# PART TWO
# Planning for logistics

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# Logistics planning overview 06

## Introduction

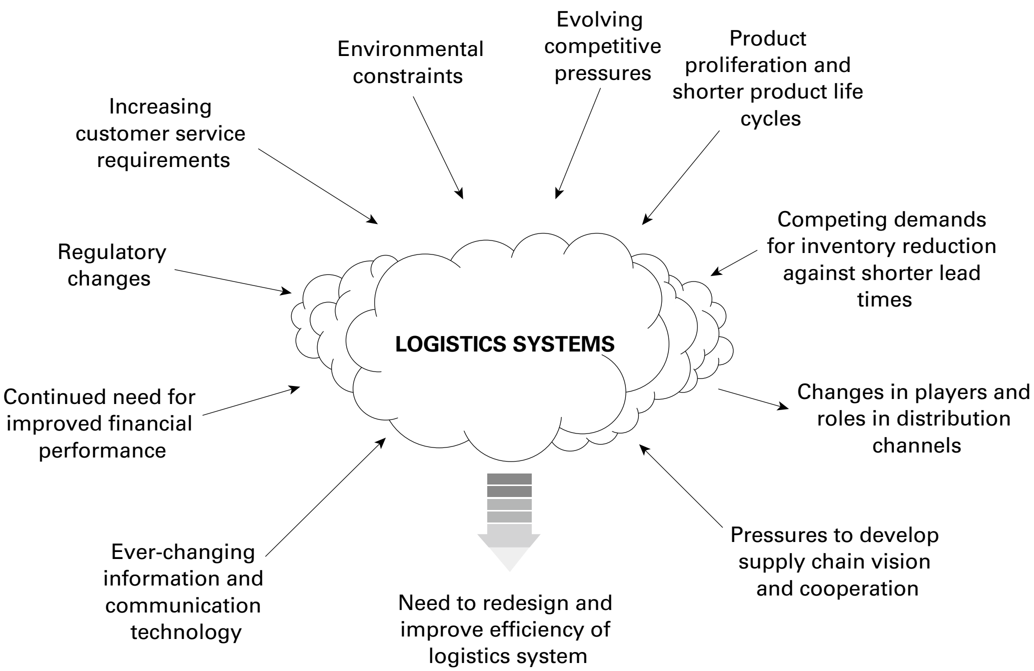
The need for a positive approach to planning was discussed in Chapter 2, together with the concept of a logistics planning hierarchy. In this chapter a generalized approach to corporate strategic planning is outlined, and this is linked to a specific logistics design strategy. The main elements of this design strategy are described. Finally, some of the fundamental influences on logistics network planning and design are detailed, in particular, product characteristics, the product life cycle, packaging and unit loads.

## Pressures for change

Many organizations adopt a piecemeal and incomplete approach to their strategic planning. This is particularly true in the context of logistics, where individual functions within logistics or the supply chain have often been sub-optimized to the detriment of the logistics chain as a whole. One of the reasons for this incomplete approach is the pressure for change exerted on companies from a wide variety of sources. Figure 6.1 provides an illustration of some of these pressures. They include:

- significant changes in communications systems and information technology, including such developments as the use of Big Data analytics, real-time information and artificial intelligence, as well as the internet, satellite and mobile phone technology
- the need for improved financial performance at a time when companies and economies are under severe pressure
- regulatory changes, such as the development and revision of economic unions, of which the Single European Market (SEM) is one example among many
- increasing customer service requirements, especially where the levels of service that logistics can provide are often seen as a major competitive edge between different companies and their products

**Figure 6.1** Pressures influencing logistics systems



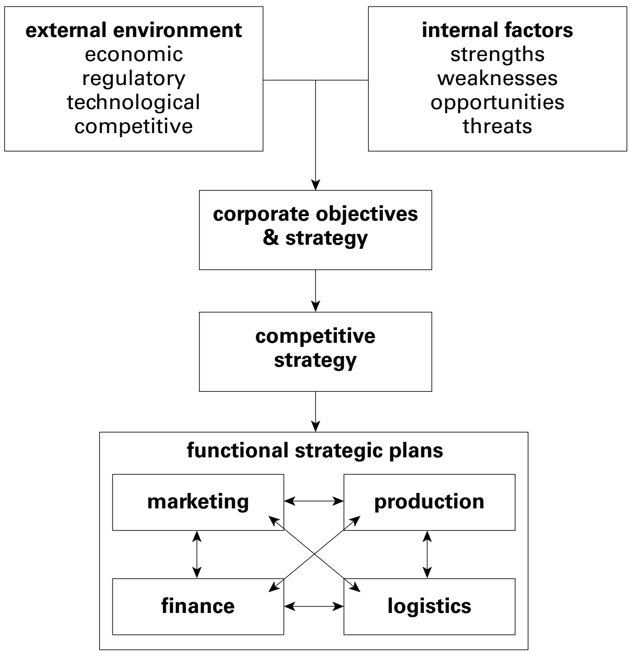

- recognition of the importance of various environmental and green issues such as the need to reduce greenhouse gas emissions
- increased competition from global as well as national companies to new breed technology disruptors
- a shortening of product life cycles, particularly for high-technology and fashion products, together with an explosion of product choice
- competing demands for inventory reduction and depot rationalization against shorter lead times and supply chain disruption
- the development of new players with new roles in channels of distribution – this includes the continued growth of third-party service providers and their move to offer global and pan-European operations and to develop supply partnerships
- the need to adopt a wider supply chain perspective when planning, redesigning and operating logistics systems

The danger for any organization is to overreact to this need for change. Thus, a measured response is required that enables distribution and logistics systems and structures to be developed as a whole in the context of company strategic plans. In this way, the likelihood of the sub-optimization of logistics activities can be avoided. The quantitative modelling of logistics requirements as a second stage of strategic business planning is an important aspect of this. This chapter thus focuses on the development and use of a framework and approach that take into account broad organizational and business issues as well as more detailed logistics issues.

## Corporate strategic planning overview

A generalized approach to corporate strategic planning is depicted in Figure 6.2. This is in many ways a classic strategic planning approach, but one important point is that it does clearly identify the logistics function as a key part of strategic planning. This is not always the case in some corporate planning processes.

**Figure 6.2** Corporate strategic planning overview




The initial phase of a strategic study is very much a data collection exercise to enable key external influences on the company and its operations to be assessed and to allow for the major internal factors that help measure and describe a company to be identified.

This review of the *external environment* within which a company operates is likely to include such factors as the economic climate, current regulations and potential regulatory changes, and any relevant technological developments. Also of importance for most companies would be some sort of evaluation of major competitors – particularly, in this context, any information regarding service and logistics strategies. One recognized approach to reviewing and evaluating the impact of the external environment is to undertake political, economic, socio-cultural, technological, environmental and legal (PESTEL) analysis. A very broad view of external factors is taken and an assessment is made of the effects of these and how they might influence the strategy of the company. Typical factors to be assessed using PESTEL analysis are shown in Table 6.1.

**Table 6.1** PESTEL analysis: external influences

| | |
|---|---|
| **Political** | **Technological** |
| Taxation policy | Government spending on research |
| Foreign trade policy | Government/industry focus on technology |
| Trade restrictions and tariffs | New discoveries/development |
| Government stability | Speed of technology transfer |
| Political stability | Rates of obsolescence |
| **Economic** | **Environmental** |
| Business cycles | Environmental protection laws |
| Interest rates | Weather, climate, and climate change |
| Money supply | Carbon footprint targets |
| Inflation | Business ethics |
| Unemployment | Sustainability |
| Disposable income | |
| Energy availability and cost | |
| **Socio-cultural** | **Legal** |
| Population demographics | Employment law |
| Income distribution | Consumer rights and laws |
| Social mobility | Health and safety law |
| Lifestyle changes | Monopolies legislation |
| Attitude to work and leisure | Discrimination law and equal opportunities |
| Consumerism | Advertising standards |
| Levels of education | Product labelling and product safety |

An analysis of relevant *internal factors* should also be undertaken. A typical approach is strengths, weaknesses, opportunities and threats (SWOT) analysis. This allows a company to review its position within the marketplace with respect to its products, the demand for its products, the service it offers its customers and the position of its competitors. This type of analysis can and should also be undertaken with respect to identifying a company's key logistical variables.

Approaches such as these enable a company to identify what its overall *corporate strategy* should be. One of the key points that must be addressed is to define what business the company is in. Many companies can be classified as 'retailers' or 'manufacturers', but often a further definition is important because it will have an influence on how the overall business is organized and structured. Beer provides a useful example. Typically, the brewing of beer has been seen as the key feature of the industry, and the brewing industry has a strong tradition that endorses this. Thus, the brewing of beer is seen as the key activity. However, there are many different aspects that need to be considered when determining how best to get the beer to the customer and many different types of customer. Different elements of a supply chain can be more or less influential dependent on the nature of the product output and the customer type. These requirements can necessitate the development of a variety of very different business and logistics environments. For example:

- *Brewing the beer:* this is the traditional role concerned with production and packaging. Beer production is often seen as a magician's art. Varieties of beer are produced, and they can be packaged in a number of different ways – barrels, kegs, cans, bottles, etc.
- *Environments in which to drink beer:* traditionally these have been pubs, clubs and bars. For the brewing industry a key question is whether or not to own these outlets (and thus have an assured sales outlet) or whether to concentrate solely on the production of the beer. A linked logistics issue is how best to get the beer to the outlets.
- *Environments in which to eat food and drink beer:* these are often known as leisure or lifestyle experiences. Typical are restaurants or 'theme' restaurants where the family might go to eat, drink and play. A major issue for these establishments is the supply and preparation of food as well as drink. For a brewer, this significantly changes the basic business objectives – there are other aspects to consider apart from brewing. Again, there are some obvious and extremely important implications for logistics.
- *Drinking beer at home:* another important aspect is the home consumption of beer and the fact that beer for home consumption is primarily bought from supermarkets, specialist shops, wholesalers or corner shops. The brewer is unlikely to have the option to own these outlets (although, of course, beer can also be bought from pubs and bars for home consumption), but there are very different business, marketing, packaging and logistics implications in competing in this environment.

These represent an overview of some of the alternative business choices a brewer might have. Before attempting to design a competitive strategy and identify possible functional strategies, a company must be clear about which business it is in and what it wants to achieve within this business – a strategy based on set objectives.

In addition to a company's corporate or business strategy, the other element that is crucial is the *competitive strategy* that the company plans to adopt. Competitive strategy has a major influence on the development of logistics strategy and in the way the physical structure of the operation may be configured. There are a number of influencing factors, but some of the key ones include the extent of globalization – the size and spread of the business, the type of competitive positioning adopted and the degree to which the supply chain is an integrated one. These factors were discussed in Chapter 2, and some of the major implications for logistics were explored.

As indicated in Chapter 2, a company should adopt a competitive strategy by competing as a service or cost leader, or where relevant (and if feasible!) as both of these. A service leader is a company that is trying to gain an advantage over its competitors by providing a number of key added-value service elements that differentiate it from its competitors in terms of what it is offering to its customers. A cost leader is a company that is trying to utilize its resources by offering the product at the lowest possible cost, thus gaining a productivity advantage.

Either of these extremes, or a combination of both, will necessitate a very specific logistics structure. A more service-oriented approach will involve investment in service-enhancing features such as next-day delivery, time-guaranteed delivery, tracking systems, or information support systems (all of which will increase costs). A more cost-oriented approach will aim to reduce costs through methods such as full load deliveries, minimum order sizes, 48- or 72-hour delivery (all of which will limit service possibilities).

## Logistics design strategy

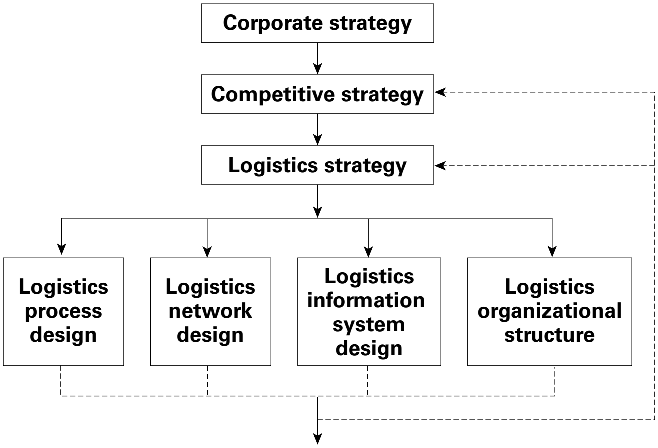
On completion of this initial phase of the business planning process, it should be possible to identify corporate strategy and objectives, and to determine a specific competitive strategy. The next task is to prepare appropriate functional strategic plans. Figure 6.2 indicates that such plans can be developed for finance, marketing, production and logistics. For some companies there will be other functions that require specific plans such as research and development (R&D). The remainder of this chapter will concentrate on the functional strategy for logistics.

There are several important issues concerning the development of a suitable logistics strategy. The first is the need to link the logistics or distribution plan directly with the corporate plan. This is best achieved by ensuring that logistics is an integral part of the corporate plan and that factors related to these functions are used as inputs in the overall planning process.

The second point concerns the extent or coverage of the logistics strategic plan. This will clearly vary from one company to another. It may well just be a 'distribution' functional plan, but it is most likely that it will be necessary to incorporate elements from other functions (marketing, production, etc) to represent the fully integrated nature of logistics or the supply chain.

The third, and in many ways most important, issue is whether or not a company has a structured logistics plan at all. Many still don't, so a first and major step may be to ensure that such a plan is developed, based of course on the company's business and competitive strategic plans. To achieve this, a logistics planning framework, as outlined in Figure 6.3, can be used.

**Figure 6.3** A framework for logistics network design




As can be seen from Figure 6.3, there are four key logistics design elements that need to be considered. Traditionally, logistics planning and design have evolved around the structure of the logistics network, such as depot numbers and location, but it is now recognized that, as well as these physical logistics elements, there are other factors that also need to be considered. These are the design of logistics processes, logistics information systems and logistics organizational structure.

Logistics *process design* is concerned with ensuring that business methods are aligned and organized so that they operate across the traditional company functions and become supply chain-oriented. Thus, they should be streamlined and should not be affected or delayed because they cross functional boundaries. A typical logistics process is order fulfilment, designed to ensure that customers' order requirements are satisfied with the minimum of time and the maximum of accuracy. The process should be designed as a seamless operation from the receipt of the order to the delivery of the goods and not as a series of different operations that occur each time a different internal function is involved – sales department, credit control, stock control, warehouse, transport, systems design. As well as order fulfilment, other logistics processes that might be considered are information management, new product introduction, returns or spare part provision. Processes might also need to be further developed to take account of different customer types, customer service requirements, product groups, etc. Logistics process design is considered in more detail in Chapter 7.

Logistics *network design* refers to the more traditional elements of logistics strategy. These include aspects related to the physical flow of the product through a company's operation, such as the manufacturing location from which a product should be sourced, the inventory that should be held, the number and location of depots, the use of stockless depots and final product delivery. One key to the determination of an appropriate physical design is the use of trade-offs between logistics components and between the different company functions. Some typical trade-offs were described at the beginning of Chapter 2. A detailed approach to physical design is provided in Chapter 10.

