highly competitive markets for companies to provide goods as soon as they are required (ex-stock).
- To minimize production delays caused by lack of spare parts. This is important not just for regular maintenance, but especially for breakdowns of expensive plant and machinery. Thus, spares are held to minimize plant shutdowns.
- Work-in-progress. This facilitates the production process by providing semi-finished stocks between different processes.

Types of stockholding/inventory

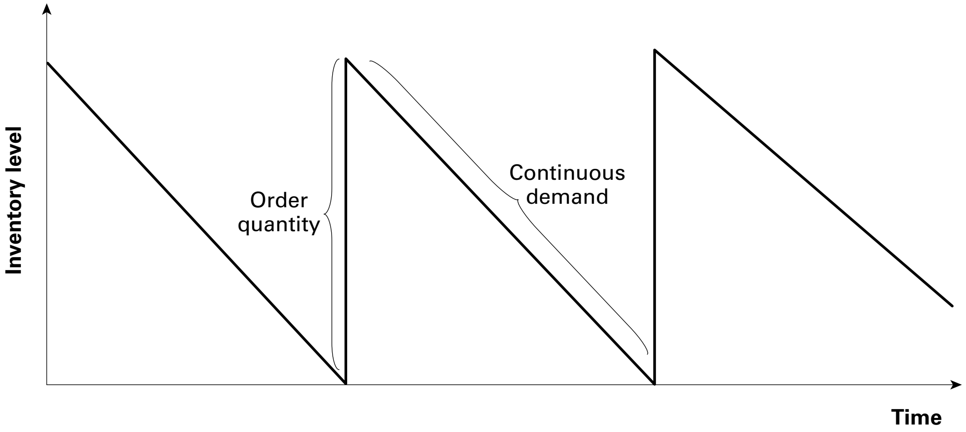
There are a number of different stock types that can be found in company supply chains. These are generally held at strategic positions throughout the company logistics network and in particular at the interfaces with suppliers or customers. The main categories are:

- *Raw material, component and packaging stocks:* generally used to feed into a production or manufacturing process.
- *In-process stocks:* sometimes known as work-in-progress (WIP), these consist of part-finished stock that is built up between different manufacturing processes.
- *Finished products:* stocks that are held at the end of the production line normally in a finished goods warehouse and sometimes known as finished goods inventory (FGI).
- *Pipeline stocks:* probably the most common type of stockholding, these are held in the distribution chain for eventual transfer to the final customer.
- *General stores:* containing a mixture of products used to support a given operation, such as a large manufacturing plant.
- *Spare parts*: a special category because of the nature of the stock, which provides a crucial back-up to a manufacturer's machinery or plant where any breakdown might be critical, and also held by service and maintenance companies for supply to their customers to support service contracts. Service industries, such as utilities, hospitals, and maintenance, repair and overhaul (MRO) providers, invest in spare parts inventory to support their service offer. They have two main stock categories: 1) consumables (nuts, bolts, etc); 2) rotables and repairables (parts that require periodic maintenance or are repairable).

Within the above categories, stock can again be broken down into other major classifications:

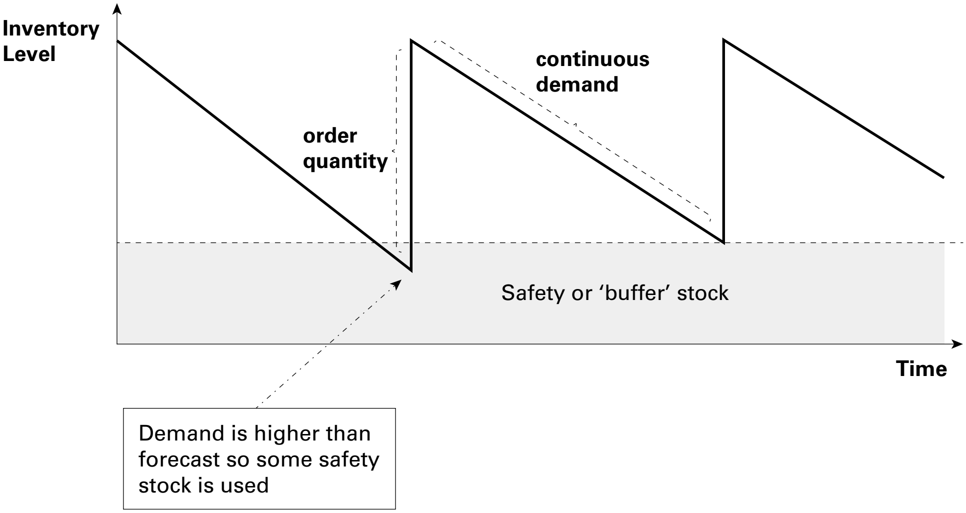
- *Cycle stock or working stock*: this refers to the amount of inventory available for normal or average expected demand in a given period, excluding safety stock. It is the stock created by products arriving in large quantities to meet frequent but small-quantity demands. A typical example is the major production stock within a production warehouse, where it reflects the batch sizes or production run lengths of the manufacturing process. This flow of inward supply and outward demand for a product in a warehouse is not balanced and is often depicted as a classic 'saw-tooth' as shown in Figure 15.1. The sharp rise in stock level represents the delivery of an order, and the steady decline in stock level represents the regular demand for the product over time (although this would in reality be more irregular than that depicted in Figure 15.1).

Figure 15.1 Inventory level showing input (order quantity) and output (continuous demand)



- *Safety stock*: this is the stock that is used to cover the unpredictable daily or weekly fluctuations in demand. It is sometimes known as 'buffer' stock, as it creates a buffer to take account of this unpredictability. This is depicted in Figure 15.2.

Figure 15.2 Inventory level with safety stock in place



- *Speculative stock:* this can be raw materials that are 'bought forward' for financial or supply reasons, or finished stock that is pre-planned to prepare for expected future increases in demand.

- *Seasonal stock:* this is product that is stockpiled to allow for expected large increases in demand. Typically, in Western Europe, this would include inventory built up prior to the Christmas demand peak.

Stockholding policy implications for other logistics functions

There are many ways in which the need to hold stock affects other logistics functions and vice versa. It is essential for effective planning that the various costs associated with inventory are minimized in relation to other logistics costs. As already discussed in previous chapters, it requires a process of balance between these functions to avoid any sub-optimization and to create a cost-effective total solution. With this in mind, it is useful to review those areas where this balance may be needed.

The *number of distribution centres* (DCs) in a distribution system significantly affects the overall cost of that system. The reasons given for having a large number of DCs are generally the perceived need to have a 'local presence' within a market and the need to provide a given level of service to customers. A distribution system that does have many sites will require high stock levels, specifically with respect to the amount of safety stock held. In addition, a large number of sites is likely to mean fairly small delivery areas, reflecting poor stock turn and higher unit costs in the warehouse.

Many companies have, in recent years, undertaken DC rationalization exercises whereby they have cut significantly the number of sites within their distribution network. This applies to both retailing and manufacturing companies. Although this leads to an increase in local transport costs because delivery distances are greater, there are large savings to be made in inventory reduction – specifically in safety stock reduction.

A simple rule of thumb exists for estimating these savings, known as the 'square root law'. Basically, the law states that the total safety stockholding in a distribution system is proportional to the square root of the number of depot locations. The law thus gives a broad indication of prospective inventory savings from any DC reduction project. For example, a site reduction from, say, 10 to 5 can lead to inventory savings of 29 per cent, as indicated in the following calculation:

$$\begin{aligned}\text{Inventory reduction} &= 1 - \frac{\sqrt{5}}{\sqrt{10}} \\ &= 1 - \frac{2.24}{3.16} \times 100 \\ &= 29\%\end{aligned}$$

Another major factor to be considered is the effect that an excess of inventory can have on the *size and operation of a DC*. Excessive stock occurs for a number of reasons, such as obsolete stock, dead stock, unnecessary storage of slow-moving lines, etc. This may mean that a DC is larger than necessary, that the site operation is hindered through a shortage of working space or even that extra outside storage is required.

One means of tackling these problems is to be more aware of the range of products held. This can be achieved by using techniques such as Pareto analysis (ABC analysis) or criticality analysis. (See Chapter 7 for a more detailed discussion of these and to see a criticality matrix.) Pareto's law provides the '80/20 rule', which states that there is an 80/20 relationship for products under a variety of circumstances. For example, it is often found that approximately 20 per cent of storage lines represent 80 per cent of the throughput in a warehouse.

Using Pareto analysis, it is possible to categorize product lines on the basis of:

'A' lines = fast movers (approximately 20 per cent)
'B' lines = medium movers (approximately 30 per cent)
'C' lines = slow movers
'D' lines = obsolete/dead stock (C+D representing approximately 50 per cent)

Policy decisions can then be made, for example: 'A' lines could be held at all DCs and have a 98 per cent availability; 'B' lines could be held at all DCs but only at 90 per cent availability; 'C' lines could be held only at a limited number of DCs and at 85 per cent availability; and 'D' lines should be scrapped.

Clearly this policy will differ according to product type, industry type, service level requirements, etc. The essential point is to be aware of the appropriate stockholding costs and to recover the costs accordingly.

There are several ways in which stockholding policy and practice can affect *transport operations*. The major example is one that has already been indicated and concerns the number of DCs in a distribution system. Whereas inventory savings can be made by reducing site numbers, this will be associated with an increase in local delivery costs because delivery distance will increase as DC catchment areas become larger. The key is to get the most cost-effective balance between transport costs and inventory and warehouse costs (as discussed in Chapter 10).

Another example where inventory policy might influence transport is in the use of backloads for return journeys by primary (line-haul) vehicles and sometimes by delivery vehicles. Empty return journeys are a recognized cost that transport managers are always keen to minimize. It may be possible to arrange for raw materials or bought-in goods to be collected by own vehicles rather than delivered by a supplier's vehicles. This may lead to higher stock levels but would mean lower transport costs.

A company's stockholding policy may also affect the *distribution structure* that the company adopts. There are three main patterns:

1. direct systems
2. echelon systems
3. mixed or flexible systems

Direct systems have a centralized inventory from which customers are supplied directly. These systems are of two main types – either supplying full vehicle loads, or direct-to-consumer (DTC) services, particularly for internet orders.

Echelon systems involve the flow of products through a series of locations from the point of origin to the final destination. The essential point is that inventory is stored at several points in the distribution chain. There may be several links or levels within these structures, perhaps from production warehouses through a central stockholding point to regional and/or local DCs. Typical examples include some of the manufacturers of fast-moving consumer goods (FMCG) products.

Mixed systems are the most common. They link together the direct and the echelon systems for different products, the key element being the demand characteristics of these products (order size, fast-/slow-moving, substitutability, etc).

Inventory costs

Inventory costs are one of the major logistics costs for many manufacturing and retail companies, and they can represent a significant element of the total cost of logistics. As has been discussed in several previous chapters, there are many major cost trade-offs that can be made with all the other key logistics components. It is important to be able to understand what the key cost relationships are within a company. To do this, an awareness of the major elements of inventory cost is essential.

There are four principal elements of *inventory-holding cost*. They are:

1. Capital financing cost: this is the cost of financing the capital tied up in inventory, normally calculated as the cost of the goods multiplied by the rate of interest paid to the bank. It may also be represented as the opportunity cost of tying up capital that might otherwise be producing a better return if invested elsewhere. This is almost always the largest of the different elements of inventory cost.
2. Service cost: the cost of stock management and insurance.
3. Storage cost: the cost of space, handling and associated warehousing costs involved with the actual storage of the product.
4. Risk cost: this occurs as a consequence of pilferage, deterioration of stock, damage and stock obsolescence. With the reduction in product life cycles and the fast rate of development and introduction of new products, this has become a very important aspect of inventory cost. It is one that is frequently underestimated by

companies. It is particularly relevant to high-tech industries, the fashion industry, and fresh food and drink.

Other important costs that need to be understood are the reorder and the set-up costs for an individual product. The *reorder cost* refers to the cost of actually placing an order with a company for the product in question. This cost applies regardless of the size of the order. It includes the cost of raising and communicating an order, as well as the costs of delivery and order receipt.

The *set-up cost* refers to the additional cost that may be incurred by the manufacturing plant if the goods are produced specifically for the company. A series of small orders will each necessitate a separate set-up cost. On the other hand, the larger the order, the longer the production run using a single set-up and the lower the production unit cost of the items in question. Of course, orders for large amounts of a product will result in the need for it to be stored somewhere – at a cost! This is yet another classic logistics trade-off decision that needs to be made. The means of assessing appropriate order quantities are discussed in the section 'The economic order quantity' later in this chapter.

The final inventory-related cost is the *shortage cost* – the cost of not satisfying a customer's order. This cost is notoriously difficult to measure. It is used to try to reflect the penalty of not holding sufficient stock of a product, which may lead to lost profit due to lost sales, loss of future sales, loss of reputation and the cost of the urgent delivery of unsatisfied orders.