Logistics *information system design* should include all of those information-related factors that are vital to support the processes and the physical structure of the operation. As well as these, however, it is important to recognize that there are also enterprise-wide information systems (enterprise resource planning or ERP systems), which may directly influence logistics process and network design. Typical information systems that may support logistics process and network design include electronic point-of-sale (EPOS), electronic data interchange (EDI) between companies, warehouse management systems and vehicle routeing and scheduling, as well as the use of Big Data analytics, real-time information and artificial intelligence (outlined in Chapter 40).

The final design element is that of the logistics *organizational structure*. It is the experience of many companies that an inadequate organizational structure can lead to substantial problems. These include issues such as sub-optimization whereby functions tend to concentrate on their own operation in isolation from the rest of the company, or even worse examples where different functions and their managers compete against one another and develop antagonistic attitudes, often styled as a 'blame culture'. These types of attitude work against the company but are also detrimental to customers and customer service. Organizational issues are further discussed in Chapter 11.

Each one of these different logistics design factors needs to be planned in association with the others. It is inappropriate to concentrate on any one without understanding and taking into account the influence of the others. Although Figure 6.3 has process design as the first logistics design factor, this does not mean that it is necessarily the first one that should be considered when a strategic study is undertaken. For different companies it may be any one of the other design factors that plays the most dominant role. For example, a company that has introduced an enterprise-wide information system may find that this has a primary influence on how logistics strategy is formulated, because it has a set structure that needs to be accommodated with the various processes that are to be developed. Equally, a company may feel that it is necessary to put a workable logistics organizational structure in place before it attempts to redesign its logistics processes and physical operations – so that those who are to manage and operate the system will also plan it and thus have a vested interest and responsibility in its success.

Note that Figure 6.3 emphasizes the need for constant reappraisal within the planning process (the arrows that refer back to previous steps in the planning process). Logistics and supply chain operations are dynamic by their very nature and require regular and ongoing reappraisal as many elements (customer demand, customer types, products, technology, etc) continue to adapt and change over time.

The different tools and techniques for undertaking logistics design are described in the next few chapters. Before considering these, the remainder of this chapter looks at some key logistics factors that also have an influence on how a logistics operation is designed.

## Key logistics design factors

### *Product characteristics*

One of the major factors to be considered when planning for logistics is, perhaps not surprisingly, the product itself. The product is, in fact, perceived to be an amalgam of its physical nature, its price, its package and the way in which it is supplied. For the logistics planner, the physical characteristics of the product and package are seen to be of great significance. This is because, in distribution and logistics, we are directly concerned with physical flow – movement and storage. The physical characteristics of a product, any specific packaging requirements and the type of unit load are all-important factors in the trade-off with other elements of distribution when seeking least-cost systems at given service levels. This potential for trade-off should continually be borne in mind.

There is a variety of product characteristics that have a direct, and often important, impact on the development and operation of a distribution system. This impact can affect both the structure of the system and the cost of the system. There are four main categories: volume-to-weight ratio; value-to-weight ratio; substitutability; and high-risk products.

### *Volume-to-weight ratio*

Volume and weight characteristics are commonly associated, and their influence on logistics costs can be significant. A low ratio of volume to weight in a product (such as sheet steel, books, etc) generally means an efficient utilization of the main components of distribution. Thus, a low-volume/high-weight product will fully utilize the weight-constrained capacity of a road transport vehicle.

The converse, a high volume-to-weight ratio, tends to be less efficient for distribution. Typical products include paper tissues, crisps, disposable nappies, etc. These products use up a lot of space, and are costly for both transportation and storage, because many companies measure their logistics costs on a weight basis (cost per tonne) rather than a volume basis (cost per cubic metre). In Europe, for example, draw-bar trailer outfits are often used to increase vehicle capacity and so decrease the transportation costs of moving high-volume products.

Companies need to recognize the extent to which both weight and volume drive their distribution costs.

## *Value-to-weight ratio*

Product value is also important to the planning of a logistics strategy. High-value products are more able to absorb the associated distribution costs because the distribution element is a relatively low proportion of the overall product cost. Low-value products need to have an inexpensive distribution system because the cost is a large proportion of the overall product cost – and if too high the effect on the total cost of the product might make it non-viable in terms of its price in the marketplace.

Once again, it is useful to assess the value effect in terms of a weight ratio: this is called the value-to-weight ratio. Low value-to-weight ratio products (e.g. ore, sand, etc) incur relatively high transport unit costs compared with high value-to-weight products (e.g. computers, mobile phones, etc). Inventory holding unit costs of low value-to-weight ratio products tend to be low in comparison with high-value products because the capital tied up in inventory is much lower for the low-value products.

## *Substitutability*

The degree to which a product can be substituted by another will also affect the choice of distribution system. When customers readily substitute a product with a different brand or type of goods, then it is important that the distribution system is designed to avoid stockouts or to react to replenish stocks in a timely fashion. Typical examples are many food products, where the customer is likely to choose an alternative brand if the need is immediate and the first-choice name is not available.

In a distribution system, this can be catered for either through high stock levels, additional local distribution centres or through a high-performance transport mode. All of these options are high cost. High stock levels will decrease the likelihood of a stockout, but will raise average stock levels and, thus, costs. Additional depots would be costly. The provision of a faster and more dependable transport function will reduce acquisition time and length of stockout, but this increase in service will be at a higher transport cost.

### *High-risk products*

The characteristics of some products present a degree of risk associated with their distribution. Typical examples include: perishability, fragility, hazard/danger, contamination potential and extreme value. The need to minimize this risk (sometimes a legal obligation) means that a special distribution system design must be used. As with any form of specialization, there will be a cost incurred. Examples of this effect are as follows:

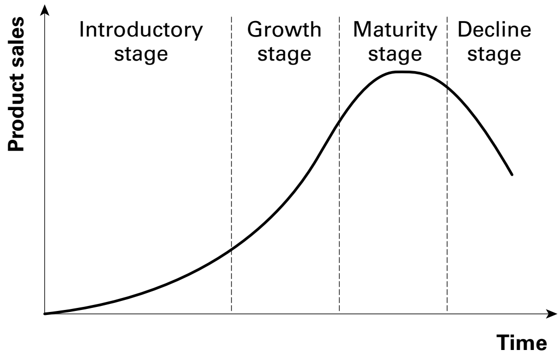
- Hazardous goods may require special packaging, a limited unit load size, special labelling and isolation from other products. Regulations for the movement of hazardous goods differ between the different modes of transport.
- Fragile products require special packaging to take account of handling and transport shocks. Specialist distribution service providers exist for some types of fragile goods.
- Perishable goods in many instances require special conditions and equipment for their distribution (e.g. refrigerated storage and transport facilities for frozen and chilled food).
- Time-constrained products – almost all foods are time-constrained, especially those with 'best before' or 'use by' dates – have implications for distribution information and control systems (e.g. first in/first out). Some products have fixed time or seasonal deadlines: daily newspapers have a very limited lifespan, which requires early morning delivery and allows for no delivery delays; fashion goods often have a fixed season; agrochemicals such as fertilizers and insecticides have fixed time periods for usage; there are the classic seasonal examples of Easter eggs and Christmas crackers, which are time-constrained. There are significant implications for the choice of distribution system for many products such as these.
- Very high-value products – cigarettes, mobile phones, computer tablets, etc – are attractive products that require especially secure means of distribution.

There are many and varied product characteristics that can impose important requirements and constraints on all manner of logistics operations. They also affect the interrelationships between the different logistics functions, providing quite complex alternatives that need to be carefully assessed according to the implications on service and on cost.

## The product life cycle

One marketing concept that concerns the product and is also very relevant to distribution and logistics is that of the product life cycle (PLC). The principle behind the PLC is that of the staged development of a product. This starts with the introduction of the product into the market and follows (for successful products) with the steady growth of the product as it becomes established. The life cycle continues with the accelerated growth of the product as competitors introduce similar products at competitive prices, which reduces the demand for the company's product, and ends as the demand for the product runs into acute decline. The PLC concept is illustrated in Figure 6.4.

**Figure 6.4** Standard product life cycle curve showing growth, maturity and decline




It is important that the performance of a logistics operation is able to reflect and respond to the developing life cycle of a product. This can be differentiated as follows:

- *Introductory stage:* here, there is usually a requirement for an operation that can provide a high response to demand with a logistics structure that gives stock availability and quick replenishment, and can react to sudden demand increases. Initial retail stockholdings are likely to be low, to avoid the overstocking of products that might not fulfil their expected demand. Thus, there is a need for speedy information and physical logistics systems, probably from a centralized stockholding base and using a fast mode of transport.
- *Growth stage:* here, sales are more predictable. The requirements for distribution are now for a better-balanced, more cost-effective system. The trade-off between service and cost can be realized.
- *Maturity stage:* this is where the introduction of competitive products and substitutes are likely to increase price and service competition. Thus, an effective logistics operation becomes vital in order to maintain market share, especially for key customers.
- *Decline stage:* here, the product is becoming obsolete. The logistics system needs to support the existing business but at minimum risk and cost.

There is a clear requirement to take account of the product life cycle when planning for logistics. A different emphasis needs to be placed on certain aspects of the logistics system according to the stage of a product's life. For operations where there are many products at varying stages of their product life cycle, the effect on the overall system may not be apparent. In many instances, however, there will be a need to plan a logistics operation that is suitably dynamic and flexible to reflect the changing characteristics of a product (see Chapter 8, 'Supply chain segmentation').

## Packaging

As a part of considering the product and its logistics requirements, it is important to be aware of other relevant physical characteristics that can influence any decisions regarding the choice of logistics operation. In terms of the physical nature of a product, it is not generally presented to the logistics function in its primary form, but in the form of a package or as a unit load. These two elements are thus relevant to any discussion concerned with the relationship of the product and logistics.

The packaging of a product is broadly determined for product promotion and product protection, the latter being the function that is particularly pertinent to logistics. There are also some other factors that need to be considered when designing packaging for logistics purposes. In addition to product protection, packages should be easy to handle, convenient to store, readily identifiable, secure and of a shape that makes best use of space – usually cubic rather than cylindrical.

Once again, there are trade-offs that exist between these factors. These trade-offs will concern the product and the logistics operation itself. It is important to appreciate that, for those involved in logistics, the package is the product that is stored and moved and so, where possible, should be given the characteristics that help rather than hinder the logistics process.

Packaging is very much a part of the total logistics function, and the design and use of packaging has implications for other functions such as production, marketing and quality control, as well as for overall logistics costs and performance.

## Unit loads

The idea of using a unit load for logistics was developed from the realization of the high costs involved in the storage and movement of products – particularly in the inefficient manual handling of many small packages. The result of this has been the unit load concept, where the use of a unit load enables goods and packages to be grouped together and then handled and moved more effectively using mechanical equipment. Two familiar examples are the wooden pallet and the large shipping container, both of which, in their different ways, have revolutionized physical distribution and logistics. From the product point of view, it is possible to introduce unit load systems to alter the characteristics of a product and thus make more effective logistics possible. One classic example has been the development of the roll-cage pallet that is in common use in the grocery industry to aid the movement of products from depots into store stockholding areas and onto the shop floor. Although the cages are expensive units, the trade-off, in terms of time saving and security, is such that overall distribution costs decrease significantly.

Much of distribution and logistics is structured around the concept of load unitization, and the choice of unit load – type and size – is fundamental to the effectiveness and economics of a logistics operation. Choosing the most appropriate type and size of unit load minimizes the frequency of material movement, enables standard storage and handling equipment to be used with optimum equipment utilization, minimizes vehicle load/unload times, and improves product protection, security and stocktaking.

# Logistics processes

07

## Introduction

As discussed in Chapter 6, one of the key elements of planning for logistics is the design of appropriate logistics processes. These processes are the methods that are used to ensure that the business operates effectively so that all major objectives are achieved. The aim is for a streamlined operation that works across the various functional boundaries that exist within any company. Thus, processes need to be supply-chain-oriented. One of the main problems with many logistics processes is that although they are very often the responsibility of one particular function, they are spread across the boundaries of several different ones, making effective planning and operations more difficult. The consequences of this are usually inefficiencies, which show up as additional costs within the logistics system or lower levels of customer service. In many companies, both of these effects occur.

In this chapter logistics processes are considered and the need to move away from functional and towards cross-functional process development is explained. The main reasons for adopting more streamlined processes are discussed. Some of the key logistics processes are described, and the 'process triangle' is introduced as a means of categorizing the different processes. A broad approach to process design is outlined, and the main steps in this approach are discussed. Finally, some key tools and techniques are described. These can be used for logistics process redesign.

## The importance of logistics processes

The reason that logistics processes are highlighted is because there is a recognition that a broader, holistic view of logistics is more appropriate than the traditional functional approach. Although functional excellence is important – if you are running a fleet of vehicles, it is still important to ensure that it operates cost-effectively and fulfils all the necessary requirements – the concept of trade-offs within logistics is now an accepted aspect of sound logistics planning (see Chapter 2). An individual element may be sub-optimized to the greater good of the operation as a whole.

Following on from this is the broader supply chain perspective that the logistics function is viewed not just across internal company functions but also across the expanse of different companies. The chief beneficiary of this has been the final customer. The aim of any supply-chain-oriented approach is to ensure that cross-company and cross-supply-chain activities are directed at achieving customer satisfaction for the end user. Thus, processes need to be developed to make this happen. They need to be able to span across internal functions and company boundaries to provide the type and level of customer service required. Unfortunately, this does not happen in a number of companies.

## *Functional process problems*

Processes were traditionally derived to enable each separate function within an organization to undertake its particular role, so they were not streamlined to act across all company functions as a united whole. An effective process should be designed as a seamless operation rather than as a series of different elements.

The order fulfilment process provides a good example of a typical logistics process. The aim of order fulfilment should be to ensure that a customer's order is received, checked, selected and delivered according to the customer's requirements, with no disruption and with complete accuracy. The process within many companies does not always work like this! As well as the possibility of error or delay within functions, there is also the possibility of error and delay between the different functions. Typical functional errors might be:

- incorrect transcription of the original order requirements
- incorrect notification of availability
- incorrect selection or picking of the order
- damage to the goods
- late delivery
- delivery to an incorrect address
- invoicing to the incorrect address

## *Cross-functional process problems*

In addition, there might also be errors and delays associated across the functional boundaries. Examples might include:

- website not designed to show real-time out-of-stock situation at time of order, resulting in customer not being advised of delayed delivery date until much later
- stock may appear to be available but is actually pre-allocated to another customer

- order details may be incorrectly transcribed because there is no automated link between one information system and another
- credit control may delay the progress of the order – but the customer may not be informed
- different goods may be picked because the original requirement is out of stock so the 'next best' is selected, and the customer may not be informed of this
- goods may not be delivered as part orders due to some product unavailability, when partial delivery may be better than no delivery
- goods may be physically delivered via an incorrect channel – to the customer's cost (next-day rather than the normal three-day service)

It is usually quite easy to identify problems that occur within individual functions and then put into place control measures to overcome these problems. It can be much more difficult to identify problems that occur between functions. First, there may be an unclear line of demarcation between functions, which makes it no easy matter to determine that there is a problem, let alone what the problem is. Second, it may be very difficult to determine what the cause of the problem is – not least because of the associated 'blame' culture that may exist between functions, so that one will traditionally blame the other regardless of the true issues.

To avoid issues such as these, some companies now seek to redesign their key logistics processes. There are three essential elements to achieving a successful redesign. Properly designed processes should be customer-facing, that is, they should aim specifically to satisfy customer demands and expectations. They should also be cross-functional, or indeed where possible they should be supply-chain-oriented in that they cross not just company functions but also the boundaries between several companies. For most companies, the aim of achieving cross-functional processes is a big and daunting challenge. Finally, they should be time-based in that they need to reflect the importance of time as a key element in the logistics offering.

Before considering the methods by which processes can be redesigned, the different process types and categories are outlined.

## Logistics process types and categories

### *Key logistics processes*

What then are the key logistics processes? Some are very common to many businesses, but others, as may be expected, vary between different organizations, different sectors and different industries. Typical examples are:

- *Order fulfilment*: probably the most common logistics process that is quoted, order fulfilment is concerned with the ability to turn a customer's requirements into an actual delivered order. Thus, it embraces many of the traditional functions usually recognized as being a part of the logistics operation. Order fulfilment will involve the information elements of receiving and specifying an order through to the physical means of selecting and delivering the goods. For some 'make-to-order' manufacturing operations, this will also have an impact on the production process itself. Some companies maintain the divide between the order-taking component (which is information-based) and the order-delivery component (which is both information-based and physical). This is a reasonable first step in process redesign, but ultimately there should be a seamless process for the operation as a whole.
- *New product introduction:* this is an area where many companies find they have problems. There are many logistics issues related to the introduction of new products into the marketplace. Very often existing, standard logistics structures and processes can be inappropriate to enable a satisfactory launch of a new product. One of the main problems is the inability to respond with sufficient speed. Standard processes are designed to deal with known products. There are two likely consequences of introducing new products using existing processes. The first is that the product takes off very quickly and very well but there is insufficient flexibility in the supply chain to ratchet up supply to the required levels. The second is that demand is lower than initially expected and so there is an oversupply of stock, which eventually leads to products being sold off at discount rates or becoming obsolete.
- *New product development:* for new product development, the idea is to design the product so that it can reach the market as quickly as possible from the initial design plan through to availability to the customer. The aim is to link the development of the product with the logistical requirements so that all secondary developments (of which there are normally many) can be identified and re-engineered in the shortest possible time.
- *Product returns:* there is a growing requirement in many businesses to provide an effective process for the return of products. This may be for returns that come back through the existing distribution network or through a new one that is specifically set up. The process may be required to include movements for a variety of reasons: it may be for product returns that will be reworked or repackaged to go into stock; product returns for subsequent disposal; or packaging returns that may be reused or scrapped. In the light of developments in environmental legislation, this is a very important area for process design or redesign.
- *Aftermarket or service-parts logistics:* for a significant number of companies, the supply of a product or series of products is inextricably linked to the subsequent

provision of service-parts to support the continuous use of the initial products. For many logistics operations, neither the physical structure nor the associated processes for the original equipment are capable of also providing a suitable support mechanism for the spare parts. This is another example of the need for the development of processes specifically designed to undertake a particular task.

- *Information management:* advances in information technology have enabled a vast amount of detailed data and information to be available and manipulated very effectively. This has led some companies to recognize the need to devise suitable processes to ensure that data is collected, collated and used in a positive and organized way. For logistics, this means detailed information can be made available for individual customers, concerning not just their product preferences but also any customer service requirements that are distribution-specific (delivery time preference, order size preference, real-time delivery tracking). This enables a much more positive, proactive approach to be adopted when considering particular customer relationships.

There are other associated processes that could also be relevant, such as supplier integration, quality, strategic management, maintenance, human resource management and environmental management.

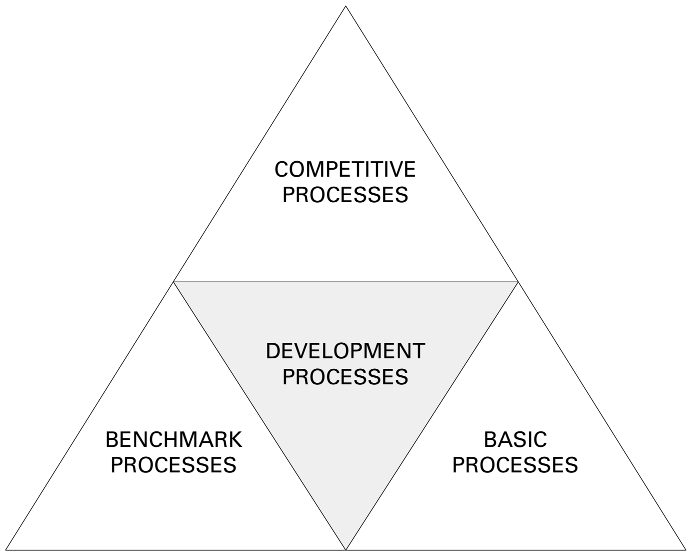
## Process categorization

Several different concepts have been proposed to try to help differentiate the type and importance of the various processes that might be relevant to any given company as it tries to position itself with its customers. Perhaps the most useful of these is known as the process triangle. This is shown in Figure 7.1. The process triangle is based around three different process categories. These can be used to help identify those particular processes that need to be highlighted for specific development. The key process categories are as follows:

- Basic processes: those processes that are essential to a business and are therefore a prerequisite.
- Benchmark processes: those processes that are seen to be important to the customer and must be of at least an acceptable standard to begin to compete satisfactorily in a given market.
- Competitive processes: those processes that are of direct significance to the competitive arena. Good practice and excellence in these processes are likely to provide a competitive edge and ensure that the company is active and successful through its logistics operations.

An assessment of what is required in these three areas and then the identification of what is missing – the 'gap' – will enable the development processes to be identified (the central element in the diagram shown in Figure 7.1). This will include all of the process areas on which further work is necessary to ensure that the company will achieve or maintain a suitable competitive position.

**Figure 7.1** The process triangle: used to help differentiate the type and importance of the various processes within a company, and to identify which processes need to be redeveloped




It would be difficult for any company to develop a suitable process to cover all possible contingencies. Thus, it is useful to understand some of the main methods of differentiating between the various factors that are fundamental to most logistics operations. Processes can then be developed to suit different requirements. Typical differentiating factors will include:

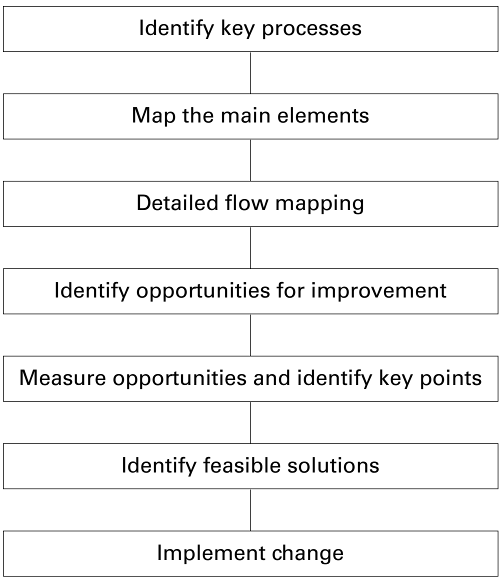
- market segmentation: there may be different requirements for different sectors – engineering, automotive, chemicals, etc
- customer types: these may vary between, for example, industrial and consumer, or international, national and local
- product groups: these may be broken down according to a variety of categories, dependent on the industry – household, industrial, consumer, or hardware, software, spares, etc
- customer service requirements: these may vary between same day, next day, normal, special, etc
- order type: these could be made to order, off the shelf, postponement (partial production)
- channel type: these could be direct, via depot, via wholesaler

# An approach to process design and redesign

In this section an approach to process design and redesign is provided and then the final section of the chapter describes a number of different tools and techniques that can be used to support the approach. The idea of redesign is introduced here to emphasize the point that it is often the redesign of existing processes that is the major concern and opportunity in most logistics operations rather than the setting up of new processes.

The approach to process design is outlined in Figure 7.2. The first step is to *identify the key processes for design or redesign*. This can be undertaken in a variety of different ways, but it is important that representatives of all the main functions from within the company are included in the team that identifies these key processes. Typically, some type of brainstorming exercise will provide the initial ideas, linked closely with a customer service study similar to that described in Chapter 3. As usual, it is imperative to get a clear view of customer service requirements, and these can only be truly identified through close contact with the customer. Any opportunity to benchmark against key competitors will also be advantageous.

**Figure 7.2** Approach to process design or redesign




The next stage is to *map out the main elements* of each process that is to be redesigned. The objective is to identify the key steps in each process and clarify which departments and people are involved. Key outcomes are to provide an understanding of what the process is all about, what it is trying to achieve, what some of the main problems are and perhaps to provide an indication of some of the potential improvements that might be introduced.

After the initial mapping stage is completed, the next step is to undertake a much more *detailed flow mapping exercise*. Here, the work flow is identified in detail as it progresses through each relevant department. Each crucial part of the process is identified, together with the specified amount of time taken to complete each of these parts. Any problems are identified and noted. The complicated nature of processes such as order fulfilment means that the mapping exercise itself is likely to take a lot of time and effort. In general, the specific opportunities that should be identified are those with a high potential for positive change, and those that are either very high in cost or very high in terms of the time taken to complete that respective part of the process, or of course all of these. Additionally, it may be possible to identify some parts of the process that are entirely superfluous. This is not uncommon with many processes that have been allowed to develop over time without any specific replanning.

Once the detailed flow mapping has been completed any *opportunities for improvement* can be identified. It is useful to set up a specific team to undertake this and the remaining stages of the process redevelopment. This team should be one that has the full backing of senior management and should also be representative of the main departments to be affected by the redesign. The team should be in a position to complete any additional or more detailed mapping or *measurement* as necessary, and from this identify any key points that arise. It should *identify any feasible solutions* and then get overall agreement for any changes that it is felt should be put into practice.

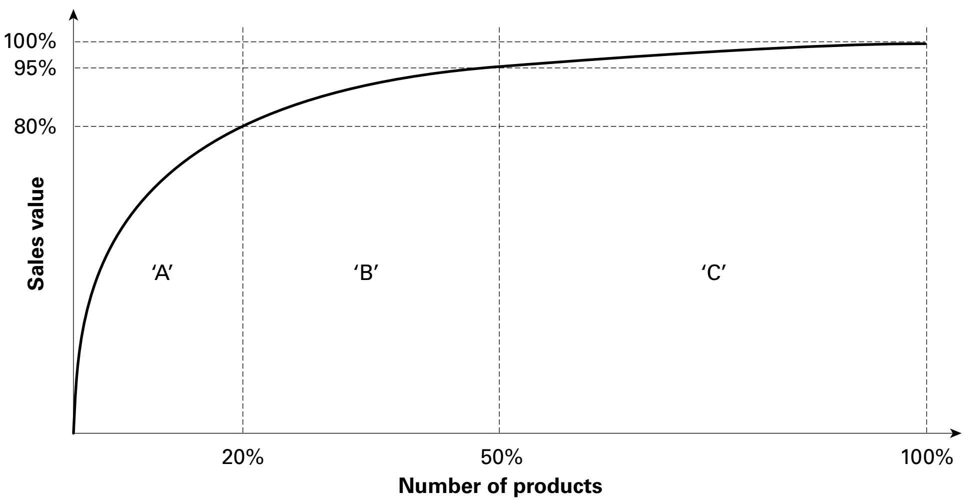
The final stage, once agreement for change has been reached, is to *implement any change*. This may be undertaken on a pilot basis at first to test the effectiveness of the redesigned process. Subsequently, measures should be put in place to monitor the process continually into the future.

## Tools and techniques

There are a number of different tools and techniques that can be used to help with logistics process redesign. These range from those that provide assistance with the initial categorization of key process objectives to those that offer a detailed assessment of the processes themselves and thus can be used to identify opportunities for improvement. Some of these techniques have been adopted in manufacturing under the umbrella known as 'Six Sigma' (see Chapter 13). Some of the main alternatives are:

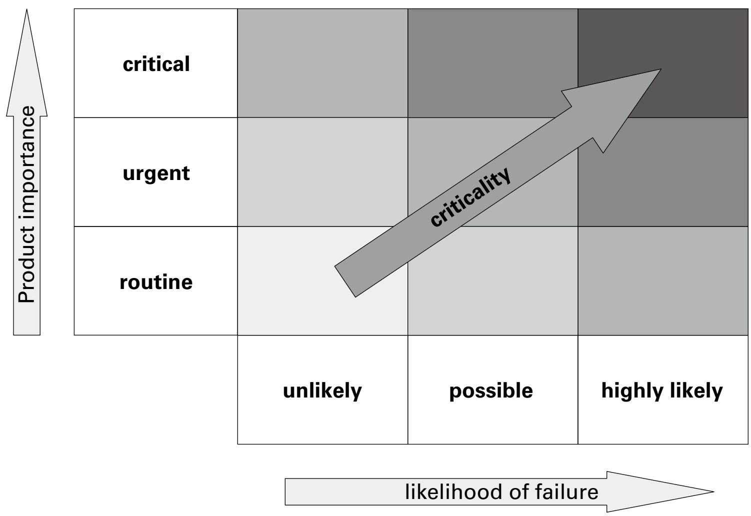
- *Pareto analysis*: this is sometimes known as ABC analysis or the 80/20 rule and it is an important method used in logistics for identifying the major elements of any business or operation. By identifying these main elements, it is possible to ensure that any analytical assessment is concentrated specifically on key aspects and is not taken up with the peripheral less consequential detail. A typical Pareto curve is shown in Figure 7.3. In this example, 20 per cent of the product lines or SKUs (stock-keeping units) are responsible for 80 per cent of the sales in value of the company's products and this shape of curve is common to most companies. This type of relationship holds true for many aspects of logistics and distribution – the most important customers, the most important suppliers, etc. Thus, it is possible to identify a limited number of key elements that are representative of the main business and to concentrate any major analysis on this important 20 per cent. Another useful result of Pareto analysis is to identify the items (customers, products or whatever) that make up the final 50 per cent of the 'tail' of the curve. These are often uneconomic to the company and should be considered for rationalization or elimination, depending on their actual profitability and their support to the overall product portfolio. In Figure 7.3, 'A' class products represent 20 per cent of the range of products, but account for 80 per cent of sales; 'B' class products represent 30 per cent of the range of products, but account for 15 per cent of sales; and 'C' class products represent 50 per cent of the range of products, but account for just 5 per cent of sales.