Reasons for rising inventory costs

Despite many companies' best efforts to reduce their inventory costs, these costs have often shown a tendency to rise. There are several reasons for this, which include:

- Reduced product life cycles: many products have significantly reduced usable lives. This applies particularly to technology-based products such as mobile phones, tablet computers and e-readers. The continuous relaunch of new and revised models leads to high levels of obsolete stock due to old models very quickly becoming out of date.
- Product proliferation: due to competitive pressure, companies have tended to offer an increased number of types and varieties of their products in order to maximize demand. This has led to higher stock levels. Ways of reducing this impact include a move to modular assembly whereby a common product platform is used with variations added at a secondary stage.
- Customer expectations: higher levels of service are being demanded by customers in terms of immediate supply on demand. This means that suppliers must hold

higher stocks in order to avoid lost sales so as to avoid customers going elsewhere for their supply.

- Demand volatility: demand for products tends to vary more quickly than in the past, probably due to better and faster consumer information. Product demand can therefore either increase or decrease quite dramatically over short time periods, making it more difficult to assess the best levels of stock to hold.
- Extended supply chains: the move to globalization means that markets can now be supplied from extreme distances. This greatly increases the possibility of supply chain delays, the main solution being the introduction of more stock within the supply system. Also, there is a need for more safety stock with extended supply chains resulting from the greater likelihood of demand variability during the longer lead times (in inventory calculations the length of lead time directly impacts on safety stock).
- Just-in-time responsibilities: although the philosophy behind the just-in-time approach is to reduce inventory by streamlining the supply process, there can be significant implications when the process is not adequately balanced throughout the supply chain. In more instances than might be expected, the adoption of just-in-time by some manufacturers and retailers can mean that although they have significantly reduced stocks, there is a pressure on suppliers to keep additional inventory to ensure that a suitable final supply to the consumer is always maintained (often known as 'just-in-case' stocks).

Inventory replenishment systems

The aim of an effective inventory replenishment system is to maintain a suitable balance between the cost of holding stock and the particular service requirement for customers. The need for this balance can be illustrated by considering the disadvantages of low stock levels (which should provide very low costs) and high stock levels (which should provide a very high service).

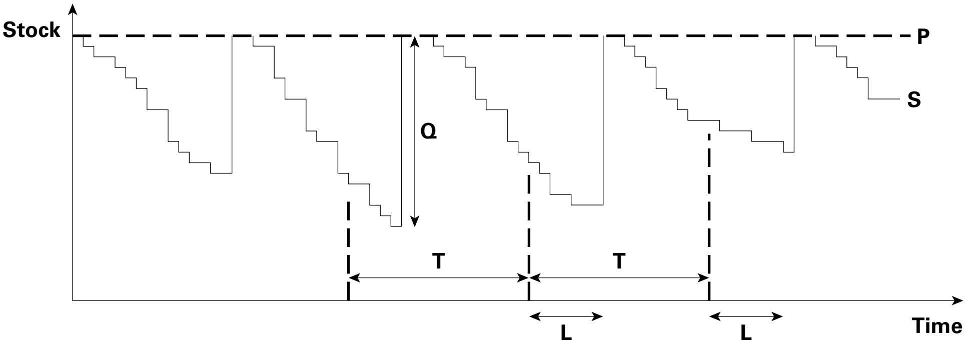
The disadvantages of low stock levels are that customers' orders cannot be immediately fulfilled, which may lead to the loss of both existing and future business, and that goods have to be ordered very frequently, which may lead to heavy ordering costs and heavy handling and delivery costs.

High stock levels have a major disadvantage because capital is tied up that might be better invested elsewhere. Also, there is the risk of product deterioration (e.g. food and drink) and of products becoming outdated, superseded or obsolete if they are stored for long periods of time (e.g. computers, mobile phones and fashion goods). A final disadvantage, previously discussed, is the expense of providing additional storage space.

Inventory replenishment systems are designed to minimize the effects of these high/low stock level disadvantages by identifying the most appropriate amount of inventory that should be held for the different products stocked. There is a variety of systems, but the two major ones are the periodic review (or fixed interval) system and the fixed point (or continuous) reorder system.

The *periodic review system* works on the premise that the stock level of the product is examined at regular intervals and, depending on the quantity in stock, a replenishment order is placed. The size of the order is selected to bring the stock to a predetermined level. Thus, the order size will vary each time a new order is placed. The system is illustrated in Figure 15.3.

Figure 15.3 Periodic review system



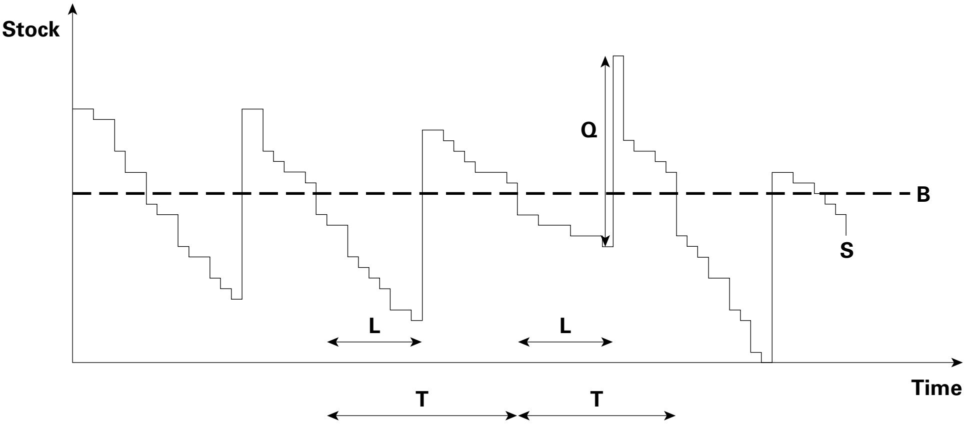
S is the stock level
P is the predetermined stock level
T is the re-order cycle time or review period (constant)
L is the lead time (assumed constant)
Q is the quantity ordered (varies)

In Figure 15.3, the change in stock level can be seen by the pattern represented by the line S. T represents the reorder cycle time, which is the regular interval at which stock is reviewed – say at the beginning of every month. An order is placed at a quantity (Q) that will bring the inventory for this product back to the predetermined stock level (P). Note that the quantity ordered includes an allowance for the time it takes for the product to be delivered from the supplier (this is the lead time, L). With this method, the quantity ordered is different each time an order is placed.

For the *fixed point reorder system*, a specific stock level is determined, at which point a replenishment order will be placed. The same quantity of the product is reordered when that stock level is reached. Thus, for this system it is the time when the order is placed that varies. This is illustrated in Figure 15.4.

In Figure 15.4, the change in stock level can be seen by the pattern represented by the line S. When the stock level reaches the fixed point reorder level (B), a replenishment order is placed. This is for a fixed order quantity (Q). L represents the lead time

Figure 15.4 Fixed point reorder system



S is the stock level
B is the fixed point re-order level
T is the order cycle time (varies)
L is the lead time (assumed constant)
Q is the quantity ordered (constant)

for the order, and the figure shows that when the order arrives the stock level is increased by the set quantity that has been ordered. T represents the time period between orders, the length of which varies from one cycle to another for this system.

The reorder point and safety stock

The fixed point reorder system requires the use of a specific stock level to trigger replenishment. This reorder point is an amalgam of the stock required to cover the lead time before the new stock is received plus the safety stock required to cover for variations in demand and supply.

Thus, the safety stock (or buffer stock) is a term used to describe the level of stock that is required to avoid stockouts, which might be caused by uncertainties in supply and demand (see Figure 15.2). Systems need to be set up to provide the necessary level of safety stock to maintain the required service level in the face of variations in both demand and in supplier lead times. Safety stock is held when there is uncertainty in the demand level or lead time for the product. In this section, the means of determining the level of safety stock is discussed.

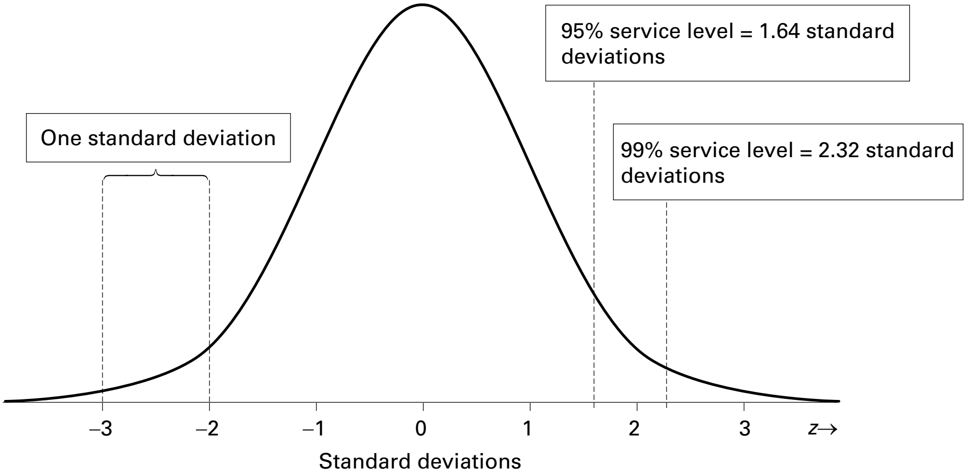
Safety stock can be calculated based on the following factors:

- the demand rate: the number of items used by customers over a given period
- the lead time: the time until the new stock is received
- the variability in lead time: supply lead times are likely to vary about an average

- the service level: the level of service based on the probability that a chosen level of safety stock will not lead to a stockout
- the forecast error: a statistical estimate of how forecast demand may differ from actual demand

Most service level variations assume a normal distribution curve. A normal distribution curve is shown in Figure 15.5, illustrating a 95 per cent service level at 1.64 standard deviations and a 99 per cent service level at 2.32 standard deviations. A normal service level may be 95 per cent, with very high priority items reaching 98 per cent or even 99 per cent.

Figure 15.5 A normal distribution curve showing 95 per cent and 99 per cent service levels



A classic approach for calculating uncertainty in both lead time and demand is given below. Both lead time and demand are normally distributed:

Demand (D) = 100 units per week
Demand standard deviation (DSD) = 20 units
Lead time (LT) = 8 weeks
Lead time standard deviation (LTSD) = 0.5 weeks

The mean lead time demand is LT × D = 8 × 100 = 800 units
and
the standard deviation of LT demand is:

$$= \sqrt{(LT \times DSD^2) + (D^2 \times LTSD^2)}$$

$$= \sqrt{(8 \times 20^2) + (100^2 \times 0.5^2)}$$

$$= 75 \text{ units}$$

For a 95 per cent service level:

Safety stock (SS) = 1.64 × 75.5
= 124 units
Reorder level = (LT × D) + SS
= 800 + 124
= 924 units

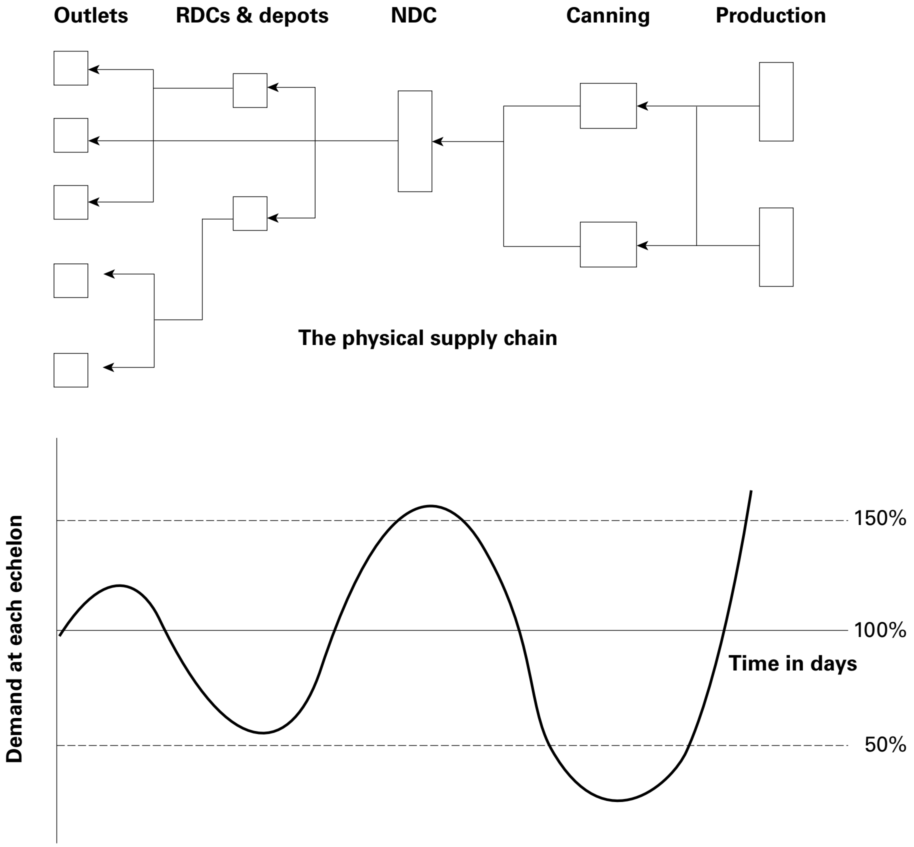
Note that these methods assume that the distributions of demand and lead time are normal distributions. In some instances, however, lead times may not be normal; they can be skewed. Other distributions (e.g. Poisson) could be used as the basis for these calculations. Another method that is receiving more attention is to use actual historic variations, also known as 'bootstrapping'. The basic idea of bootstrapping is that inference about a population can be drawn from using sample data. In this way, instead of using a Normal, Poisson or other standard statistical distribution to estimate how high safety stocks would need to be to provide a 95 per cent service level, actual historic data can be used to provide a more accurate representation of the demand distribution for that product. As well as these data analytic methods, artificial intelligence can be used to learn the most appropriate combination of techniques over time.