**Figure 7.3** A typical Pareto curve showing that 20 per cent of products represent 80 per cent of sales value



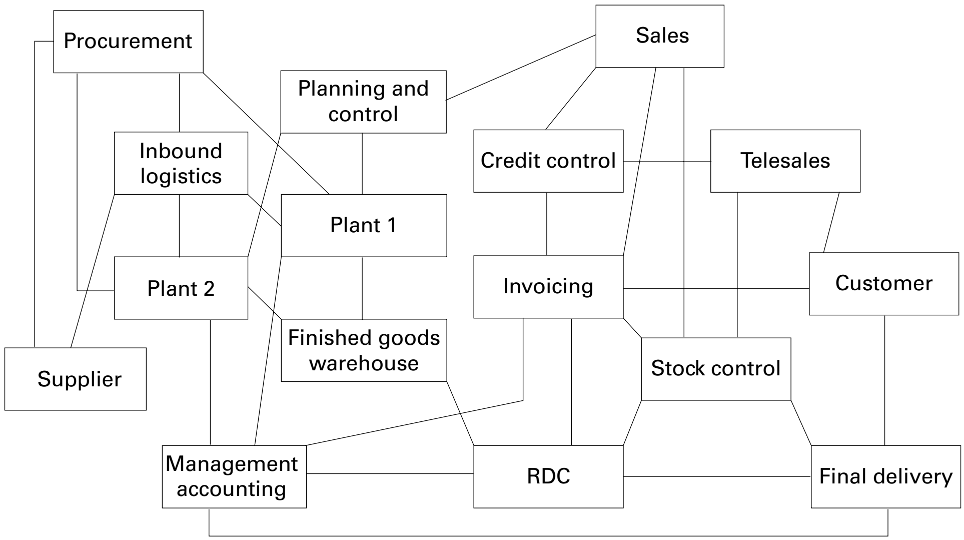

- *Criticality analysis*: this can be used to rank products according to their importance and to differentiate the way in which they may be considered in a variety of circumstances. For example, it can be used for spare parts in order to identify how critical they are to a given machine. Critical parts may then be given a high service level, and non-critical parts a lower service level. This procedure can be conducted as a quantitative analysis or, where data is limited, as a qualitative (subjective) analysis. A criticality matrix can be developed, which is a graphical or visual means of identifying and comparing the criticality or service level requirements of all products within a given system or subsystem and their probability of occurring with respect to severity. The matrix can be used to prioritize products according to their service requirements. An example of a 3×3 criticality matrix is given in Figure 7.4.

**Figure 7.4** An example of a criticality matrix




- *Market or customer segmentation*: one of the main objectives of the design of suitable logistics processes is to ensure that they are 'customer-facing' and to align them in such a way that all customers' needs are met. Clearly, not all customers are the same and therefore not all customer requirements are the same. It is important to be able to identify different types of customers and different types of market and to adopt the appropriate service requirements to take account of these differences. Through the use of suitable customer service studies (as described in Chapter 3) it should be possible to categorize companies according to different types of service requirement. Suitable processes can then be based around the different categories of customer or segments of the market.
- *Customer service studies*: as already described in Chapter 3, a customer service study should be used as the basis for identifying key service requirements on which to design suitable logistics processes.
- *Relationship mapping*: this is used at an early stage of logistics process design to identify the main departments within a company (or across the broader supply

**Figure 7.5** Relationship mapping: used to identify key departments and their interrelationships




chain if this is possible) that are specifically involved in a particular process. An example is given in Figure 7.5. As well as identifying these key departments, so that they can be brought into the design process, this will help to pinpoint the major relationships and will highlight the complexity within any particular process, thus indicating its need for redesign.

- *Process charts*: processes can be represented using a variety of different methods, whether by straightforward flowcharts or by a matrix, as shown in Figure 7.6. The flowchart approach can be based on traditional flowcharting techniques. This is useful because standard shapes are used to represent different types of activity (storage, movement, action, etc), and the importance of flows can be highlighted in terms of the number of movements along a flow. The matrix chart of Figure 7.6 provides a more systematic way of representation and can be beneficial where time is to be represented.
- *Value/time analysis*: this type of analysis can be used to identify the points in a process where cost is incurred and value is added to the product. The aim is to highlight, and subsequently eliminate, those parts of the operation that provide a cost but add no value. Traditionally, for most manufactured products, value is added when a process changes the nature of the product (such as production, which alters the physical attributes; or transport, which alters the physical location). Value is not added, but waste occurs through the passing of time, for example, when a product is stored as work-in-progress between operations. Figure 7.7 provides an example of a value/time analysis. This is not an easy type

**Figure 7.6** A matrix process chart

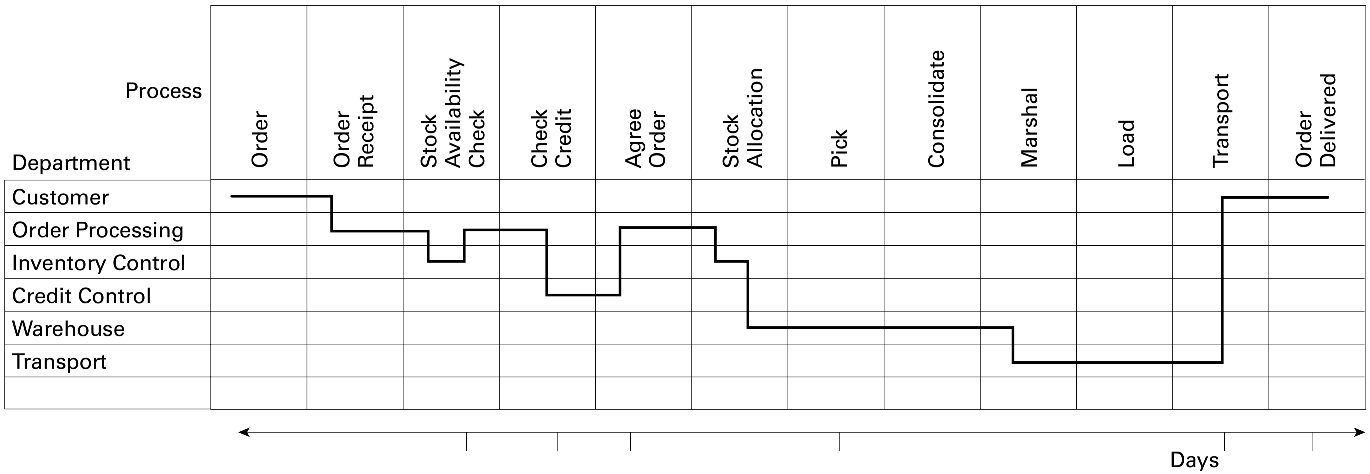
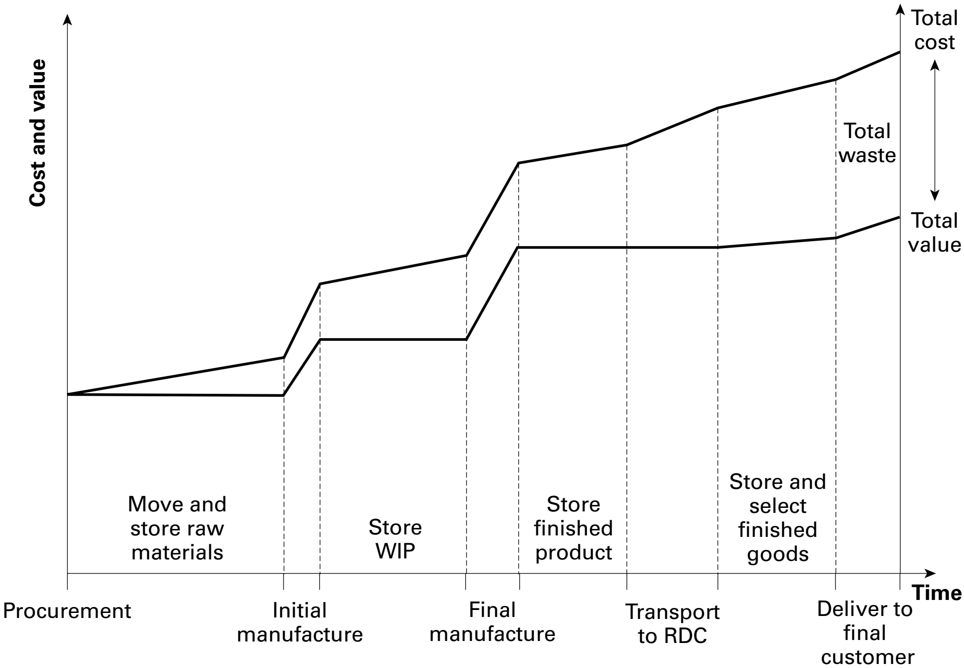


**Figure 7.7** Value/time analysis




of analysis to undertake, especially for the early downstream activities when it becomes difficult to isolate the true time and costs attributable to partially manufactured products.

- *Time-based process mapping*: this is another method of identifying and eliminating wasted time in a process. The idea is to understand and record a process in detail and to be able to identify what is active or useful time and what is wasted time. The output from such an exercise is the opportunity to engineer the wasted time out of the process so that service is improved and cost is reduced through a reduction in the overall time taken to complete the process. The simple steps are:

  **a** Map the process by 'walking' through the actual operation and recording the key steps and the associated time taken.

  **b** Identify and differentiate between what is value-adding (e.g. necessary) and what is non-value-adding (e.g. unnecessary) and record this.

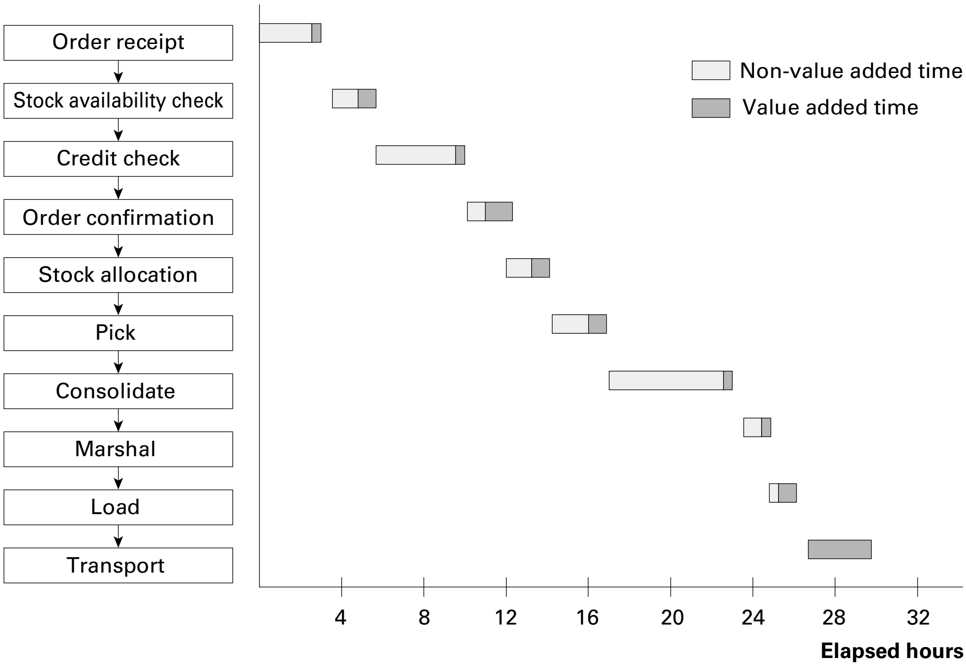
  **c** Calculate the relative time spent on the different activities and identify the most appropriate for improvement.

  **d** Analyse the causes of the problem and assess any opportunities for change.

  **e** Develop solutions and implement.

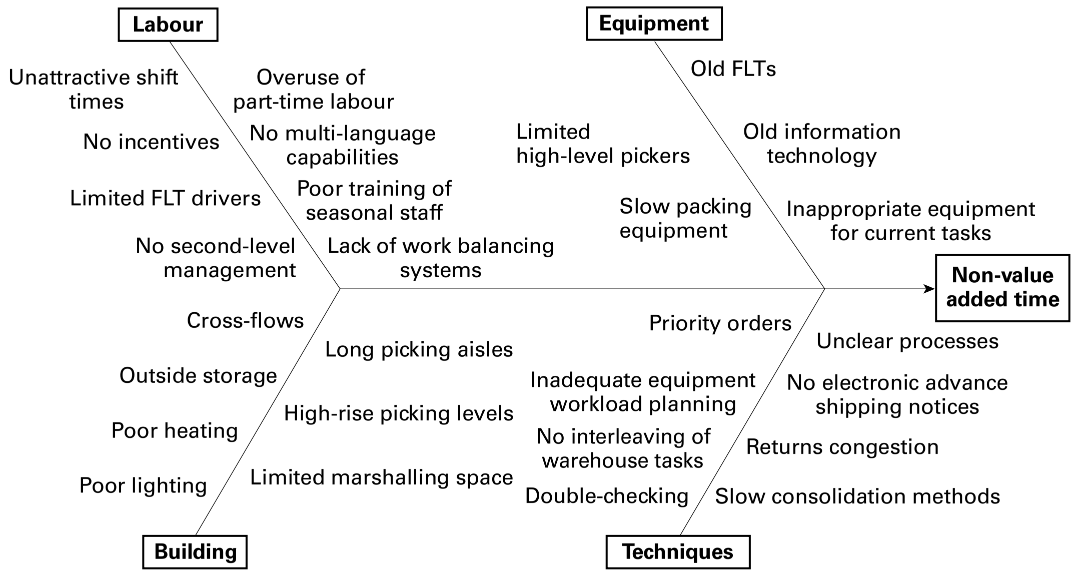
  An example of a time-based process map is given in Figure 7.8.

**Figure 7.8** A time-based map illustrating the order to dispatch process broken down into value-added and non-value-added time




- *Root cause analysis*: this is a method that can be used to help to identify the causes of non-value-added time. The example here is based on an Ishikawa diagram and is shown in Figure 7.9.

**Figure 7.9** Root cause analysis: finding the cause of non-value-added time in a depot using an Ishikawa diagram



# Supply chain segmentation 08

## Introduction

As noted in Chapter 2, a 'one-size-fits-all' approach to logistics is not appropriate in most instances. Some form of supply chain segmentation is therefore necessary for a company to satisfy the different service and cost needs of its customers. In addition to the channel options discussed in Chapter 4, this raises the question of exactly how a company's own supply chain should be segmented. For example, one type of supply chain may be appropriate for large bulky items and another for small parcels. Similarly, a supply chain may be necessary for highly demanding customers separate to that generally available to the market. There are many different ways in which supply chains may be segmented and this chapter explores some of the more common segmentation approaches that are available.

## Product segmentation

It may be necessary to have different supply chains because of the very nature of the products. For example, when delivering to petrol stations the fuel may be delivered in large road tankers whereas the food and other items for the petrol forecourt shop would need to be delivered in clean, enclosed vans or trucks. Some key product characteristics were described in Chapter 6. Such product characteristics are often an important basis for supply chain segmentation. Examples include:

- Size: the size of the product (or the total order) may determine whether it is best suited to be delivered via a palletized delivery network or by parcel carrier or by post. Another example is where large items, such as beds or sofas, require two people to unload and, in such instances, it is often found more cost-effective to set up a separate network just for large bulky items, rather than having two people in a vehicle for all deliveries.
- Temperature regime: there are three main temperature regimes for food products, namely frozen (about –18°C to –25°C), chilled (about +2°C to +5°C) and ambient

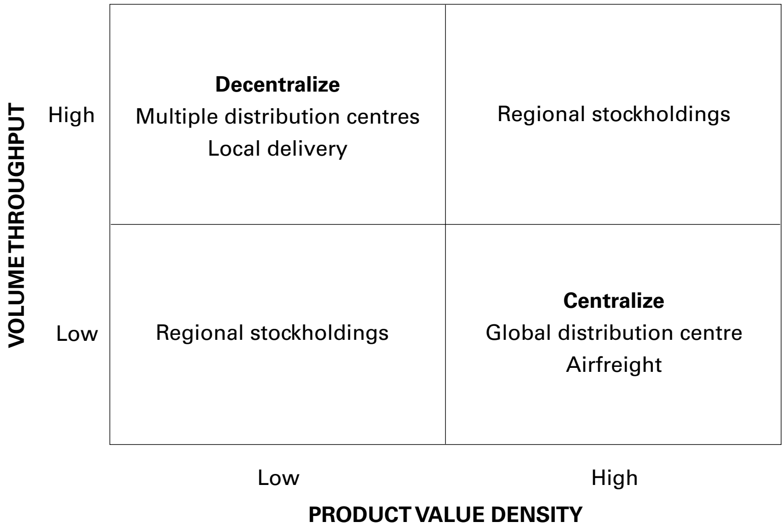
(normal outside) temperatures, although some fresh foods, for example, may need temperatures slightly different to these. The three main temperature regimes often form the basis for segmented supply chains, although it is quite common to find chilled and ambient goods combined. In fact, it is possible to combine all three in a single supply chain that comprises multi-temperature warehouses and compartmentalized vehicles.

- Bulk: some products are well suited to bulk handling (e.g. liquids, powders and granules) and therefore require specialist storage, handling and transport facilities.
- Hazard: hazardous goods may require a separate supply chain so that all the necessary safety measures can be implemented.
- Contamination: even where goods are not hazardous, they may be able to contaminate other products (e.g. by their smell).
- Pilferable goods: certain goods may be the target of opportunistic or planned robberies and therefore require greater security. An obvious example of this is where armoured vehicles are used for bank note and bullion deliveries.
- Value: the value of goods may be important for segmentation purposes as this affects how costly it is to hold inventory in the supply chain. For example, goods that are low in value may be held at multiple locations close to the customers, whereas high-value goods may be centralized so as to reduce safety stocks (as explained in Chapter 15). This concept can give rise to a segmentation basis as shown in Figure 8.1, whereby high throughput but low value-density products (i.e. a low value compared to their weight or cube) may be dispersed geographically, while a low throughput but high value-density product may be held at a single global distribution centre and air freighted from there around the world. A typical example of the former product type is photocopy paper; a typical example of the latter is high-value electronic parts.
- Variety: some goods by their nature are sold in a wide variety of forms. For example, a single shirt 'product line' may have many different collar sizes, colours and sleeve lengths. Each combination of these is significant to the customer and therefore many individual stock-keeping units (SKUs) need to be made available for sale. It is very difficult to forecast demand at the SKU level for every geographic region and therefore, as with high-value goods, the stockholding of these may be centralized so as to minimize safety stocks.

## Demand and supply segmentation

In addition to the physical characteristics of the goods, there may be a distinction between whether the demand for the goods is predictable or unpredictable in nature.

**Figure 8.1** Segmentation by throughput and value-density




**SOURCE** Adapted from Lovell et al, 2005

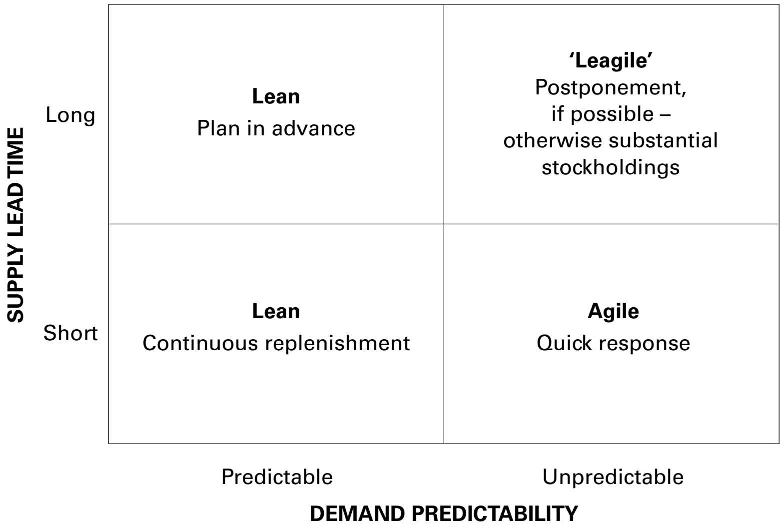
Goods with a predictable demand pattern may be best suited to a cost-efficient supply chain whereas goods with unpredictable demand may require a much more responsive supply chain. This type of distinction is often associated with lean and agile concepts respectively, as explained in Chapter 5.

Demand is, however, only one side of the supply chain. The nature of supply also needs to be taken into account. An important factor on the supply side is the length of the supplier lead time – from the time of placing orders on the supplier up to the time of physically receiving the goods. A segmentation framework using a combination of demand and supply factors is shown in Figure 8.2.

Under this segmentation framework, lean supply chain principles can be applied where there is predictable demand. In the case of long lead times, the sourcing, production, storage and movement of goods can be planned in advance in the most cost-effective manner. Where lead times are short, then quick response and continuous replenishment policies can be adopted so that goods are supplied on a 'just-in-time' basis at the last possible moment, again keeping inventories and waste to a minimum.

However, if demand is unpredictable, agile policies can only be fully adopted where supplier lead times are short. In this circumstance, supply can flex to meet the rapidly changing demands of the marketplace, and again inventories can be kept low. However, where supplier lead times are long, then this is likely to lead to either an oversupply of goods (leading to high inventories) or an undersupply (leading to lost sales). Other approaches therefore need to be explored to combat this, such as production postponement, whereby goods are configured to the actual specification

**Figure 8.2** Segmentation by demand and supply characteristics




**SOURCE** Adapted from Christopher et al, 2006

of the customer at the last possible moment. Goods are therefore held in a generic form, which can be more easily forecast than at a more detailed level. An example of this would be the holding of personal computer components ready to be assembled once an order is received, rather than manufacturing computers to exact specifications of memory size etc and holding a multitude of finished goods SKUs in stock (see Chapter 13 for further details on postponement). Policies such as postponement that combine elements of lean and agile approaches are sometimes referred to as 'leagile'. However, particular circumstances will dictate whether such approaches are possible, as a combination of long supplier lead times and unpredictable demand tends to result in the need for high safety stocks. This has been found to be the case in many industries that are served by global supply chains.

The geographic location of supply is obviously a very important factor in supply chain design. Separate supply chains will be needed, for example, to bring goods from the Far East to European markets, rather than from local European suppliers. In fact, the decision as to where to source is often part of the supply chain design process. For example, goods with predictable demand may be sourced from low-cost suppliers in distant parts of the world (i.e. part of a 'lean' approach) whereas goods with unpredictable demand may be sourced locally where lead times are generally much shorter and therefore supply can easily be changed to meet fluctuating levels of demand (i.e. part of an 'agile' approach). Understanding factors such as these is key to the development of an effective logistics operation and is integral to the logistics network planning process described in the next two chapters.

However, it may be rather simplistic to categorize the demand for goods as being either predictable or unpredictable. Another approach is to examine whether there is a 'base' demand that can be identified separately from any unpredictable 'surge' demand. In this circumstance, it may be advantageous to segment the supply chain accordingly, with a lean supply chain for the base demand (e.g. by sourcing in low-cost countries) and an agile supply chain for the surge demand (e.g. by sourcing locally).

A similar approach could be taken by segmenting in accordance with the Pareto classification of the goods. Thus, fast-moving goods normally have more predictable demand than slow-moving goods, as the latter tend to be demanded only occasionally and in small quantities. A lean approach could therefore be adopted for the fast-moving goods and an agile approach for the slow-moving goods.

## Marketing segmentation

Segmentation has been adopted in marketing for many decades. It is used for demand creation purposes and it has long been recognized that different classifications of customer require different marketing approaches. As it is the customer that supply chains are trying to satisfy, it would be sensible to examine whether marketing segmentation frameworks are relevant to supply chain design.

There are many categorizations of marketing segments but one such classification that can fit particularly well for the supply chain is as follows:

- geographic: the location of the customer, e.g. by continent, country, region or urban/rural
- demographic: populations are often broken down into categories according to such factors as age, gender, income, home/car ownership, employment and ethnic origin
- psychographic: this form of segmentation is concerned with the interests, activities and opinions of consumers, and is often related to lifestyles
- behaviouristic: this relates to how consumers behave, in terms of, for example, how frequently they buy certain products and whether they remain loyal to particular brands
- firmographic: in the case of industrial customers, a common form of segmentation is by such factors as turnover, number of employees and industry sector

The geographic location of the customer is obviously relevant to supply chain, as well as marketing segmentation. For example, export orders are often segregated within warehouses for specialist packing and are frequently dispatched using different logistics companies than is the case with home orders. Similarly, some companies deliver to the main urban conurbations using their own vehicles, while they may use third-party logistics providers for more distant locations (as such providers can combine deliveries with goods from other companies in order to improve their load factors and routeing efficiency).

It may also be argued that the other marketing segmentation frameworks are highly relevant to the supply chain in that each segment may represent a different demand characteristic that needs to be supplied in a different way. For example, psychographic factors, such as lifestyle, are important in the fashion industry. Customers who require standard commodity garments (e.g. low-price jeans) can probably be supplied using lean principles as demand tends to be fairly stable. However, the demands of fashion-conscious buyers (i.e. who seek the latest fashions as seen on the catwalks or fashion blogs) need to be satisfied in a much more agile way – for example, using rapid design and manufacturing techniques, local suppliers and cross-docking through the distribution network immediately to the stores. Of course, it must also be remembered that individual customers may fit into both of these categories depending on the nature of a particular purchase (e.g. for everyday wear or for special occasions).

Behaviouristic segments may also be very important for supply chain design. For example, Gattorna (2006) used personality types to investigate buying behaviours, particularly of commercial customers, and identified four common categories:

- Collaborative: this is where customers are seeking a close working relationship whereby both parties may benefit. It is a common behaviour when dealing with mature products where demand is fairly predictable and is often associated with a supply chain design using continuous replenishment principles.
- Efficient: this is commodity-type buying where price tends to be the 'order winner'. A lean supply chain at minimum cost is therefore suited to this segment.
- Demanding: in this segment, a rapid response is needed, often to cope with unpredictable supply and demand situations. An agile type of supply chain is therefore required.
- Innovative: this tends to be where the customer is continually seeking new developments and ideas from suppliers. The latter therefore need to be innovative in terms of supply chain solutions and fully flexible in their response.

Each of these categories of buying behaviour may therefore require a different supply chain design.

## Combined segmentation frameworks

Most segmentation policies involve some combinations of the various frameworks described above. For example, one that has been proposed (by Childerhouse et al, 2002) has been named 'dwv$^3$' with the key factors being as follows:

- duration: this refers to the stage in the product life cycle and its duration
- window: this is the time window for delivery or the delivery lead time that is required
- volume: this relates to the Pareto volume classification, i.e. whether the products are fast or slow-moving
- variety: this relates to the product range, particularly in terms of the number of individual SKUs (e.g. colours, forms, sizes, etc)
- variability: this relates to demand variability and unpredictability

This framework was applied successfully to the supply chains of a lighting manufacturer. However, some later investigations have found that additional factors may need to be incorporated, such as order line value and weight, and the number of customers buying each product, as well as, of course, the numerous other factors mentioned throughout this chapter.

## Two-tier supply chains

The above segmentation frameworks assume that a company is selling directly to the end consumer. However, this is not always the case. For example, manufacturers in industrial markets may sell through distributors while manufacturers in consumer markets may sell through retailers. In such instances, the question often arises as to who is the real customer – the end consumer or the intermediary? One approach to this segmentation problem is to associate categories of end consumer to categories of intermediary – for example, in sports footwear, marathon runners may tend to purchase their running shoes from specialist retail stores. One framework for developing a supply chain segmentation strategy in such circumstances is described by Roscoe and Baker (2014):

- Step 1: define behavioural segments for end consumers by category (e.g. marathon runner or casual weekend runner).
- Step 2: determine where the end consumer in each behavioural segment is likely to make a purchase (e.g. by type of retailer).
- Step 3: decide upon the order winning criteria (e.g. price, service, customization) for each retailer type, taking into account the consumer category served.
- Step 4: identify the value proposition to be offered to each retailer type (e.g. innovation and responsiveness for the customizable and specialist running channels).
- Step 5: define which product at which price points would suit each retailer type.

- Step 6: describe the demand attributes of each article sold (e.g. predictability, growth trends).
- Step 7: define the demand pattern of the product type for that specific retailer (e.g. seasonal, erratic).
- Step 8: establish which supply chain type would suit that demand pattern (e.g. lean, continuous replenishment, agile – responsive, agile – customized).
- Step 9: configure the supply chain accordingly.

In this way, a segmented supply chain strategy can be developed so that each category of intermediary is serviced in accordance with the requirements of the end user categories that purchase through that type of intermediary. This may involve decisions on, for example, sourcing, manufacturing batch run size, customization, location of decoupling point, inventory levels and transport modes, so as to construct the appropriate supply chains in terms of cost and responsiveness.

## Implementation

Supply chain segmentation can therefore be very complex as there is a wide range of factors that could be used as a basis for segmentation. Obviously, if a company decided to use all of these possible segmentation bases then it would find itself with a multitude of different supply chains that would be impossible to manage. It is therefore important to choose the segmentation frameworks that are most relevant to the particular product, supply, demand and buying characteristics experienced. Many of the different segments that could be identified will in fact require the same or similar supply chain designs and therefore these can be grouped together. The objective is to have a manageable number of cost-effective supply chain networks that adequately meet the different demands of the market.

It should be noted that there are a number of different elements involved in designing a supply chain, such as:

- sourcing (e.g. local supply, 'near-shoring', or 'off-shoring')
- manufacturing
- distribution network (e.g. the number, location and role of warehouses)
- transport modes (e.g. road, rail, sea or air freight)

The implementation of segmented supply chains requires decisions on all these elements. For example, a 'lean' supply chain may involve 'off-shore' sourcing (e.g. from a distant low-cost supplier), cross-docking through warehouses to meet a predictable demand and transport by sea freight, which is relatively low cost. An 'agile' supply chain, on the other hand, may require local suppliers that can react quickly, a network of local depots holding small buffer stocks to service the immediate needs of customers and the use of road freight, which tends to be relatively fast and flexible in nature. There may be synergies that can be gained by merging certain aspects of segmented supply chains – for example, the use of the same warehouses for holding buffer stocks and for cross-docking.

The design of segmented supply chains is an important business decision and requires the involvement of various departments across a company, including marketing, manufacturing, procurement and logistics. The various elements of supply chain design are described further in Chapters 9 and 10.

# Logistics costs and trade-off analysis 09

## Introduction

In the next chapter, an approach to logistics network planning is developed and described, but before attempting this, it is essential to be fully aware of the key factors that underpin a distribution and logistics operation. This is the basis for this current chapter of the book.

The main elements of a logistics network planning study revolve around the location and use of the distribution centres (DCs) that are generally the distinctive part of any logistics operation. The way in which these DCs coexist with the other key elements, such as inventory and transport, needs to be understood. This involves both the cost- and the service-related aspects that are so important to any successful operation. It is this that is at the heart of this chapter.