The bullwhip or Forrester effect

The systems described in the previous section, and variations of them, have been used for many years and generally work quite well. They do have one significant drawback, however, which is that they can create unnecessarily high or low stock levels, especially when demand occurs in discrete chunks. This is particularly true of multi-echelon distribution systems where the demand at each level is aggregated at the next level up the supply chain. Thus, small changes in demand for finished products are amplified as they move back through the supply chain. This is because each part of the chain is acting independently of the others. The result is a surge in demand up the supply chain as each inventory location individually adjusts to the demand increases. This is known as the 'bullwhip' or Forrester effect. It is illustrated in Figure 15.6.

An example of this might occur where an unexpectedly hot day causes an increase in demand for cold soft drinks. This will lead to additional orders from a variety of outlets – supermarkets, pubs, corner shops, vending machines, etc. As these requirements move up the supply chain through the different channels of distribution, they will be converted into additional orders of various sizes and at different order frequencies. They might be for weekly mixed pallet loads from cash-and-carry outlets, twice-weekly full pallet loads from grocery regional DCs and daily vehicle

Figure 15.6 The 'bullwhip' or Forrester effect



loads for manufacturers' national DCs. The consequence at the canning factory and point of production for the drink will be for a massive increase in demand for the product and a very confusing picture of what the true requirements are. This is echoed back into raw material and packaging supply.

Other possible causes of the bullwhip effect include:

- order batching (e.g. placing a large order at the end of a month, rather than as increased demand occurs, or batching to form a pallet load, etc) – the impact of minimum order quantities is part of this
- promotions, causing disruptions in demand patterns
- the impact of any rationing during periods of low supply availability
- demand forecast updating (e.g. reaction of forecast algorithms to increases in demand)
- behavioural buying patterns (e.g. fear of stockouts)
- lack of information or sporadic information.

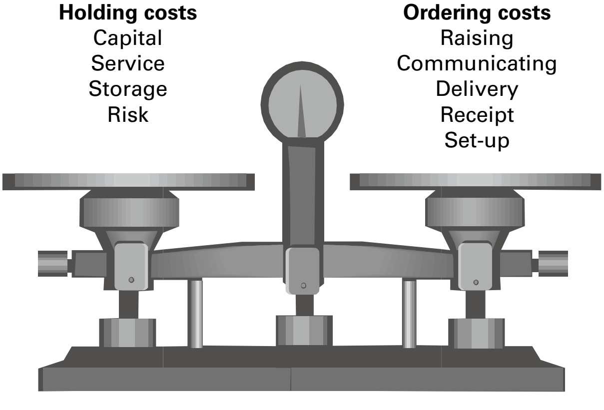
Thus, it can be very difficult to forecast demand based only on the immediate next or lower level of demand. Accurate forecasts need to reflect the requirements at all levels, which is often very difficult because companies have traditionally been loath to share information with their suppliers. This is one of the reasons for the move towards more open information systems that provide a clearer vision of stockholding and demand throughout the supply chain. These are discussed in Chapter 16.

The economic order quantity

Calculating the economic order quantity

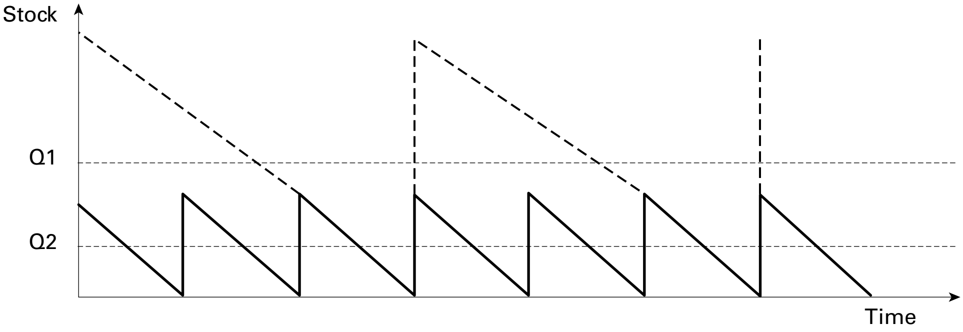
The two reorder systems described in the previous section require either fixed or variable quantities of different products to be ordered. The next question that needs to be addressed is how much product should be reordered. To answer this question is not easy, and there are many different views as to the best means of arriving at an answer. The traditional method of calculating the appropriate quantity is known as the economic order quantity (EOQ) method. The EOQ method is an attempt to estimate the best order quantity by balancing the conflicting costs of holding stock and of placing replenishment orders. This is illustrated in Figure 15.7.

Figure 15.7 The EOQ balance



The effect of order quantity on stockholding costs is that: the larger the order quantity for a given item, the longer will be the average time in stock and the greater will be the capital, service, storage and risk costs. On the other hand, the placing of a large number of small-quantity orders produces a low average stock, but a much higher cost in terms of the number of orders that need to be placed and the associated administration and delivery costs. These two different effects are illustrated in Figure 15.8. The large order quantity gives a much higher average stock level (Q1) than the small order quantity (Q2). The small order quantity necessitates many more orders being placed than with the large order quantity.

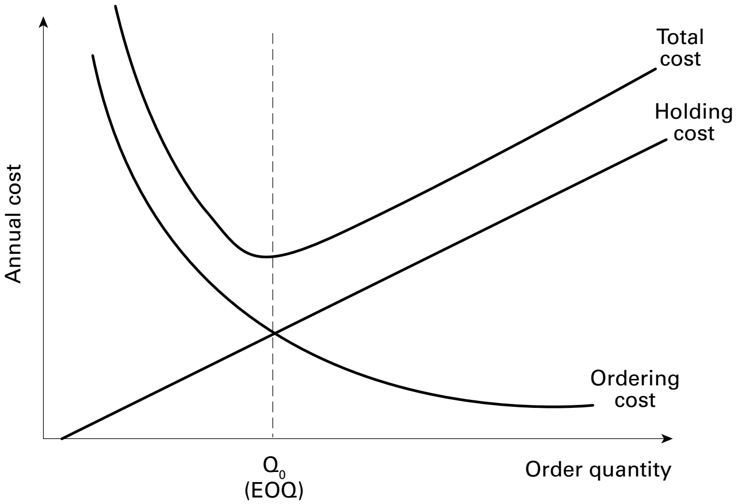
Figure 15.8 Reorder quantities



Q1 = average stock for large order quantity
Q2 = average stock for small order quantity

The best approach is, once again, one of balance, and it is this balance that the EOQ method aims to provide. Figure 15.9 helps to illustrate how this balance is achieved between the cost of holding an item and the cost of its reordering. There is a specific quantity (or range of quantities) that gives the lowest total cost (Q_0 in the figure), and this is the economic order quantity for the product.

Figure 15.9 The economic order quantity (EOQ) principle



There is a simple formula that enables the EOQ to be calculated for individual stock-keeping units (SKUs). This is shown in Figure 15.10, together with an example of how the formula can be applied. It should also be appreciated that the EOQ model is based on a number of assumptions that need to be taken into account when the method is used. It is a deterministic model: the demand for the product is known with certainty and is assumed to apply at a constant rate; each order is delivered with zero lead time; stockouts do not occur. However, when used in association with other methods, such as the fixed point reorder system, and with safety stock provision, the EOQ is very valid and can be applied to many different products.

Figure 15.10 The EOQ formula with worked example

Formula:

$$\text{EOQ} = \sqrt{\frac{2PD}{UF}}$$

P = Cost of placing an order
D = Annual demand in units
U = Cost of a unit of inventory
F = Annual stock-holding cost as a fraction of unit cost
UF = Cost of holding stock per unit per year

Example:

P = £75 = Cost of placing an order
D = 2,400 = Annual demand in units
U = £50 = Cost of a unit of inventory
F = 25% (1/4) = Annual stock-holding cost as a fraction of unit cost

$$\textbf{EOQ} = \sqrt{\frac{2 \times 75 \times 2{,}400}{50 \times 0.25}}$$

$$\textbf{EOQ} = \sqrt{\frac{360{,}000}{12.5}}$$

$$\textbf{EOQ} = 170 \text{ units}$$

Associated factors

There are a number of additional factors that need to be considered before the final order quantity is confirmed. These factors are of two types. The first type applies specifically to an individual company operation or to a particular industry. The second type relates to factors of a more general nature, which tend to be relevant to most stock control or stock reorder systems. An important point to appreciate is that factors such as these may need to be considered as well as any suggested order quantity that derives from a stock control or stock reorder system as indicated above. Some of these factors may be included within the stock reorder system itself, but this is often not the case.

The first set relates to *special factors* which may apply to specific companies or industries. The order quantity requirement for each product must be assessed and readjusted accordingly. The factors include the following:

- New product lines. These may be one-off items, or items that are expected to show a sharp increase in demand. There will be no historic data on which to base demand forecasts, so care must be taken to ensure that adequate stock levels are maintained.
- Promotional lines. National or local promotion (via TV, newspapers, special internet offers, etc) may suddenly create additional demand on a product, so stock levels must cater for this.
- Test marketing. This can be used for assessing the likely demand for a new product. The testing process can lead to spiky unplanned demand. Tests may be undertaken over a given period of time or be in a certain geographic area only.
- Basic lines. Some companies feel that a certain number of their basic stock lines should always be available to the customer as a matter of marketing policy. To provide this service, higher stock levels must be maintained.
- Range reviews. A company may adopt a policy to rationalize, or slim down, its range of products – particularly if new lines are being introduced. To do this it may be necessary to reduce the reorder quantities for some products.
- Centralized buying. Sometimes, where centralized buying occurs, it is necessary to hold excess stock, or run out of stock, because the buying department is negotiating large bulk discounts.

The second set relates to more *general factors* which may need to be taken into account. These include:

- Outstanding orders. These are orders already placed but not delivered. It is important to include these in the analysis, as otherwise overstocking may occur.
- Minimum order quantities. For some products there may be a minimum order quantity, below which it is uneconomic (or even impossible) to place an order.
- Seasonality. Many products have a peak demand at certain times of the year. The most common peak in the UK, for example, occurs just prior to Christmas (toys, games, wines and spirits, etc). When estimating stock levels and when forecasting trends in demand, it is essential to take these into account.
- Pallet quantities. As with minimum order quantity, it is often more economic to order in unit load quantities – which are often a pallet or number of pallets. A good economic unit load order is often a full truck load.

Issues with the EOQ calculation

The EOQ method has been in use for many years and, used in association with other factors such as those previously indicated, it is still valid for many companies. There are some issues, however, with the pure EOQ calculation – for example, it does not take into account the fact that unit delivery costs vary with the quantity ordered. This may often be a much more significant trade-off (i.e. inventory versus transport costs) than that considered by the EOQ model (i.e. inventory versus reorder costs).

Although still a useful and valid tool in many circumstances, some of the main assumptions on which it is based are less realistic for companies that have adopted a more streamlined approach to their logistics and supply chain activities. For example:

- Demand is not as predictable as it may once have been.
- Lead times are not constant: they can vary for the same product at different order times.
- Costs can be variable: order cost relationships have changed with the introduction of automatic and electronic data interchange (EDI) related ordering procedures.
- Production capacity can be at a premium: it may not always be feasible to supply a given product as and when required.
- Individual products are closely linked to others and need to be supplied with them, so that 'complete order fulfilment' is achieved.

Thus, the main assumptions that are the basis for the EOQ are questionable for a number of companies and their products. This can be linked to the introduction of continuous replenishment, which is now at the heart of many companies' supply policies. This means that orders are for much smaller quantities and are required much more frequently. The rules that once applied to inventory planning are undergoing a change. Although this is certainly true for many large companies, the application of EOQ is still very relevant to many small and medium-sized enterprises. Thus, the EOQ method does rely on a number of basic assumptions, some of which may not be so applicable with the new concepts and approaches to inventory that have been derived in recent years. These concepts are discussed in Chapter 16.

Inventory and the supply chain

16

Introduction

In the previous chapter, the basic concepts behind inventory planning and management were described. Because of new approaches in inventory thinking some of the traditional methods of inventory planning are now becoming less applicable for many companies. This applies to the economic order quantity (EOQ) concept and these issues were discussed in the previous chapter.

In this chapter inventory techniques are reviewed in relation to the different types of demand that can be found within the context of push and pull systems. This includes the differentiation between dependent and independent demand and the nature of demand with respect to push and pull systems. Also, the importance of the 'decoupling point' is explained. The need for a company to hold inventory is explored with respect to the lead-time gap. This is the difference between the length of time it takes to complete an order and the amount of time a customer is prepared to wait for that order to be satisfied. Different approaches to inventory reduction are considered, and some of the main methods of measuring inventory and its relationship with time are reviewed.

Push and pull systems

For some products, appropriate inventory-planning techniques need to be chosen based on the different types of demand that are prevalent. The nature of this demand is likely to have an influence on the most suitable approach that should be adopted to manage the inventory. Indeed, the type of inventory policy may not just be dependent on the nature of demand, but sometimes by supply as well. Several key aspects are explained below.

Dependent demand versus independent demand

One important way of differentiating between demand types is that of dependent or independent demand. Whichever of these types of demand is the major characteristic of a product will have an influence on the nature of the inventory-management technique that is appropriate. This is also reviewed in Chapter 13.

Independent demand occurs where the demand for one particular product is not governed by the demand for any other product. Consumer demand for a tablet computer is, for example, independent as it is not required to support another product. Indeed, most consumer products are independent of the demand for other finished goods. This is an important distinction, because products with an independent demand require the use of forecasting to help determine expected demand levels and associated inventory requirements. The EOQ approach is commonly used for products with independent demand.

Dependent demand occurs where the demand for a particular product is directly related to or dependent on another product. In the case of a desktop computer, for example, the demand for the power leads or the connecting cables would be directly dependent on the number of computers sold as finished goods. Dependent demand can be classified in two ways. It may be vertical (e.g. the chip actually required in the production of the computer) or it may be horizontal (e.g. the instructional manual that is packed with the computer as a finished product). Typically, most raw materials, components and sub-assemblies have their demand dependent on the demand for the finished product. Because of this dependence, there is a far more limited requirement for the forecasting of the demand for these elements, as the actual needs are directly related to the finished product requirements themselves. MRP and MRPII systems are used for these elements (as described in Chapter 13).

'Push' versus 'pull'

One feature that is particularly relevant concerns the nature of the demand requirement. Is it a 'push' system or a 'pull' system?

- A push system is where inventory replenishment is used to anticipate future demand requirements (build-to-stock).
- A pull system is where the actual demand for a product is used to 'pull' the product through the system (build-to-order).

A push approach to inventory planning is usually based on a set plan that is predetermined according to certain rules of inventory reordering. This approach is a proactive one in the sense that it is planned on the basis of known demand (existing customer orders) and estimated, or forecast, demand for products from customers. The aim is to anticipate the extent and location of this demand and ensure that adequate stock is available in the right place at the right time. Typically, a push system is applicable for dependent demand and for cases where there are uncertainties in supply, source or production capacity limitations or the need to cater for seasonal demand. This was outlined in Chapter 15.

The pull approach is a reactive one where the emphasis is on responding directly to actual customer demand, which pulls the required product through the system. The idea of a pull system is that it can react very quickly to sudden changes in demand. The pull system is most useful where there is independent demand and where there is uncertainty of demand requirements or of order cycle time, otherwise, a push system must be used. The most common form of pull system is just-in-time, as the orders are placed only when working stock is at such a level that a replenishment order is triggered.

The 'decoupling point'

For many companies there is a need to adopt a hybrid system that combines the concepts of both the 'push' and 'pull' types of approach. Hybrid systems are often used in practice because most companies operate at some point in between pure build-to-stock and build-to-order systems. Thus, a typical manufacturer might base its early production decisions on forecasts resulting in an inventory of semi-finished products. The final steps are then based on the actual customer order, which involves the customization of the semi-finished product into the finished product (called postponement). This point in the supply chain is known as the 'decoupling point'. It is when the process moves from build-to-forecast to build-to-order, or from 'push' to 'pull'. This is when the major stockholding of products should occur.

Figure 16.1 The decoupling point at different positions in the supply chain showing where inventory is held

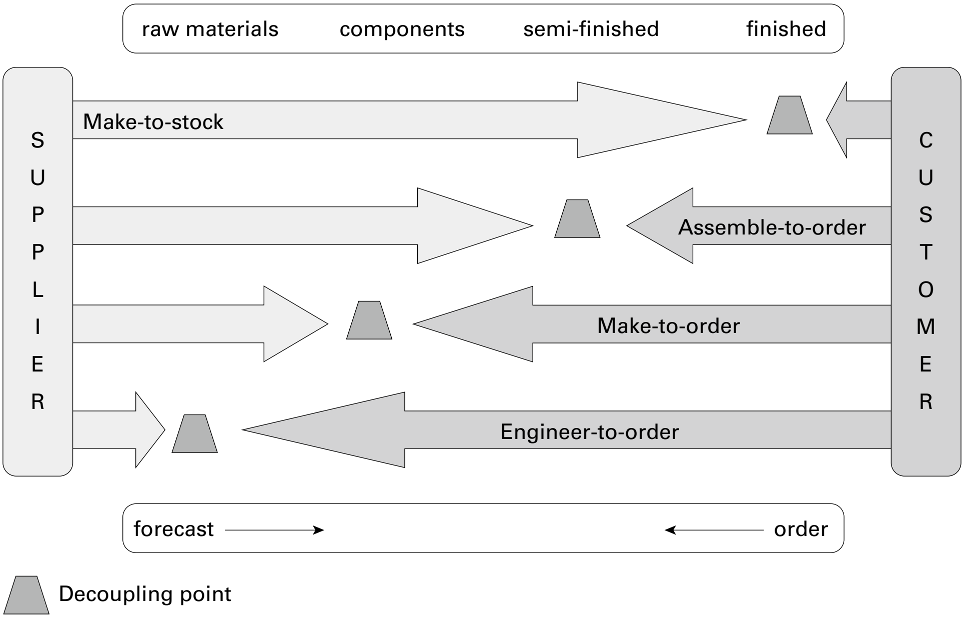


Figure 16.1 illustrates some of the key alternatives for positioning the decoupling point in the supply chain. Inventory is shown to be held at different points in the supply chain dependent on the type of manufacturing and how this relates to different customer demand. Key manufacturing types are represented as:

- *Make-to-stock:* here, customers are serviced from finished goods inventory. The finished goods stock is manufactured ready for use by the final customer. Inventory may then be held by a variety of players within the distribution system (distributors, wholesalers, retailers) and at a variety of locations (finished goods warehouses, distribution centres, satellite depots). This positioning is determined in line with the choice of distribution channel (see Chapter 4) and choice of logistics location (see Chapter 10).
- *Assemble-to-order:* a number of pre-assembled modules and different products are combined to satisfy a customer requirement. Key to this is to bring together the complete order, of which some may be specially ordered and some may be from stock.
- *Make-to-order:* whereby the products that are ordered are made specifically for the customer from raw materials and component parts.
- *Engineer-to-order:* this alternative takes one further step back as the products are also designed with the customer and are then manufactured by the supplier (and/or by other suppliers).

The determination of this decoupling of demand from supply is extremely important as it provides the basis for designing inventory management policy across the whole supply chain. Key to this is that the flow of goods upstream of the decoupling point is controlled by forecasts – thus it is a type of 'push' system. Downstream of the decoupling point, the flow of goods is based directly on customer orders – thus it is a 'pull' system.

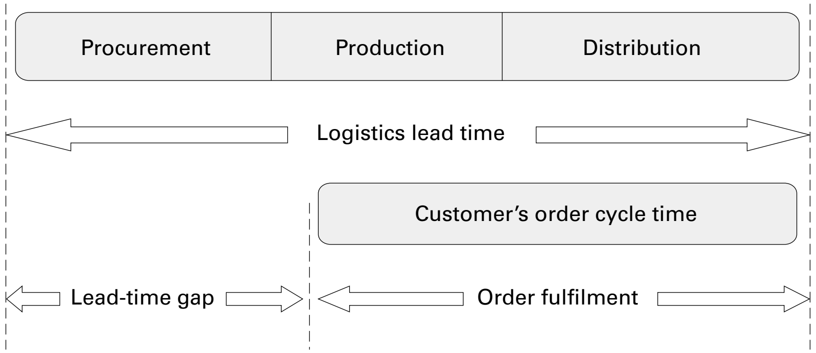
An important additional point is that the position of the decoupling point in the distribution chain (for the make-to-stock scenario) is largely determined by the customer lead time offered. For example, if same-day or two-hour service level is offered then stock must be held in multiple locations close to the customers. On the other hand, if a 24-hour or longer service level is offered the decoupling point can be further upstream and therefore more centralized.

The lead-time gap

One of the major reasons for the build-up of finished goods inventory is because of the long time that it takes to manufacture and deliver products. Ideally (for the manufacturer) the customer would be prepared to wait the full amount of time that is required. If this were the case, there would be no need to hold any stock at all. This, of course, happens only rarely for special 'made-to-order' products. The vast majority of products are required either immediately, as for many consumer products at the point-of-sale in shops, or within a short timescale, as for industrial products and also for consumer products when the retailer orders them in the first instance from the manufacturer.

The total time it takes to complete the manufacture and supply of a product is often known as the logistics lead time. Customers are generally prepared to wait for a limited period of time before an order is delivered. This is the customer's order cycle time. The difference between the logistics lead time and the customer's order cycle time is often known as the lead-time gap. The concept of the lead-time gap is illustrated in Figure 16.2. It is the existence of this lead-time gap that necessitates inventory being held. The extent of the lead-time gap, measured in length of time, determines how much inventory must be held. The greater the lead-time gap, the greater the amount of inventory that must be held to satisfy customer requirements. Thus, the more this gap can be reduced, the less inventory will be required. Recently there has been a move towards identifying different approaches for reducing this gap. A number of these approaches are described in the next section.

Figure 16.2 The lead-time gap



SOURCE Cranfield University

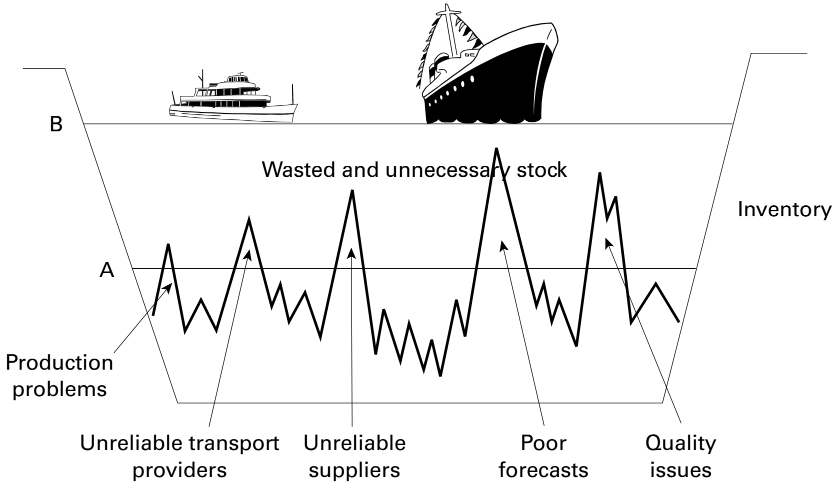
Inventory and time

High levels of inventory can hide a number of problems that occur throughout the supply chain. Companies may have sound and acceptable reasons for holding stock – as outlined in the previous chapter – but sometimes high levels of inventory can conceal other issues that are unidentified and should be addressed. The implications of this are illustrated in Figure 16.3. This shows that there can be significant waste in many logistics systems, concealed by unnecessary inventory (the difference between A and B). These can be problems such as:

- unreliable suppliers
- inaccurate forecasts
- production problems
- quality issues
- unreliable transport providers

There is, of course, a very real cost associated with these high inventory levels. This is caused by the amount of capital tied up in the value of the inventory itself, and also in the other associated costs. These include the costs of the storage facility and the cost of obsolescence when products become outdated and have to be sold at discount rates or even scrapped.