The chapter begins with a discussion of the role of distribution centres and warehouses. The major part of the chapter is then concerned with identifying and representing the various costs of the key logistics elements together with a view as to how they can be considered with respect to the overall assessment of logistics costs as a whole. The final step is to understand the concept of logistics trade-off analysis, which is the focal point of logistics network planning and analysis.

## The role of distribution centres and warehouses

There are a number of reasons why DCs and warehouses are required. These vary in importance depending on the nature of a company's business. In general, the main reasons are:

- To hold the inventory that is produced from long production runs. Long production runs reduce production costs by minimizing the time spent for machine set-up and changeover.
- To hold inventory and decouple demand requirements from production capabilities. This helps to smooth the flow of products in the supply chain and assists in operational efficiency, enabling an 'agile' response to customer demands.

Note that many supply chains have strategic inventory located at several different points, whereas this buffer only needs to be held at what is known as the decoupling point: the point at which discrete product orders are received.

- To hold inventory to enable large seasonal demands to be catered for more economically.
- To hold inventory to help provide good customer service.
- To enable cost trade-offs with the transport system by allowing full vehicle loads to be used.
- To facilitate order assembly.

These reasons emphasize the importance of getting the facilities location decision right, and also give an indication of the complex nature of that decision. It is possible to summarize the main reason for developing a logistics network as 'the need to provide an effective service to the customer, while minimizing the cost of that service'. Service and cost factors are thus of paramount importance when determining the number, size and location of facilities.

For the best possible customer service, a DC would have to be provided right next to the customer, and it would have to hold adequate stocks of all the goods the customer might require. This would obviously be a very expensive solution. At the other extreme, the cheapest solution would be to have just one DC (or central depot) and to send out a large truck to each customer whenever his or her orders were sufficient to fill the vehicle so that an economic full load could be delivered. This would be a cheap alternative for the supplier, but as deliveries might then only be made to a customer once or maybe twice a year, the supplier might soon lose the customer's business.

There is obviously a suitable compromise somewhere between these extremes. This will usually consist of the provision of a number of DCs on a regional or area basis, and the use of large primary (line-haul) vehicles to service these, with smaller vehicles delivering the orders to several customers on each trip that they make. For certain operations, of course, even these simple relationships will vary because of the need for very high levels of customer service or the very high value of products.

In addition, it should be noted that there are a number of different types of DC, each of which might be considered in the planning of a suitable physical distribution structure. These might include:

- finished goods DCs/warehouses – these hold the stock from factories
- distribution centres, which might be central, regional (RDC), national (NDC) or local DCs – all of these will hold stock to a greater or lesser extent
- trans-shipment sites or stockless, transit or cross-docking DCs – by and large, these do not hold stock, but act as intermediate points in the distribution operation for the transfer of goods and picked orders to customers

- seasonal stockholding sites
- overflow sites

Logistics network and DC location strategies are aimed at establishing the most appropriate blend of storage and transport at a given customer service level. The interrelationship of the different distribution elements and their associated costs thus provides the basis for decision-making.

## Cost relationships

To plan an efficient logistics structure, it is necessary to be aware of the interaction between the different distribution costs, specifically as to how they vary with respect to the different site alternatives (number, size, type and location), and what the overall logistics cost will be. This is best undertaken by comparative analysis of the major alternative configurations. Before this can be achieved, the detailed make-up of the individual distribution cost elements must be understood.

Many companies have cost information based on their conventional accounting systems, but almost always these costs are too general to allow for any detailed breakdown into the integral parts that reflect the company's distribution structure. (See Chapters 38 and 39 for alternative methods of collecting and measuring logistics costs.) Without this cost information, and the understanding that goes with it, it is impossible to measure the effectiveness or otherwise of the existing operation. It is also impossible to gain the necessary insight into the distribution operation to allow for successful planning and management. The component parts of a distribution system necessarily interact with one another to form the system as a whole. Within this system, it is possible to trade off one element with another, and so gain an overall improvement in the cost-effectiveness of the total system. An appreciation of the make-up and relationship of these key costs is thus a vital link to successful distribution planning and operations. These major cost relationships are outlined in the following sections of this chapter. (Also see Chapter 30 for more detailed information concerning road freight transport costs.)

### *Storage and warehousing costs*

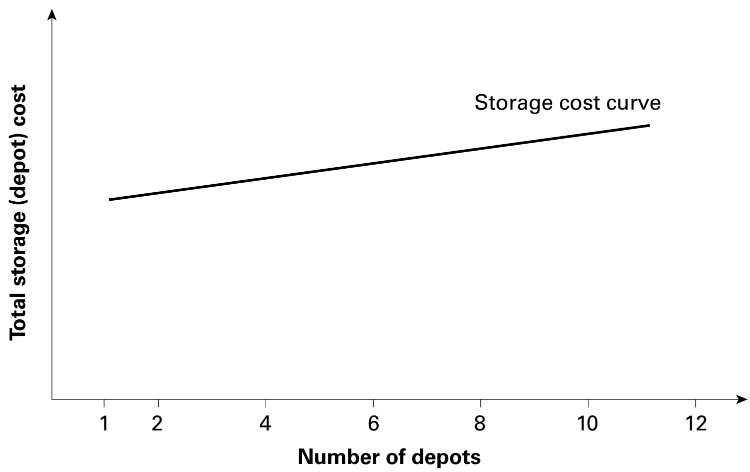
The major cost breakdown for storage and warehousing is between building, building services, labour, equipment and management/supervision. The relationship of these costs will, of course, vary under different circumstances – industry, product type, volume throughput, regional location, age of building, handling system, service level agreements (SLAs), etc. In conventional DCs, the direct labour cost is likely to be the greatest element, with the building cost likely to fluctuate from very high (new building, prime location) to very low (old building, peppercorn (low) rent, low rates or local taxes). (See Chapter 18 for more detailed discussion.)

With respect to the cost relationship of warehousing with other parts of the distribution system, the importance of storage and warehousing costs will be dependent on such factors as the size of the DC and the number of DCs within the distribution network as a whole.

The effect of site size is illustrated by the economies of scale experienced if larger DCs are operated. It has been established that the cost of operation of a site and the amount of stock required to support a DC tend to be higher (per unit) for a small site than for a large one. This is because larger DCs can often achieve better space and equipment utilization and can benefit from spreading overhead costs over the higher throughput. It should be noted that, eventually, diseconomies of scale can occur, because very large DCs can be adversely affected by such conditions as excessive internal travel distances, problems of management, etc.

The effect of a different number of warehouses or DCs in a given distribution network can be seen by developing the 'economies of scale' argument. If a distribution network is changed from one site to two sites, then the overall DC/storage costs will increase. The change is likely to be from a single large site to two medium-sized sites. This will not, therefore, double the costs, because the change is not to two large DCs. It will certainly increase costs, however, because there will be a need for more stock coverage, more storage space, more management, etc. In simple terms, this can be described by a graph, illustrated in Figure 9.1. Thus, as the number of DCs in a distribution network increases, then the total storage (DC) cost will also increase.

**Figure 9.1** Relationship between number of depots (i.e. storage capacity) and total storage cost



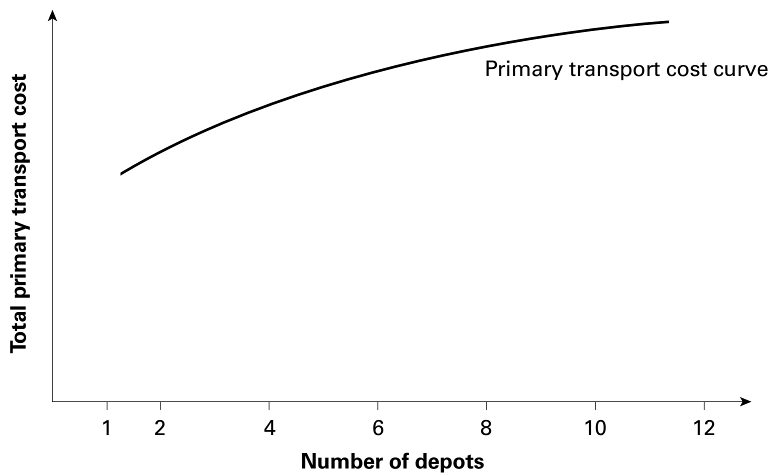

One point that should be appreciated is that some care must be taken over any generalization of this nature. In practice, it will be found that each individual site may differ in its cost structure from the other sites in a system for a variety of practical reasons. These may include, for example, high (or low) rent and rates according to the location of the DC (e.g. very high in cities) or high (or low) labour costs.

## Road transport costs

The two most important categories of transport costs are: primary transport (sometimes called trunking or line-haul); and delivery transport (sometimes called final or secondary distribution). The requirements and costs for these two types of transport vary according to the number of DCs in a distribution network.

The *primary transport* element is the supply of products in bulk (i.e. in full loads) to the DCs from the central finished goods warehouse or production point. This element is generally undertaken using road freight transport, but of course for some bulk products other modes of transport are used. The number of sites affects the overall cost of this type of transport. In this instance, the effect is not a particularly large one, but it does result in an increase in primary transport costs as the number of DCs increases. The effect is greatest where there are a smaller number of sites, as the graph of Figure 9.2 indicates.

**Figure 9.2** Primary transport costs in relation to the number of depots




The second of these two types of transport, *delivery transport*, is concerned with the delivering of orders from the DC to the customer. This can be carried out by a company using its own fleet of vehicles or by a third-party carrier. Whichever alternative is used, the cost of delivery is essentially dependent on the distance that has to be travelled.

The distance travelled by delivery transport can be divided into two different elements:

1 'Stem' distance, which is the distance to and from a delivery zone (from the DC outwards to the first 'drop' point and return from the final 'drop' point back to the DC).

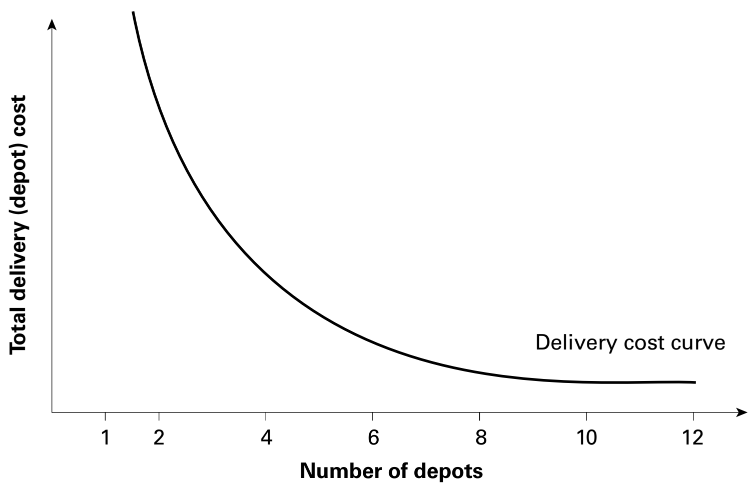
2 'Drop' distance, which is the distance travelled once a drop or delivery zone has been reached (starting from the first 'drop' point and finishing at the final 'drop' point).

Stem distance to any particular delivery zone will depend on the location of the DC. If the DC is changed (because of a decision to reduce the number of DCs in the system) then the stem distance will also change (it will increase if there are fewer DCs and will decrease if there are more DCs).

Drop distance will not change if the number of DCs change because the delivery zone(s) will remain the same.

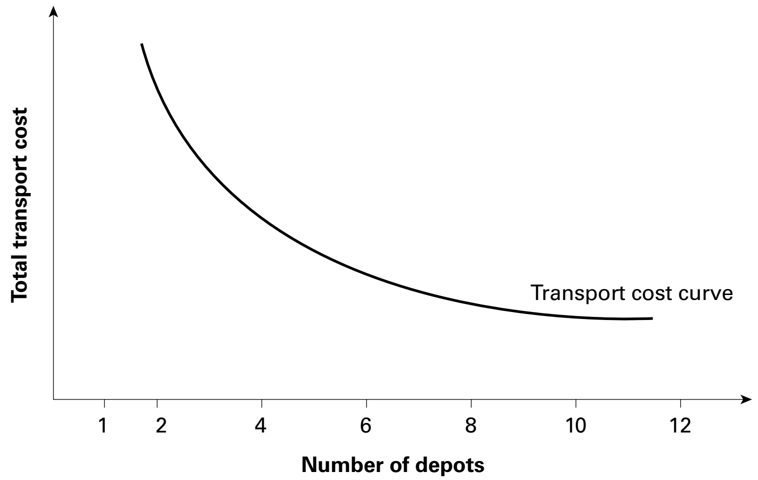
Thus, while the drop distance remains the same whatever the distance from the supplying DCs, the stem distance varies according to the number of DCs in the system. The greater the number of DCs, the less the stem distance. This can be described by a graph, as shown in Figure 9.3.

**Figure 9.3** Delivery transport costs in relation to the number of depots




If the costs for both primary and delivery transport are taken as a combined transport cost then these total transport costs can be related to the different number of DCs in a distribution network. The overall effect of combining the two transport costs is that total transport costs will reduce, the greater the number of sites that there are in the system. The effect can be seen in the graph of Figure 9.4.

**Figure 9.4** Combined/total transport costs (primary and delivery) in relation to the number of depots




## *Inventory-holding costs*

Another important cost that needs to be included is the cost of holding inventory. The main elements of inventory holding are considered in a little more detail in Chapter 15. The key costs can be broken down into three main areas:

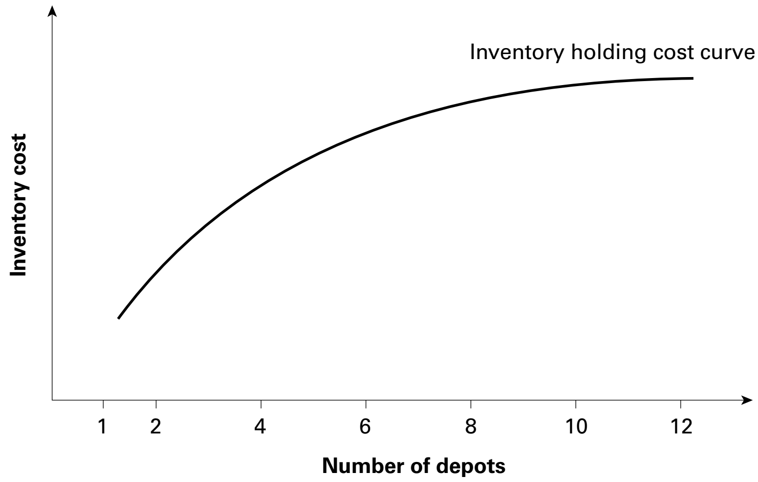
1. Capital cost: the cost of the physical stock. This is the financing charge, which is either the current cost of capital to a company or the opportunity cost of tying up capital that might otherwise be producing a return if invested elsewhere.
2. Service cost: that is, stock management and insurance cost (the cost of servicing the inventory – not to be confused with customer service which is a very different cost).
3. Risk costs: which occur through pilferage, deterioration of stock, damage and stock obsolescence.

These costs, when taken together and measured against the number of DCs in a system, can be represented as shown in Figure 9.5.

## *Information system costs*

The final cost element for consideration is that of information system costs. These costs may represent a variety of information or communication requirements ranging from order processing to load assembly lists. Usually, some type of computerized

**Figure 9.5** Inventory-holding costs in relation to the number of depots




information system is used to provide these requirements. These costs are less easy to represent graphically because of the fast rate of change of information systems and because costs can vary considerably, dependent on the level of technology introduced. The higher the number of depots in a logistics operation, the higher information system costs are likely to be. This relationship can be broadly represented as shown in the graph of Figure 9.6.

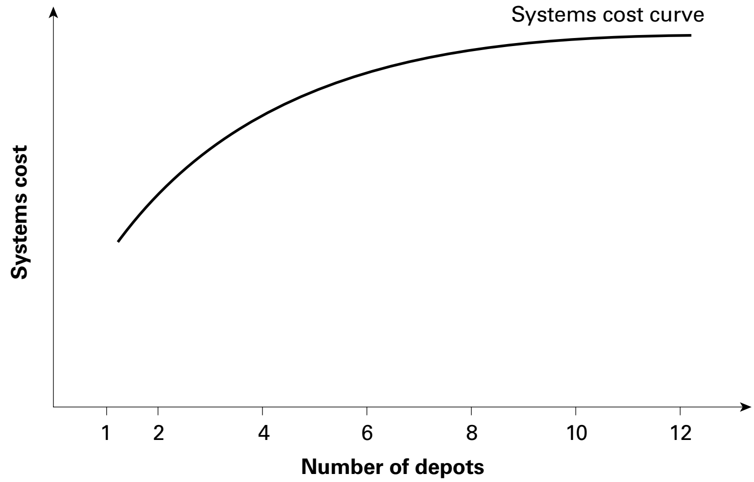
## Total logistics costs

By its very nature logistics operates in a dynamic and ever-changing environment. This makes the planning of a logistics structure a difficult process. It is also not an easy matter to appreciate how any changes to one of the major elements within such a structure will affect the system as a whole. One way of overcoming this problem is to adopt a 'total' view of the system, to try to understand and measure the system as a whole as well as in relation to the constituent parts of the system.

Total logistics cost analysis allows this approach to be developed on a practical basis. The various costs of the different elements within the system can be built together. This provides a fair representation, not just of the total logistics cost, but also of the ways in which any change to the system will affect both the total system and the elements within the system.

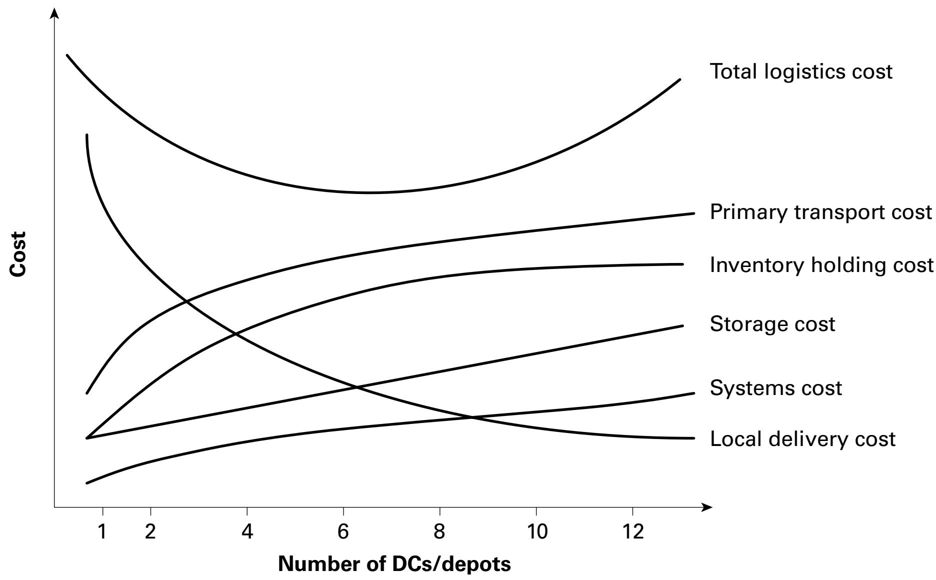
The total cost approach can be represented in a graphical format by building up a picture from the graphs used to illustrate the cost elements in the earlier section of

**Figure 9.6** Information system costs in relation to the number of depots




this chapter. This is illustrated in Figure 9.7 and demonstrates how the individual distribution and logistics cost elements can be added together to give the total logistics cost. It shows, in this example, the individual functional costs and the total logistics cost for an operation as the number of depots in a given network changes.

**Figure 9.7** The relationship between total and functional logistics costs as the number of depots in a given network changes



The overall cost effect of using a different number of sites can be explained by such a graph and can be used for facilities location planning. The top line on the graph shows the overall logistics cost in relation to the different number of DCs in the network. It is obtained by adding together the individual cost curves of the key distribution elements that correspond to each number of sites. For just a single DC, for example, there is a large local delivery cost to add to the much smaller costs of primary transport, inventory, storage and system costs.

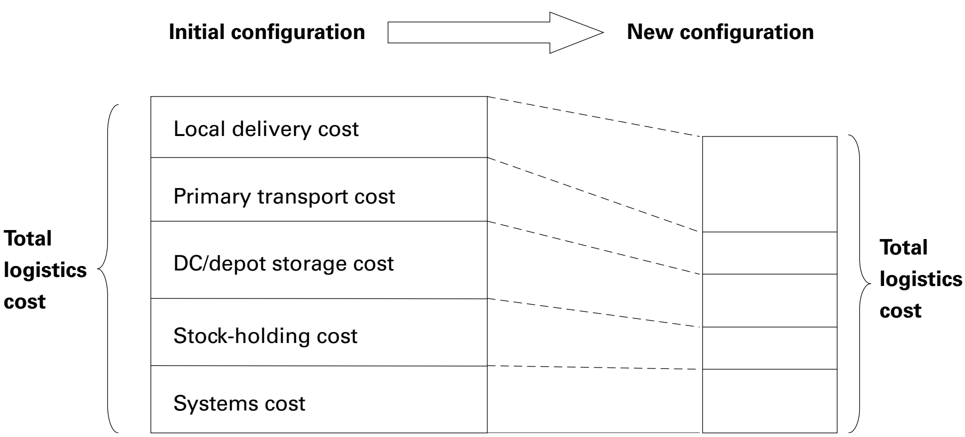
It can be seen from the graph that the least expensive overall logistics cost for this particular demand area occurs at around the 5–7 DC number. The minimum point on the overall logistics cost curve represents this lowest-cost solution. The results, in practice, will depend on a number of factors: product type, geographic area of demand, demographics and population density, service level required, availability of suitable buildings.

These relationships are the key to the planning of logistics strategy and structures. As will be discussed in Chapter 10, computer models have been developed that allow this type of detailed quantitative analysis to be carried out so that least-cost solutions can be identified and implemented.

## *Trade-off analysis*

The concept of trade-off analysis is a key feature of this total cost approach to logistics planning. It has been shown that any change in one of the major elements within a logistics system is likely to have a significant effect on the costs of both the total system and the other elements. Indeed, it is often possible to create total cost savings by making savings in one element, which creates additional costs in another but produces an overall cost benefit. This can be seen in Figure 9.8.

**Figure 9.8** Trade-off analysis showing that a change in configuration can lead to a reduction in total logistics cost while some cost elements increase and others reduce



In this example, a DC rationalization policy has been adopted whereby the number of sites in a logistics system has been reduced. Although this has led to an increase in local delivery costs (because vehicles must travel further to deliver products), savings in some of the other main elements of distribution have produced overall cost benefits.

The cost and service trade-offs within any logistics structure will, of course, vary from one company to another depending on the role the company plays within the supply chain as a whole. In the main, however, the following major costs and their associated trade-offs may need to be considered and assessed:

- Production costs: these will vary according to the type of production process or system used and the type of product manufactured. Make-to-stock or make-to-order will also be relevant. Factories may be 'focused' on one or two specific types of product or may make a large range of different products. Different distribution structures may be required to support different types of product. The effect on primary transport costs will be very relevant.
- Packaging costs: these are mainly concerned with the trade-off between the type of packaging and the handling and transport costs, although the influence of packaging costs will become more influential as environmental concerns increase. The type of load unitization will also be important.
- Information systems costs: these cover a wide area from order receipt to management information systems. The type of DC network will affect many of these costs.
- Lost sales costs: these might occur because of inadequate customer service, and are very relevant in the context of the proximity of the DC to the customer, together with the reliability and speed of service.
- Inventory costs: these include the cost of capital tied up in inventory as well as the cost of obsolescence, etc. They have a fundamental relationship with the DC network in terms of the number of stockholding points and the hierarchy of stockholding according to DC type.
- Transport costs: the number and location of sites within the distribution structure, and the associated throughputs significantly affect transport costs. Both primary transport and final delivery costs are affected by DC numbers and location.
- Warehousing costs: these costs vary according to the type of storage and handling systems used, product characteristics and the volume and throughput at the site. The size and type of site will thus be important, as will the location.

# Logistics network planning 10

## Introduction

In this chapter a particular approach to logistics network planning is described and developed. The main content follows on from, and links very closely with, the planning framework that was proposed in Chapter 6 as well as the key flows and cost relationships that were introduced in Chapter 9.

The question of determining the number, size and location of facilities in a company's distribution system is a complex one to answer. There are many different elements that go to make up the distribution mix, and it is necessary to take into account all of these when considering network structure and facilities location. Prior to the DC location decision, a lot of work must be undertaken. This is necessary to help to understand the key requirements of the company and to collect and collate a large amount of data. This enables a numerical picture of the distribution structure to be constructed so that appropriate analysis can be carried out to test potential options for improvement.

Before trying to determine the most appropriate number and location of DCs, it is also necessary to ensure that there is an efficient flow of products from source to final destination. This assessment of the different patterns of product flows is known as 'sourcing analysis'.

The complexity of sourcing and location decisions has led to the development of some quite sophisticated mathematical models that attempt to find the optimum flows and the optimum number of DCs to serve a system. The detailed mathematical principles used as the basis for these models will not be covered here, but consideration will be given to the relationships involved, and the approaches that can be undertaken when making location decisions.

It is important to recognize that the vast majority of location studies are undertaken when a company already has an established logistics network – a number of DCs and their associated delivery areas. Thus, location studies are rarely based upon the premise that the 'best' results can be applied across the board. Generally, it is necessary for a compromise to be reached between what is 'best' and what is currently in existence. The very high cost of DCs and vehicle fleets is the main reason for this – there is a high cost and great disruption involved in making changes to existing structures and systems as well as the likely impact on customer service. Despite this, it is very important for companies to know how their distribution networks might be improved and to move towards this improvement.

Although networks are often planned at the beginning of a company's operation, the majority of existing systems have just evolved, with limited if any planning, based very much on the way that the company has developed over time. This may be a steady growth (or decline), or may be in short steps or large leaps as mergers and takeovers occur. Often these business changes are not adequately reflected in the logistics operation that has developed. Probably the most common reason why logistics networks are out of balance is that of inertia, because of the great amount of work and effort required to make changes.

It needs a forward-looking management or a particularly significant change for a company to undertake a large-scale study of this nature. The understanding of the importance of logistics to most companies, and the need to cut costs and improve efficiency, now often provides sufficient impetus for companies to review their logistics and distribution structure with a particular emphasis on the use and location of DCs and warehouses.

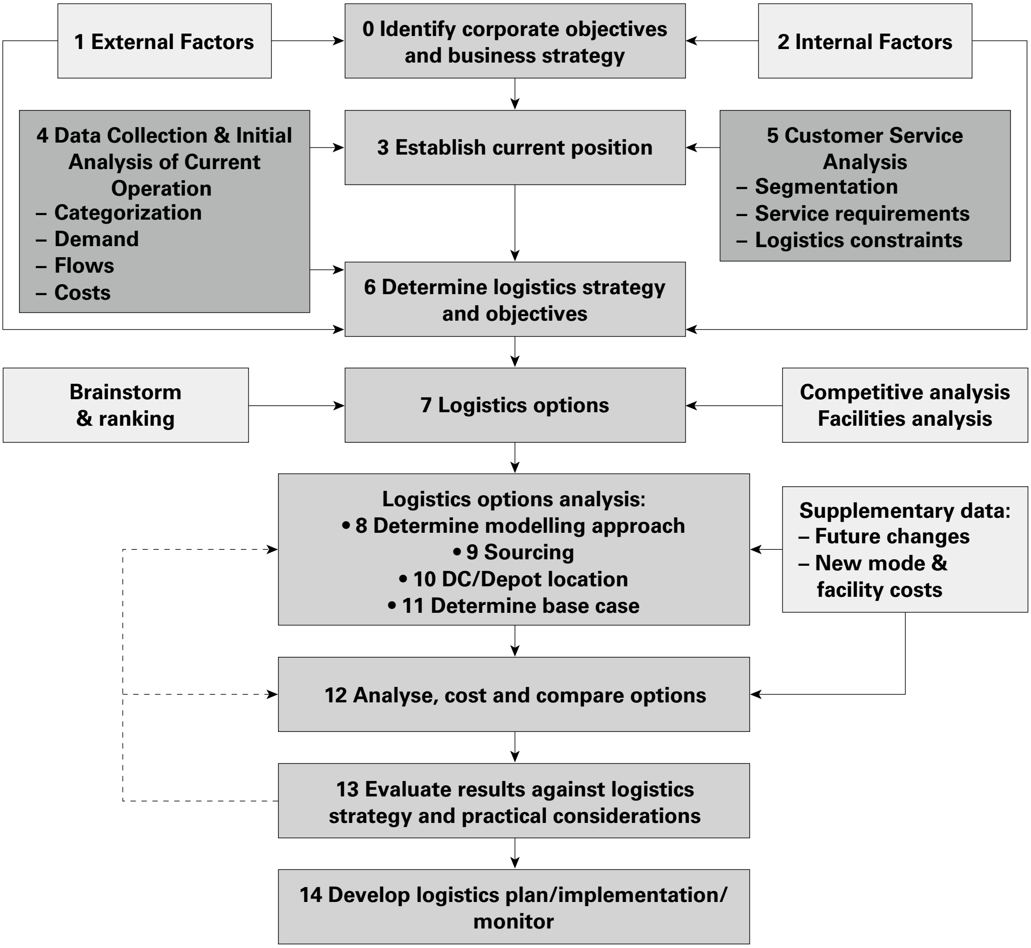
## A planned approach or methodology

An approach to logistics and distribution strategy planning is outlined in Figure 10.1. This approach describes the practical steps that need to be taken to derive a logistics strategy from a corporate business plan, as described in Chapter 6. This type of approach requires the collection, collation and analysis of a great deal of data. It is thus quantitative, although a degree of qualitative assessment may also be necessary.