Figure 16.3 High inventory levels can hide other supply chain problems



Finding a solution to these inventory-related problems can lead to a significant reduction in the requirement to hold stock. In Figure 16.3, their elimination would mean inventory coming down from level B to level A. How can inventories be lowered in this way? As well as confronting the particular problem areas directly, another approach is through what is known as lead-time reduction. This approach recognizes the importance of time within the inventory decision-making process. The aim of lead-time reduction is to reduce the amount of unnecessary time within the order-to-delivery process and thus reduce the need to hold so much inventory as cover for this time delay. This can be achieved in a number of different ways, as follows:

- Manage the supply chain as one complete pipeline. This will allow stock to be reduced at various stages in the total pipeline because it is clear that other stock exists to provide the necessary safety stock cover. The section on 'Analysing time and inventory' in this chapter will explain this further.
- Use information better. If there is a clearer picture throughout the supply chain of what the true final demand for a product is, then it will be much easier to provide more accurate forecasts of the likely demand at other points in the supply chain. Such an approach could help prevent issues such as the bullwhip effect described in Chapter 15.
- Achieve better visibility of stock throughout the supply chain for all participants. This will allow for clearer and more confident planning of stock requirements at the various stockholding points in the chain and thus reduce the need to hold safety stocks.
- Concentrate on key processes. Make sure that the greatest planning and monitoring effort is spent on the most important processes in the supply chain. These may well be those that are providing the biggest bottlenecks or hold-ups in the system. It will often be necessary to undertake specific analysis to identify these bottlenecks using flowcharts such as those described in Chapter 7.
- Use just-in-time (JIT) techniques, where applicable, to speed up the flow of products through the supply chain. These will reduce lead times and thus mean that less stock is required within the supply chain.
- Use faster transport. This is, of course, one of the classic trade-offs in logistics. Faster transport will almost certainly cost more, but there will be an associated reduction in the need to hold stock, and inventory cost savings will be made accordingly. This may provide an overall cost reduction in the supply of that product as a whole. It is also likely to result in a faster and more responsive service level.
- Develop supply chain partnerships. It is important to understand the need to identify lead-time reduction opportunities that lie outside a company's own boundaries. The most spectacular savings in stock reductions occur where companies in the same supply chain can work together, share information and build up a trust that allows them to reduce stocks with confidence.

Analysing time and inventory

To help understand the relationship of time and inventory it is useful to be aware of the concept of activities that add value to the supply chain and those that do not add value. An activity that adds value is one that provides a positive benefit to the product or service being offered. This can be assessed in terms of whether the customer is prepared to pay for this activity. An activity that does not add value is one that can be eliminated from the supply chain process and will not materially affect the finished product as far as the final customer is concerned. The analysis of supply chain activities in terms of the extent to which they add value to a product has thus become an important factor in the assessment of supply chain efficiency. The aim is to identify and eliminate those activities that add cost but do not add value. The holding of inventory within a supply chain is often one such activity, and many companies are now trying to eliminate unnecessary inventory from their supply chains.

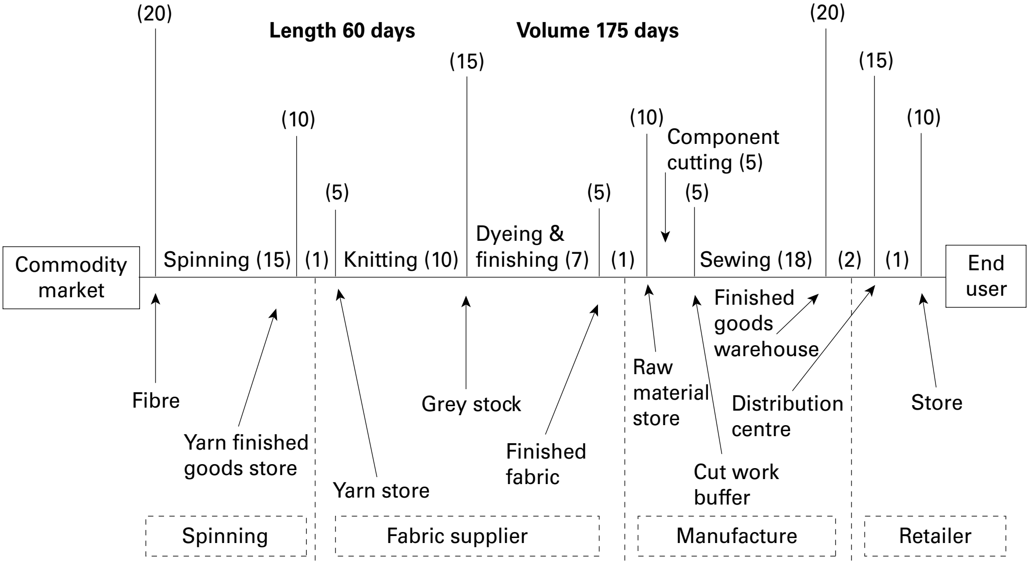
One method of highlighting unnecessary inventory is through the use of supply chain mapping. This technique enables a company to map the amount of inventory it is holding in terms of the length of time that the stock is held. An example of this technique is provided in Figure 16.4. This is one of the original examples used from the US clothing industry. It shows:

- Value-adding time, which is represented along the horizontal axis. This shows the total of the manufacturing and transport time for the whole supply chain process from the initial raw material (fibre) to the supply of the finished product to the end user. It is value adding because the product is changed either through a production process or through a movement process (the value added to the process in the movement of product is by creating time and space utility). The total manufacturing and transport time amounts to 60 days.
- Non-value-adding time, which is represented by the vertical lines that rise from the horizontal axis. These show the various occasions when the part-prepared or finished product is held as some form of inventory. This is adding no specific value to the product. This amounts to 115 days.
- The total time, or pipeline time, is the addition of the value-adding horizontal time and the non-value-adding vertical time. This is a time (or volume) of 175 days. This therefore includes all the time that it takes through all the different manufacturing, storing and transport processes.

Note that in some instances transport is treated as non-value-adding (movement between production processes) and in others as value-adding (movement to the final customer).

The example clearly indicates the opportunities for reducing time within the supply chain by reducing unnecessary inventory. Some inventory will be required, but as illustrated by this particular example there is a lot that is not. For example, there are 20 days of inventory in the finished goods warehouse and 15 in the distribution centre, and they come next to each other in the supply chain. With better visibility in the supply chain, there is almost certainly scope for eliminating inventory

Figure 16.4 An example of a supply chain map showing inventory mapped against time



SOURCE Scott and Westbrook, 1991

at this point. This situation is typically found where the FG warehouse is a supplier and the DC is a customer. Each is, perhaps, not fully confident of the other's commercial acumen and so they both hold additional inventory (above the prescribed safety stock allowance) to avoid any potential problems that might arise. Very few companies undertake this type of analysis, and those that do are usually surprised by the results they get as large inventory levels are identified. It should also be emphasized that this type of analysis has particularly dramatic results where a complete supply chain can be measured. (See Chapter 17 for further discussion on inventory planning for the supply chain.)

Inventory planning and demand forecasting

17

Introduction

In the previous two chapters the basic concepts behind inventory planning and management were described and some of the more recent developments concerning the way that inventory is viewed across the supply chain as a whole were discussed. It was noted that inventory requirements can differ from one product to another for a variety of reasons, including the nature of the demand requirement. Different demand requirements for a product can depend on whether it is part of a 'push' or a 'pull' system, and whether demand is dependent or independent of the demand for another product or the position of the decoupling point in the supply chain for that product.

This chapter is concerned with inventory planning and the use of demand forecasting to help determine the amount of inventory that should be held in the logistics network to meet customer service. Different inventory-planning horizons are described.

The main qualitative and quantitative demand forecasting methods are introduced. Qualitative forecasting methods are largely judgemental or experimental. A number of different quantitative forecasting methods are described, the main categories being: causal, common projective, advanced projective and life cycle. Among the common projective techniques that are explained are the moving average, exponential smoothing and regression analysis. It is also shown that demand can be broken down into trend, seasonal and random factors by using the time series approach. A planned approach to demand forecasting is provided.

Finally, there is a description of some of the main inventory-planning techniques that are used for manufacturing, retailing and the supply chain as a whole.

Inventory-planning horizons

Planning horizons for logistics were introduced and discussed at the beginning of Chapter 2. It was shown that these are generally classified as strategic (medium- to long-term), tactical (short- to medium-term) and operational (daily to short-term). Inventory-planning horizons are similar but are more often classified as follows:

- *long-term:* more than three years and covering, for example, new product development and facilities planning for manufacturing
- *medium-term:* three months to three years and covering, for example, aggregated demand, production schedules, inventory, materials and component requirement levels
- *short-term:* less than three months and covering, for example, forecast throughput, inventory levels, supply synchronization, etc

Long-term planning is used at the strategic level, as discussed in Chapters 2 and 6, and is not relevant to the level of inventory planning that is covered in this chapter. Medium-term planning includes techniques such as material requirements planning (MRP) and distribution requirements planning (DRP), which were introduced in Chapter 13 and will be summarized in the final sections of this chapter. The main focus of this chapter is on short-term planning for inventory, commencing with the important elements of demand forecasting.

Demand forecasting

Different forecasting methods

Different methods of demand forecasting are used to try to estimate what the future requirements for a product or SKU might be so that it is possible to closely meet customer demand. Forecasting, thus, helps in the inventory-holding decision process to answer questions about what to stock, how much to stock and what facilities are required. It is often said that 'all mistakes in forecasting end up as an inventory problem – whether too much or too little!'

There are several different approaches that can be used for forecasting. These are shown in Figure 17.1. The major categorization is between *quantitative* and *qualitative* forecasting methods, with the former being numbers-based and the latter relying on opinions. For the short-term inventory forecasting of individual SKUs, the quantitative methods are most commonly used and these will be given most attention in this chapter.

Qualitative forecasting methods

As can be seen from Figure 17.1 qualitative forecasting methods can be split into judgemental and experimental methods.

Judgemental methods

Judgemental methods are subjective assessments based on the opinions of experts such as suppliers, purchasing, sales and marketing personnel, and customers. These methods are used when historic demand data is very limited or for new products where there is no numerical demand data available. They include:

- *Executive brainstorming:* the opinions of a small number of senior managers in the company are taken together and an estimate of likely aggregate demand levels is made from the collective view.
- *Scenario planning:* a group of suitably experienced company employees and key customers is formed and they draw up and agree likely demand outcomes with regard to the products in question.
- *Delphi studies:* a panel of experts, both internal and external to the company, is formed. Each person is asked individually for their estimates of demand and then an iterative process occurs whereby each person sees the overall group range of results and alters their input as they think appropriate until a reasonable consensus view is determined.

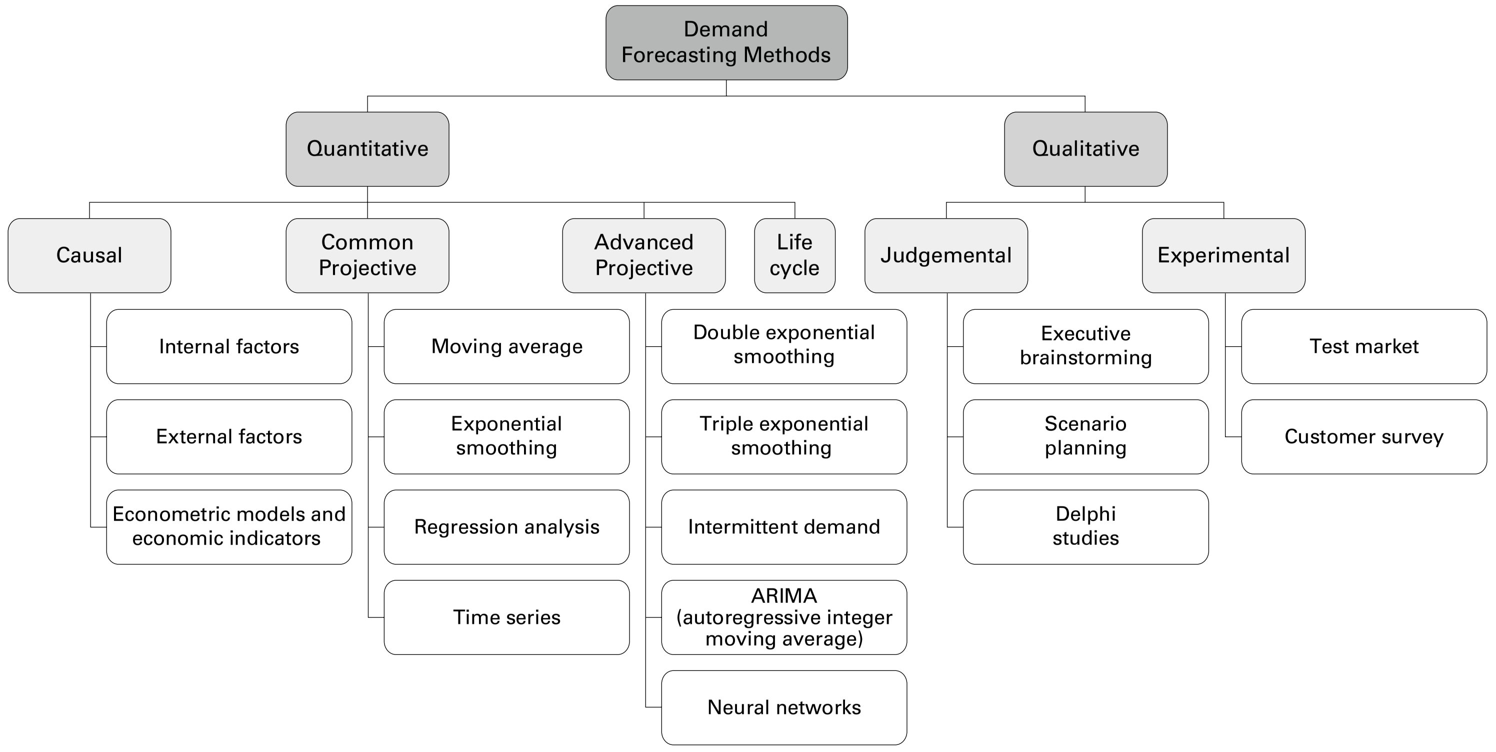
Experimental methods

Experimental methods are used when there is no information available on which a forecast can be based: again, this is likely to apply to new products. Companies may set up a group of existing customers and determine from them what the likely demand might be. Results are then extrapolated to a larger population and a forecast is produced. Sometimes companies use a small geographic area as a ‘test market’ to identify likely demand and then extrapolate this to the full market area. As well as test marketing, methods might also include customer questionnaires and consumer panels.

Quantitative forecasting methods

There are a number of different methods that are used for quantitative forecasting, as Figure 17.1 illustrates. These vary dramatically from some fairly simple, but very

Figure 17.1 Different demand forecasting methods



useful, approaches to some that are extremely complicated. The next several sections will describe some of the key methods listed in Figure 17.1.

Causal methods

Causal methods are used where the demand for a product is dependent on a number of other factors. Very often they are used in conjunction with another quantitative forecasting method because they enable the forecast to be adjusted more accurately with respect to certain other factors that have an influence on demand. These factors may be internal or external to the company. *Internal* factors are generally under the control of the company and include aspects such as promotions and price. *External* factors are likely to be out of the control of the company and may be directly business-related (competitors' plans, legislation) or indirectly related (seasonality, weather, the state of the economic cycle).

Classic causal methods of forecasting include the use of economic indicators (gross domestic product, interest rates) to gauge causal trends in demand for products and services, enabling forecasts to be adjusted accordingly. A more sophisticated approach is that of econometric modelling whereby a variety of economic variables are taken together and are used in mathematical models to forecast the underlying demand for products and services.

Common projective forecasting methods

In this section, some of the more common and most straightforward methods of forecasting are described. The basic methods are the moving average (and the weighted moving average) and exponential smoothing. These approaches use past demand data to estimate what demand is likely to be in the future. This can then become the basis for determining what stock levels are required to meet these forecast customer demands. In addition, the process of regression analysis is explained whereby the demand trend for a product can be estimated through the means of 'fitting' a line to a series of historic data points. These methods attempt to predict future demand based on historic data, but for many products there are additional factors that can also have an important influence on the accuracy of these predictions. These factors include trends over time, seasonality, general cyclical behaviour and random fluctuations. Time series analysis is often used to enable factors such as these to be taken into account and this is reviewed in the final part of this section.

Moving average/weighted moving average

The simplest method is the moving average, which takes an average of actual demand for a certain number of previous periods and uses this average as the forecast of demand for the next period. Such a system is able to respond to trends and is suitable for some products, but is not effective if the product has seasonal demand or random demand variations (see time series later in this section).

The formula is as follows:

$$F_t = \frac{A_{t-1} + A_{t-2} + A_{t-3} + \ldots + A_{t-n}}{n}$$

where:

F_t = the forecast demand
n = the number of periods to be averaged
A_{t-n} = actual demand in the past up to ‘n’ periods

An additional problem with this method is that it ignores the age of the observations, as all are treated equally in the process of determining the forecast demand level. It takes no account of changes over time, which is not really representative of demand in most logistics systems – because things do tend to change over time. This problem can be reduced by use of the weighted moving average, which puts more emphasis on the use of the most recent data, so reflecting actual demand more accurately.

The formula is as follows:

$$F_t = \frac{w_1A_{t-1} + w_2A_{t-2} + w_3A_{t-3} + \ldots + w_nA_{t-n}}{n}$$

where:

w = a weighting factor

Exponential smoothing

A more sophisticated version of this method of forecasting is known as exponential smoothing. This also gives recent weeks far more weighting in the forecast, but each forecast is in fact a weighted average of all prior observations. The weighting process declines exponentially with the increasing age of the observations, thus both emphasizing the importance of the most recent weeks and taking account of the value of the earlier data. The formula for exponential smoothing is as follows:

$$F_t = aY_{t-1} + (1 - a)F_{t-1}$$

where:

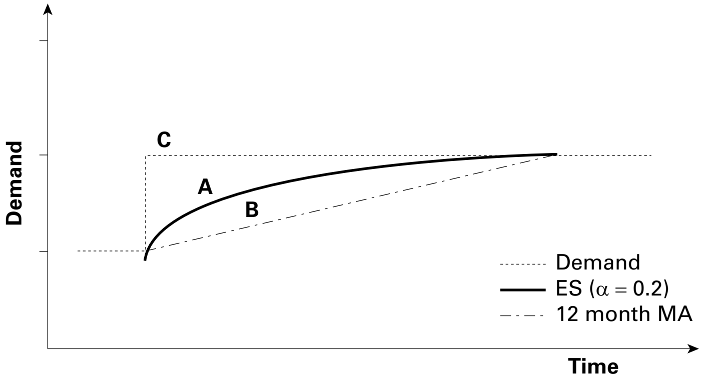
F_t = the forecast demand
Y_{t-1} = previous actual demand
F_{t-1} = previous forecast demand
a = an exponential smoothing factor (the smoothing constant)

The exponential smoothing approach can also include a consideration of the forecast error to improve the accuracy of the forecast – that is, the difference between the forecast and the actual demand for the previous period.

Forecasting methods such as exponential smoothing tend to give a much faster response to any change in demand trends than do methods such as the moving average.

Figure 17.2 provides an example of some of these different approaches. The dash-dotted line (C) represents actual demand, the dash–dot line (B) represents a forecast using the moving average method and the single line (A) represents a forecast using exponential smoothing. It can be seen that the single line (exponential smoothing) responds more quickly to the demand change than does the dash–dot line (moving average).

Figure 17.2 The moving average (MA) method (B) and the exponential smoothing (ES) method (A) of forecasting shown working in response to a step change in demand (C)



Regression analysis

Another method used is regression analysis, where a line of 'best fit' is statistically derived to identify any correlation of the product demand with other key factors and from this a trend line can be determined. Using the least squares method, a straight line is fitted around a scatter of data points. A correlation coefficient can be derived to indicate how well the regression line fits the data, as the larger the scatter of points around the line, the less strong is the relationship. This type of analysis works around the assumption that demand is normally distributed, but this may not necessarily be the case as aspects such as customer behaviour, price changes, weather changes, etc may distort this type of relationship. Regression analysis is also not a good method for taking account of seasonal fluctuations and cyclical factors.

'Time series' models

These projective forecasting techniques use historic demand data to identify any trends in demand and project these into the future. Unlike causal techniques they take no account of judgement or opinion. So, although based on actual past demand, they take no direct account of future events that may affect the level of demand. There are several different projective forecasting methods available, and it is important to select the most appropriate alternative for whatever type of demand is to be measured.

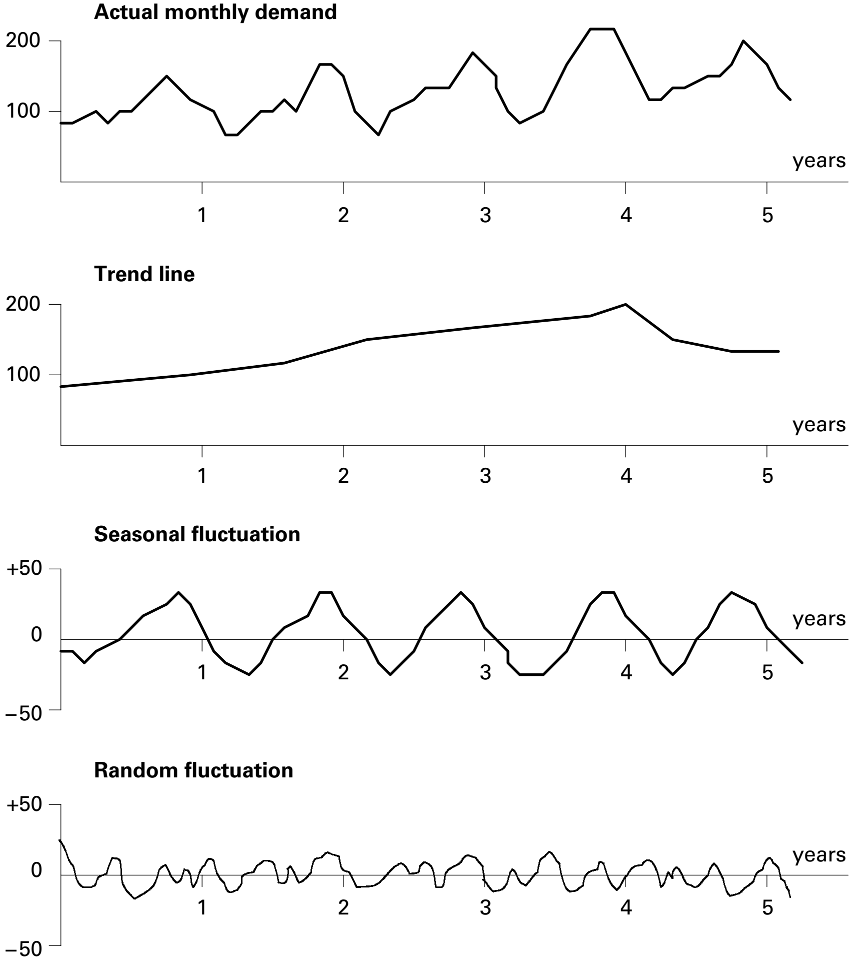
An additional point that needs to be emphasized is that there are different ways in which the demand for a product can vary over time. Some of these factors cannot be taken into account by just using the forecasting methods described so far. They need to be understood and data need to be adjusted before accurate forecasting can take place. These different elements of demand have been recognized and are taken into account by the use of 'time series' analysis. This is illustrated in Figure 17.3, where it can be seen from the graphs that the overall demand pattern can be divided into the following:

- *A trend line over several months or years:* in the graph, the trend is upward until the end of year 4, and then downward. It is this trend that can be forecast by using methods such as exponential smoothing.
- *A seasonal fluctuation:* this is roughly the same – year in, year out. In the graph, there is high demand in mid-year and low demand in the early part of the year. A classic example in the UK for many products is the high demand that occurs at Christmas.
- *Random fluctuations that can occur at any time:* these can be totally random but they may be causal and thus identified by using some of the qualitative methods described earlier. The classic example is – if it rains, umbrella sales increase!

Thus, a number of different approaches can be used and linked together to provide the most accurate forecasting of demand for any given product or group of products and allow for appropriate inventory levels to be identified and fixed. Each of the key elements should be taken into account by a good forecasting system and its associated stock control system:

- the trend, by setting inventory levels and replenishment cycles using an appropriate forecasting system
- seasonality, by adjusting inventory levels on a timely basis via seasonal analysis
- random, by providing sufficient safety stock

Figure 17.3 Elements of a demand pattern



Advanced projective forecasting methods

There are a number of more advanced projective methods of forecasting that can be used. They are fairly sophisticated but are very relevant under certain circumstances. They include techniques such as:

- Double exponential smoothing, which smooths random variation and trend, e.g. Holt-Winters method.
- Triple exponential smoothing, which smooths random variation, trend and seasonality, e.g. Winters method.
- Croston's exponential smoothing, which is used where there is intermittent demand. This involves simple exponential smoothing on the non-zero data and a

separate application of exponential smoothing to the times between non-zero data.

- Autoregressive integer moving average (ARIMA), which is fitted to time series data to help in understanding the data and to predict future points in the series, e.g. Box-Jenkins.
- Artificial intelligence (AI), where there is automated learning from past experience. Demand sensing, for example, uses current information to determine how the supply chain should react, employing pattern recognition technology to analyse real-time demand signals and create forecasts that are automatically input into supply chain planning systems. Thus, real-time data, algorithms and automation are combined to actively sense demand changes and quickly respond. These are digital supply chain planning platforms that are powered by AI and machine learning (ML) in particular.

Life cycle forecasting

Life cycle forecasting is relevant as it recognizes the key factor that over the life cycle of a product the characteristics of demand can and do change quite dramatically and that this affects the inventory and replenishment requirements for the product. For many high-technology products, for example, this is particularly important because the length of product life can be very restricted as new, more up-to-date products come into the marketplace and supersede them. It is essential, for example, that inventory levels are not held at very high levels in order to avoid high and costly wastage due to product obsolescence.

There are four stages to the product life cycle – introductory, growth, maturity and decline – all of which have relevance to logistics, including implications for inventory holding and replenishment. The product life cycle was discussed in the final sections of Chapter 6 (see particularly Figure 6.4).

Key implications for logistics and particularly for inventory include:

- setting suitable initial stock levels at the introductory stage
- the importance of stock availability at the introductory stage
- the danger of overstocking if a product doesn't take off
- the danger of losing business if a product is understocked at the early stages
- the need for cost-effective logistics and inventory levels at the growth stage
- care not to overstock in the maturity stage due to competitive and substitute products competing in the market
- avoiding obsolescence costs by minimizing stock in the decline phase

Alternative forecasting and modelling approaches that can be used to assist in life cycle inventory planning include input–output models, simulation models and life cycle models.

Accuracy and level of forecasting

Another important aspect of forecasting is measuring how accurate the forecast is. In this regard, there are various measures. For example, bias can be measured (e.g. the forecast always tends to be too high or too low) and error can be measured. Measures include:

- MAD: mean absolute deviation
- MSE: mean square error
- MPE: mean percentage error
- MAPE: mean absolute percentage error

Another point about forecasting is that where there are numerous combinations of options for an item (e.g. a car can have various body colours, trim colours, automatic or manual gearbox, air conditioning, etc) then it may be best to forecast at car type level and then split by percentages (based on historic demand, for example) for each of these options. This is often preferable to regarding each possible combination as an SKU and trying to forecast at SKU level.

Product groups or product lines may be categorized by demand pattern in order to determine the most suitable forecasting algorithm. One common method is to show a chart with demand volatility on one axis and demand frequency (i.e. interval between demands) on the other. All SKUs are then plotted on this chart. Often, a 2×2 matrix is then used to identify, say, four different algorithms.

An approach to demand forecasting

It is sensible to adopt a very methodical approach to demand forecasting. To achieve this, it is recommended that a number of key steps are used. These can be summarized as follows:

1. Plan. Ensure from the outset that there is a clear plan for identifying and using the most appropriate factors and methods of forecasting. Understand the key characteristics of the products in question and the data that is available. Consider the different quantitative and qualitative methods that can be used and select those that are relevant. If necessary and feasible, use a combination of different methods. Identify ways of double-checking that the eventual results are meaningful – it is unsafe merely to accept the results of a mechanical analytical process.

Forecasting at individual SKU level is a typical 'bottom-up' approach, so check results with suitable 'top-down' information.

2. Check. Take care to review the base data for accuracy and anomalies. Poor data that is analysed will produce poor and worthless results. Where necessary, 'clean' the data and take out any abnormalities.
3. Categorize. A typical range of company products can and do display very different characteristics. Thus, it is usually necessary to identify key differences at the outset and group together products with similar characteristics. It is likely to be valid to use different forecasting methods for these product groups. Use techniques such as Pareto analysis to help identify some of the major differences: high versus low demand, high versus low value, established products versus new products, etc.
4. Metrics. Use statistical techniques to aid the understanding of output and results (standard deviation, mean absolute deviation, etc). There may be a number of relevant issues that can impact on the interpretation of results: the size of the sample, the extent of the time periods available.
5. Control. Any forecasting system that is adopted needs to be carefully controlled and monitored because changes occur regularly: popular products go out of fashion and technical products become obsolete. Control should be by exception, with tracking systems incorporated to identify rogue products that do not fit the expected pattern of demand and to highlight any other major discrepancies and changes.

Inventory planning for manufacturing

MRP I and II

Key developments in inventory planning are aimed at solving some of the problems encountered by the use of the more traditional approaches to stock replenishment. They are based on the concept of *materials requirements planning* (MRP), which is a computerized system for forecasting materials requirements based on a company's master production schedule and bill of material for each product. This has subsequently been developed into *manufacturing resource planning* (MRPII), which is a broader-based system, used to calculate the time-phased requirements for components and materials with respect to production schedules, taking into account replenishment lead times, etc. This approach enables inventory levels to be significantly reduced, and service levels, in terms of shorter production lead times, to be improved. MRP systems are now quite well established, as are other related techniques such as 'just-in-time' (JIT) or kanban systems (see Chapter 13).

DRP, ERP and SCP

The obvious advantages of MRP and JIT systems to manufacturing have led to the further development of associated techniques for distribution – *distribution requirements planning* (DRP). DRP systems are designed to take forecast demand and reflect this through the distribution system on a time-phased requirements basis. DRP thus acts by pulling the product through the distribution system once demand has been identified. It is particularly useful for multi-echelon distribution structures to counter the problems of requirements occurring as large chunks of demand (see the Forrester effect, described in Chapter 15).

The most recent systems adopt an even broader planning approach. These are time-phased and enable planning across a whole business and even across complete supply chains. They are known, respectively, as *enterprise resource planning* (ERP) and *supply chain planning* (SCP).

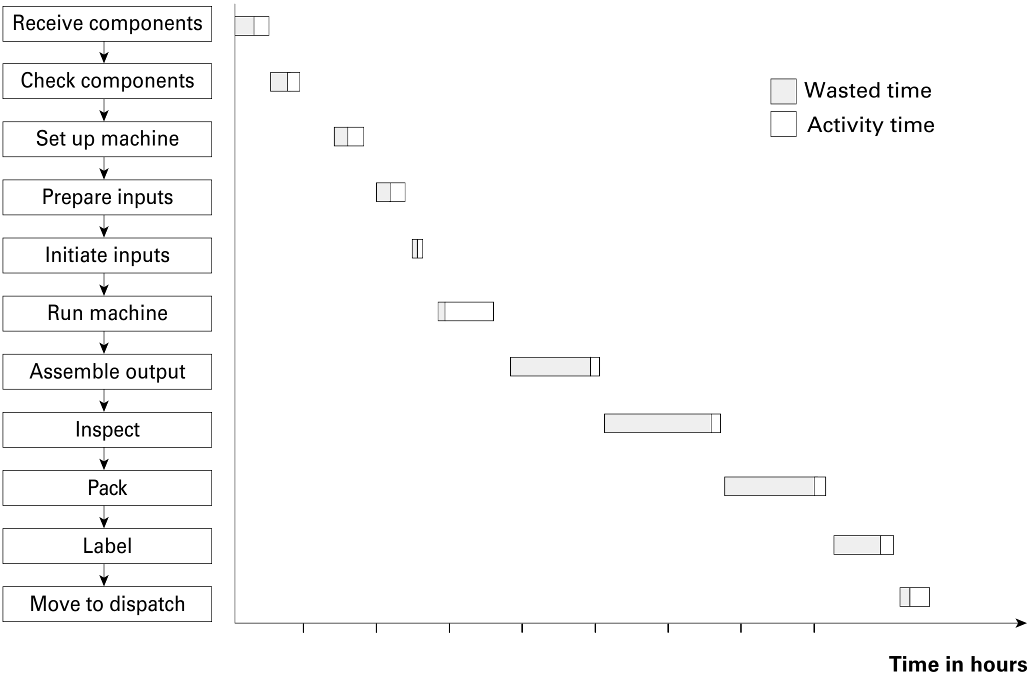
These systems are also discussed in Chapters 13 and 40.

Time compression

The concept of *time compression* is an important approach in the planning of manufacturing inventory requirements, or perhaps it should be termed as the planned reduction in manufacturing and WIP inventory. The opportunities for such reductions have been illustrated in Chapter 16 in the discussion on analysing time and inventory, where the use of supply chain mapping enables the identification of feasible time and inventory savings. Time compression techniques provide the means for achieving these improvements. Factors that need to be considered when planning a time compression study include:

- The need to take a complete supply chain perspective when planning: beware sub-optimization.
- The need to undertake appropriate analysis: as with many logistics studies, much time and effort has to be invested in the data collection, validation and analysis stages.
- The identification of unnecessary inventory and unnecessary steps in key processes: this is where savings and improvements of real value can be found.
- Working towards customer service requirements as well as cost minimization when planning for production.
- Designing products to be compatible with supply chain requirements: it can be very difficult to achieve this in some companies that have a strong, traditional manufacturing base.

Figure 17.4 Time-based process mapping



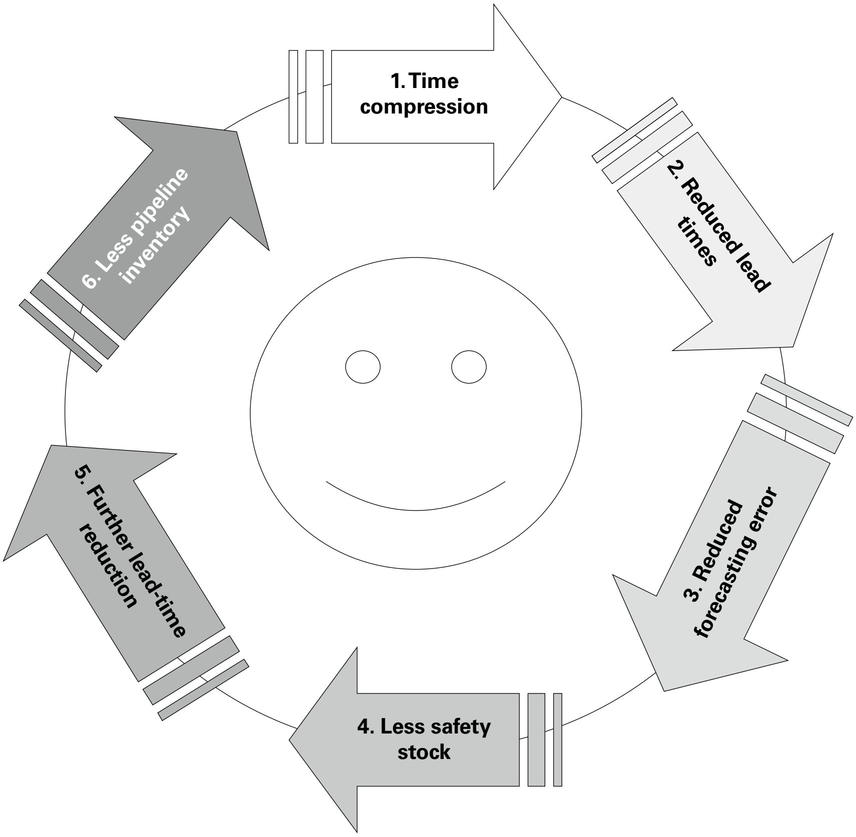
- Designing production processes to be compatible with supply chain requirements: the ability to postpone processes until later in the supply chain can lead to significant inventory reduction.

Time compression can be a relatively simple exercise to undertake but the benefits can be quite considerable. A typical approach could be as follows:

- Supply chain mapping can be used as the starting point to help identify the major opportunities for time and inventory saving.
- The next stage is then to 'walk the process', taking care to follow and record every detailed step in the process.
- Each activity is then measured according to the total time, including both 'value-added' time and 'wasted' time (see Figure 17.4).
- The process is then reassessed or re-engineered to eliminate as much wasted time as is possible.

Time, and thus inventory, is taken out of the system and in this way overall cost is reduced. Time compression is a technique that provides a means to identifying and improving processes that can lead to a number of potential benefits. It is a way of creating a 'virtuous circle' of improvement that can include shorter lead times, better forecasting and reduced inventory, as illustrated in Figure 17.5.

Figure 17.5 The virtuous circle of time compression



Inventory planning for retailing

In recent years, power within most supply chains for consumer products has lain very firmly in the hands of retailers rather than manufacturers. This has applied to all but the strongest brand names. The development of internet and home shopping has had little if any impact in changing this. Many retailers have tended to outsource their distribution and logistics activities but, although this continues to be the case, retailers are now taking a much closer interest in the impact that an effective logistics operation can have on their overall service offering – and consequent company profitability. This applies to distribution and also particularly to inventory management policy and practice.

Inventory management at distribution centre (DC) level for both retail national distribution centres (NDCs) and retail regional distribution centres (RDCs) poses similar problems to those experienced by manufacturers. At the retail store, however, inventory requirements can be quite different, depending on the product availability strategy and the merchandising policies that are used. New types of inventory management systems have been developed to cater specifically for these different requirements. Some of these approaches have significant similarities, but the overall aim is to promote the greater visibility of information within the supply chain, to enable inventory to be reduced and to enhance customer service in terms of product availability. The main planning techniques are as follows.

Vendor-managed inventory (VMI)/co-managed inventory (CMI)

Vendor-managed inventory is where the manufacturer is given the responsibility for monitoring and controlling inventory levels at the retailer's DC and in some instances at the retail store level as well. Specific inventory targets are agreed, and it is the responsibility of the manufacturer to ensure that suitable inventory is always available. Such arrangements depend on accurate and timely information, and suitable computerized systems have become available in recent years. The main advantage for retailers lies in the reduction of operating costs and also the delay in payment for the products in question. For manufacturers, it is suggested that running a VMI system for a retailer provides the opportunity to develop a much closer, and hopefully more binding, relationship with the retailer as well as giving a much better visibility of real demand. This can make the planning of production much easier and can lead to significant reductions in inventory holding right through the supply chain. However, it can also make it more difficult for the retailer to change suppliers. Co-managed inventory (CMI) is similar to VMI but with CMI the inventory replenishment order is confirmed by the retailer.

Continuous replenishment programme (CRP)

The aim with CRP is to develop free-flowing order fulfilment and delivery systems, so that pipeline inventories can be substantially reduced. Such systems use up-to-the-minute point-of-sale information (via electronic point-of-sale – EPOS – systems) to identify real-time demand and to pull product through directly from the supplier, through the DC and on to the retail outlet. CRP systems are thus able to synchronize this flow of product by focusing on end user requirements via the use of real-time demand, linked to flow-through distribution systems that allow for cross-docking, store-ready packaging and automated handling. Once again, pipeline inventory is kept to a minimum or completely eliminated.

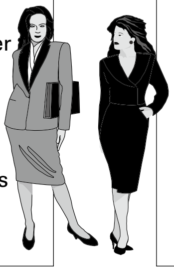
Quick response (QR)

A further development of the JIT approach is that of quick response (QR). Here the aim is to link the manufacturer more closely to the actual demand at the retail level. There are strong similarities with continuous replenishment systems, but with QR the emphasis is on time compression and the opportunity for the manufacturer to redesign production operations to allow for a 'little and often' approach to resupply. Short production changeovers and small batch sizes enable the manufacturer to respond to changes in demand in a very short timescale. A classic example is the Benetton operation, particularly in its initial composition. This demonstrated most of the key characteristics of a QR system. It has allowed the company to offer an extremely responsive supply to its retail outlets and to reflect the fast-changing nature of the fashion industry. Figure 17.6 provides more information.

Figure 17.6 The Benetton Group: initial quick response system

Background

- Integrated manufacturer and retailer
- Knitwear, casuals, accessories
- 80 million garments a year
- All with a pre-placed order
- From 7,000 licensed Benetton stores
- In 110 countries



Distribution

- Distribution via automated central warehouse in Italy
- Automated and linked to factories
- Cartons barcoded and electronically sorted
- 15,000 cartons shipped per day
- 50% air freight, 50% rail/sea/road

Ordering

For each of two main fashion seasons:

- Store managers adjust product mix for local requirements
- Each store commits for 80% of orders seven months ahead, which are shipped on a 20-day order cycle to provide regular new 'collections'
- Remaining 20% by quick response in seven days
- Orders transmitted by EDI direct from shops to factory (via regional agents)

Logistics efficiency

Provides:

- Fastest order cycle times in the industry
- No excess work in progress
- No 'pipeline' inventory build-ups
- Little residual end-of-season stock for 'clearance'
- Extremely high customer service to stores
- Extremely responsive product provision

Efficient consumer response (ECR)

This is another concept that uses the most recent advances in information technology to allow a streamlined approach to the supply of products to retail stores. ECR was originally set up and run in the United States with the aim of improving service and reducing costs in the grocery industry by focusing on the efficiency of the supply chain as a whole rather than on individual components in individual companies. The goal of ECR is therefore to develop a customer-driven system that works across the supply chain. One original definition is still very applicable today: ECR consists of:

> A seamless flow of information and products involving manufacturers and retailers working together in joint planning and demand forecasting. Both sides might take on functions traditionally handled by the other if they can do it better and at a lower cost.

ECR combines a number of different concepts and strategies. The basic tenets of ECR are:

- a heavy use of electronic data interchange (EDI) for exchanging information with suppliers
- an extremely efficient supply chain using cross-docking and direct store deliveries, thus keeping inventory holding to a minimum
- the use of sales-based ordering, notably through continuous replenishment programmes (CRP)
- much greater cooperation with suppliers, using where appropriate, co-managed inventory (CMI) or full vendor-managed inventory (VMI)

There are four key strategies in the use of ECR. These are store replenishment, store assortment (ensuring the right mix of products in the store to maximize consumer satisfaction), promotion and new product introduction. It is, however, the first two of these – speedier replenishment and better store assortment – where the greatest benefits are to be found in both cost reduction and service improvement. Some of the key factors and their associated benefits include:

- automated systems that reduce labour and administrative costs
- sharing information, which leads to more timely deliveries and falling inventory levels at the store
- cross-docking, which reduces inventory levels at the DC
- concentrating on fewer suppliers, which reduces transaction and administration costs
- offering the right products to the right customers, which increases volume sales and economies of scale
- more timely, more accurate information, which means that customer needs are more fully addressed
- the ability to tailor the products and services on offer in the store, which allows a company to take account of local preferences

- rapid replenishment, which can reduce stockouts, and means that customers seeking a particular product or brand will not leave empty-handed

A common approach for the implementation of ECR by a retailer is to focus on the consumer and then to develop a particular IT strategy and capability. This is likely to include the use of EDI, EPOS, computer ordering, computer routeing, etc. It is important to create a climate for change and to re-engineer existing business practices, as they are unlikely to be adequate for the successful implementation of ECR. The next requirement is to develop a responsive replenishment strategy jointly with key suppliers for key products. Finally, a workable flow-through distribution operation must be planned and implemented. A typical flow-through operation is likely to involve:

- *Pre-distribution identification:* vendors pick, sort and pre-label final orders using barcodes.
- *Automated cross-docking:* this will require conveyors, diversion lines and barcode readers.
- *A disciplined appointment-scheduling procedure:* inbound receipt scheduling will need to match available labour and minimize vehicle waiting.
- *New facility design:* this should ideally include shipping doors around the circumference of the building. The use of conveyors will eliminate put-away and picking.
- *Floor-ready merchandise:* suppliers should provide tags and labelling to reduce DC and retail store work and handling.

Category management (CM)

This has been developed to provide greater support for product and inventory control and management. It is essentially a means of categorizing products into 'families' that have very similar characteristics in terms of their selling profile. Thus, SKUs from very different product groups may be categorized together and their inventory holding planned in the same way because they have the same order or usage patterns. Typical examples of these categories are:

- *Vital and expensive:* products that require close control and monitoring. Supply sources need to be reliable, and delivery performance must be consistently good. A continuous stock review policy should be applied to products in this category.
- *Desirable and expensive:* inventory should be held at minimum levels and a continuous stock review policy should be applied.

- *Vital and inexpensive:* these should be stocked at maximum levels, and a reliable source of supply should be substantiated. Delivery performance should be carefully monitored. A weekly periodic stock review policy should be used.
- *Desirable and cheap:* hold maximum stock levels and use a monthly periodic stock review policy. Keep order frequency to a minimum number of times per year.
- *Common usage spares:* hold stocks at reasonable levels and use a monthly periodic stock review policy.

Note that this approach takes account of the important factor that product requirements can vary considerably between one product and another. Inventory planning using category management caters for this. Companies that do not recognize this and adopt a 'one-size-fits-all' approach to inventory planning are likely to suffer either high-cost or low-availability issues for some of their portfolio of products.

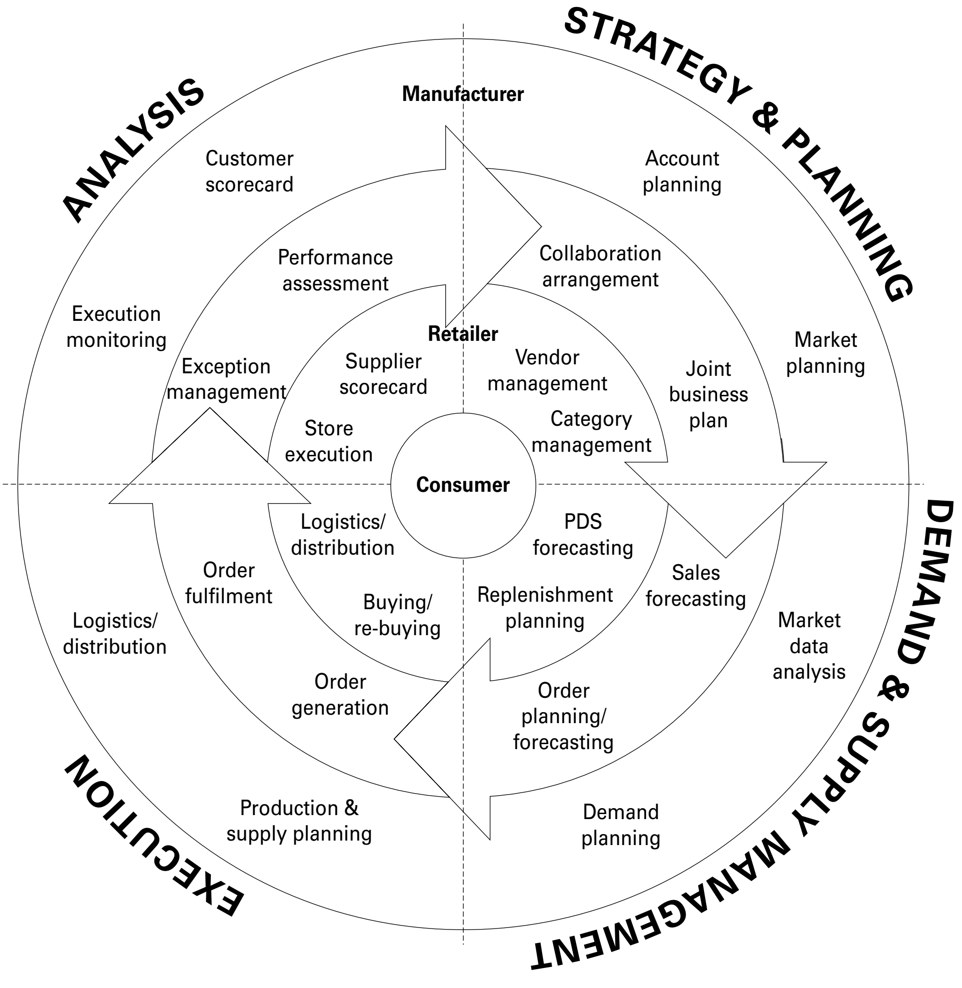
Inventory planning for the supply chain

Some of the inventory-planning techniques previously described in the manufacturing and retailing sections of this chapter have reflected the advantages of being able to take a broader, supply chain view of demand and inventory requirements. This section briefly describes some additional approaches that use this as their central proposition, but which do not have a specific leaning towards either manufacturing or retailing.

Collaborative planning, forecasting and replenishment (CPFR)

Collaborative inventory management has been developed as a long-term approach to minimizing the type of demand amplification illustrated by the Forrester effect (see Chapter 15, Figure 15.6). This requires end-to-end coordination of activities across the different echelons of the supply chain and combines multiple trading partners in the planning and fulfilment of customer demand. Sales and marketing best practice (e.g. category management) is linked to supply chain planning and operational processes to increase product availability at the same time as minimizing inventory and logistics costs. A general framework is used to help the retailer/buyer and manufacturer/seller to work together to satisfy the demand of the customer. This is known as collaborative planning, forecasting and replenishment (CPFR) and, as Figure 17.7 demonstrates, there are four main areas for collaboration:

Figure 17.7 CPFR model



- *strategy and planning:* identifying and agreeing the overall rules for the collaboration, including product mix and placement, and event plans
- *demand and supply management:* the forecasting of consumer demand derived from point-of-sale information and replenishment requirements
- *execution:* the placing of orders, delivery shipments, restocking of products on shelves, etc – these are all of the events in the 'order to cash' cycle
- *analysis:* monitoring of exception orders, calculating key performance indicators (KPIs) and assessing continuous improvement opportunities

Supply chain inventory optimization

Inventory optimization is a scientific approach to determine the ideal inventory levels across a complete supply chain, that is, across different company thresholds. The aim is to identify the most effective inventory locations and stock levels for the supply chain as a whole. For example, traditionally, where a product moves from one company to another within a supply chain there is often evidence of two large adjacent stock builds: where the goods leave the supplier and where they arrive at the customer. This is due to a variety of factors, such as unreliable supply, a lack of confidence, uneven demand patterns and poor information on the real demand requirements for the finished product. An inventory-optimization approach can reduce these unnecessary inventory levels without damaging service levels.

This type of approach has become feasible because of the extent of data that is now available and the ability of computer systems to analyse such large quantities of data. This multi-echelon software can optimize inventory levels across the whole supply chain, taking into account the multiple stages in the supply chain, different types of inventory and time-phased demand. This type of modelling is, generally, undertaken at SKU level and the results can reflect the different inventory requirements for products at the various stages of the supply chain and the demand for the same SKU in different geographic locations.