This type of analysis is a very time-consuming task! Each key step is described in the remainder of this chapter, but a few general points are worth appreciating prior to contemplating such a study:

- Great care should be taken to define the precise overall problem. It is likely to be concerned with the use and location of DCs within a distribution network, but certain elements may or may not be included. For example, are production facilities included in the mix and, if so, must some be retained? Can products be sourced at different production sites? Are there existing DCs that cannot be closed down?
- The planning horizon must be agreed. How far into the future is the strategy to be determined?
- Customer service requirements provide a key input to any logistics network planning study. It is essential to understand what customer service levels need to

**Figure 10.1** An approach to logistics and distribution strategy planning




be achieved because these will have a vital impact on the type of logistics structure that should be developed.

- Both cost and service elements are vital inputs to the logistics planning process.
- All relevant logistics cost relationships need to be identified and understood. This is no small task, but it is crucial to the success of the entire strategic review.
- The relevant product flows for different patterns of demand and supply need to be established. Important aspects will include the identification of different types of product, the origin of these products (factories etc), the destination of products (shops, hospitals, factories, etc) and the amount of each product type going through the system (throughputs etc).

- The identification of all relevant data and information requires consideration. There are always problems in finding and obtaining the data and information required. It may be necessary to make compromises over the data that is available. Data collection is always the largest part of a study. Data should be collected in the format in which it will be finally used in the analysis.
- A sourcing or 'flow' model is likely to be an important link in the process of moving from a corporate to a logistics plan.
- Essential to the development of a suitable logistics plan is the need to carry out some fairly detailed quantitative analysis.
- Additional planning tools and models may also be used as add-ons to this planning process, but they are normally used as a second stage. They include, for example, inventory models (to determine stock levels, mix and location) and vehicle routeing and scheduling models (to determine fleet size and vehicle mix).
- Once a suitable logistics strategy has been identified, it is essential to undertake the dual process of evaluating this strategy against the preferred business strategy and ensuring that due account has been taken of any practical considerations.

The following sections of the chapter involve a discussion of the key steps outlined in Figure 10.1, where the numbers in the text refer to the box numbers in the diagram. Step 0 has already been described in Chapter 6.

## Initial analysis and option definition

### *1. External factors*

Any number of external factors may be relevant in a logistics-based study and they must be factored into any planning or review process. These will, of course, vary according to the industry, the company, the marketplace, etc. Some of the factors that may be relevant will include:

- transport mode availability
- infrastructure changes (e.g. new roads, rail links, etc)
- regulatory changes (transport legislation, customs regulations, etc)
- information technology (EDI, EPOS, etc)
- technology changes (new vehicle design, unit load technology, etc)
- environmental impacts
- industry trends

Examples of these factors were described in Chapter 6.

## 2. Internal factors

The importance of the many internal factors will certainly vary from industry to industry. It is generally possible to categorize these in two ways: first, qualitative or descriptive factors that relate directly to the operation under review; and second, quantitative facts and figures. Both qualitative and quantitative information is used to help 'describe' the business in an operational context. These factors need to be developed in great detail to represent the inputs into the modelling process for costs, product flows and customer service requirements.

## 3. Establish the current 'as-is' position

This major element of the study usually begins with a detailed written description of the current operation but is ultimately aimed at producing a mathematical description of the main existing material and product flows and costs of the logistics operation. The resultant mathematical model of the current operation will be used as the basis against which all alternative solutions are measured later in the study, so data accuracy is crucial. Developing and validating this mathematical model is a very detailed and necessarily time-consuming process but is essential to the study as a whole. Care should be taken when choosing the period of trading being studied. Peak or seasonal times will provide distorted or inflated results. Therefore, a normalized or average period should be chosen for analysis. In addition, the actual service level position needs to be identified.

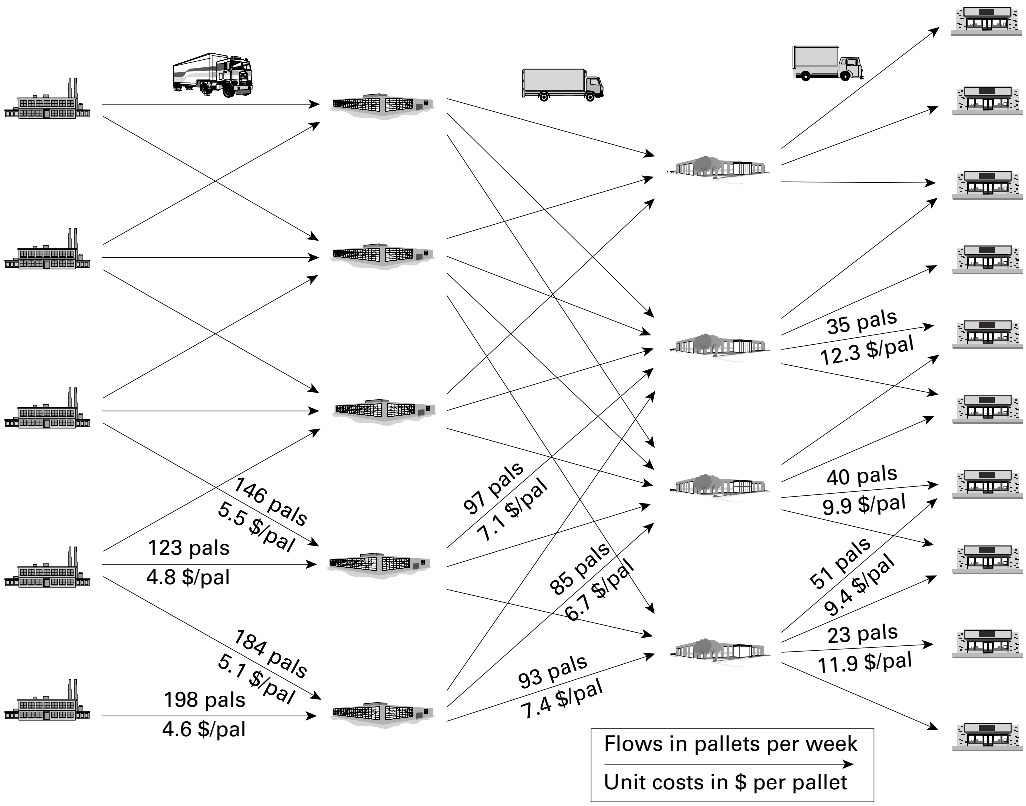
The complicated nature of the data requirements is illustrated in the (relatively simple!) network diagram of Figure 10.2, where examples of some of the typical major flows and costs are given. The network consists of five production points and shows product flow through finished goods warehouses and distribution centres to retail stores. For each pathway (or transport link) there is an associated volume flow and unit cost of which only a few are shown as examples in the diagram. Storage and handling costs and throughputs are not shown.

## 4. Data collection and initial analysis

This section provides a summary of the data that will be used as the basis for determining the current situation and for the subsequent logistics modelling and analysis that will underpin the entire strategy planning process.

Several important decisions concerning data collection should be made very early in the data collection process. These decisions will affect key areas such as the type of data to be collected, the different data categories that need to be determined and suitable time periods. These include:

**Figure 10.2** Logistics network flow diagram, showing some examples of major flows and costs




- *The unit of measure:* this should be suitably representative of the whole logistics operation that is being assessed. This is often not easy to determine, as there may be several different descriptive measures that are used within a company – pallets for bulk stock, cartons for picking and roll-cages for transport. In some industries a common unit is used as a standard – in the brewing industry, for example, the barrel is a universal measure.
- *Product groups:* it is not possible to model each individual product, so products must be categorized into suitable groups that reflect similar logistics characteristics. These might be by sector (cosmetics, personal care, cleaning), by format (powder, liquid, hazardous), or by pack type (box, bottle).
- *Customer classification:* this is necessary so that different service level requirements can be assessed for key customer types. These might be industrial, consumer (retail) and consumer (direct).
- *Time periods:* generally, a financial year is most suitable (and easiest), but data collection time periods will vary if, for example, seasonality needs to be determined (several years are needed for this) or if product life cycles are limited.

Typical examples of descriptive data include:

- product groups
- sourcing locations (own and bought-in products)
- number and types of sites and facilities
- major transport modes used
- handling systems used
- unit load types
- own and third-party operations
- main customer groups
- customer service levels
- logistics information systems

Examples of quantitative data are:

- major product flows
- transport modal split for the major flows
- demand by region, by major product group, by customer type
- market segmentation
- customer service goals and achievement
- carrier analysis
- inventory-holding profile
- product profile
- customer profile
- expected growth rates
- planned future expansion requirement

As well as preparing numerical tables of data, it is also a good idea to make visual representations. This can be essential in helping to understand the implications of the data in terms of the demand for different product groups in different geographical areas and the subsequent recommendations for DC location. There are many software packages that provide this functionality. Figure 10.3 is an example of such visual representation.

It is advisable to collect initial data in the format that can be used for the subsequent logistics strategy modelling exercise. This will apply to the following key variables and key data requirements:

**Figure 10.3** Map showing a representation of the demand for different product groups in different geographic areas



Manufacturer of laundry, household cleaning and personal care products

- *Variables:*
  - location and capacity of each plant, DC and trans-shipment depot
  - cost functions for storage, primary transport and local delivery
  - demand locations and amounts
- *Data:*
  - current and future customer location and demand
  - DC throughput
  - primary transport costs (fixed and variable)
  - local delivery costs (fixed and variable)
  - inventory-holding costs

Quantitative data may not always be readily available, so descriptive information or alternative data may have to suffice. For example, it may be recognized that customers can be broadly profiled in terms of, say, national accounts, key accounts, dealers, distributors and specialist users. It may not be possible to make precise quantitative comparisons in terms of tonnage distributed per annum to each grouping, but some type of value analysis may be available.

The quantitative data derived is crucial to the analytical process carried out and thus to the final conclusions and recommendations made. Although collection is extremely time-consuming, it is important that data is correct and that it does adequately reflect the real flows and costs within the business.

## 5. Customer service analysis

As indicated previously in this chapter, customer service requirements provide a key input to any logistics network planning study. Appropriate customer service levels that need to be achieved must be identified. These are essential ingredients to help determine the type of logistics structure that should be developed. As discussed in Chapter 2 (see Figure 2.7), there is a vast difference between offering a low-cost (high-productivity) solution compared to a high-cost (value-added) solution, and the ideal logistics structure will vary accordingly. A logistics network is likely to serve several different markets and needs to be designed accordingly in order to satisfy all of the different customer service requirements. A detailed approach to determining customer service requirements is given in Chapter 3.

## 6. and 7. Determine logistics objectives and options

An assessment of corporate objectives and business strategy (as discussed in Chapter 6) together with the most relevant external and internal factors should allow for clear logistics objectives to be determined. From these, and from the analysis of the current situation, customer service requirements, competitive analysis and facilities analysis it should be possible to generate a long list of alternative options that would be worth considering for modelling and assessment. For any strategic review, it is also important to enable any innovative alternatives to be considered within the planning process. These can often be identified through the use of techniques such as lateral thinking and brainstorming sessions.

With approaches such as these, it is usually possible to develop a long list of options (some of which may, initially, appear to be less than ideal) and then by fairly simple assessment determine which of them, or which combination, may be feasible in the context of the planning horizon. A shortlist of alternatives can then be drawn up for quantitative evaluation in the modelling process.

# Logistics modelling: logistics options analysis

## *8. Determine modelling approach*

Many modelling techniques used in logistics concentrate on the detailed representation of specific parts of the logistics operation, e.g. production optimization, DC location and vehicle routeing. These methods, however, have the potential risk of optimizing only part of a logistics operation when greater economies or benefits could come from changes to other parts of the operation or from a complete restructuring of the operation.

The problem with such multifaceted optimization is that suitable techniques do not exist to consider simultaneously all the possible alternatives. The combinatorial problem of considering all products, made at all sites, shipped via all modes, to all customers, via all DCs, is simply prohibitive. If the techniques did exist, solutions would require uneconomic run times on large computers. The development of what is known as 'Big Data' and its analysis may offer exciting new options in the near future (see Chapter 40).

A similar situation occurs in the specialist area of production planning known as MRPII (see Chapter 13) and here, the technique of rough-cut capacity planning was introduced. Instead of trying to produce initial plans at a most detailed level, a rough-cut plan considers the overall requirement for key resources.

This type of approach can be adopted for logistics planning and can be described as trying to establish the 'economic footprint', roughly the physical boundary that the facility can serve. The economies of scale of production, the customer service requirement and the logistics cost are all considered to give an optimum factory size and radius of operation, hence the economic footprint. A brewery with canning lines has large economies of scale and a product with sufficient shelf life to give a medium to large economic footprint. A bakery has much lower economies of scale and a product with a short product life and thus has a smaller footprint.

A means of 'rough-cut modelling' for the whole of a logistics operation is to use sourcing models. Costs of raw materials, production rates and capacities, together with approximate logistic costs across a geographical area, are used to calculate the trade-off between the major elements.

## *9. Sourcing models*

With multiple products from multiple sources, it is only too easy to assume that the lowest-cost solution is to source each market from the closest available plant with available capacity. In some situations this is true, but if plants have significant changeover (set-up) times for certain product types, it *may* be more cost-effective for these to have long production runs, high inventory and high transport costs. Thus, the first step in rationalizing a logistics system is to investigate optimal sourcing patterns. One definitive pattern may not be sufficient, as sourcing could change according to market conditions, product price, raw material costs and transport costs.

Linear programming is a mathematical technique that finds the minimum cost or maximum revenue solution to a product sourcing problem. All available sources are described with capacities, changeover penalties and raw material costs. Approximate logistics costs from sources to markets are defined as linear cost functions. Under any given demand scenario, the technique is able to identify the optimum solution for the sourcing of products. Most spreadsheet packages have an optimization feature that allows this type of analysis to be undertaken. A typical sourcing model equation operates under the following constraints:

- that each plant has a measurable availability for different production and changeovers
- that customer demand should be met
- that the least-cost solution is required

The objective of a typical sourcing model equation is to minimize the following, given the run rate of each product at each plant:

- raw material cost
- materials handling cost
- production variable cost
- logistics cost from plant to customer

## 10. Distribution centre location modelling

The output from a sourcing study is the optimized major product flows from source points to final customer. The next stage is to take these flows and to develop the most cost-effective logistics solution in terms of the most appropriate number, type and location of DCs, transport mode, etc. Thus, the overall trade-offs of the supply chain are considered and assessed during the sourcing study, and a preliminary sourcing allocation is made. The detailed logistics of modes, rates and site structure can then be considered using a DC location study.

Cost trade-off analysis (see Chapter 9) can be used as the basis for the planning and reassessing of logistics and distribution systems. Clearly, this approach is a time-consuming and often daunting task, not least because of the difficulty in obtaining the appropriate data and information from within a company's accounting system, but also because of the somewhat complicated models that have to be used. Several different approaches can be used for this:

- *Mathematical programming* uses a number of well-known mathematical techniques (such as linear programming) that are particularly applicable to solving the DC location type of problem. They are prescriptive, using a logical step-by-step procedure to reach the optimal or 'best' solution. The main drawbacks with these techniques are that linear relationships are not always adequate (if linear programming is used) and some solutions can be 'local' optimums, that is, they are not the best from the overall point of view.
- *Heuristics* is a Greek-based word, used to describe the method of solution that is derived on a 'rule-of-thumb' principle. Heuristic methods are determined by using experience and common sense to reject unlikely solutions from the outset. In this way, problems can be reduced to a more manageable size in terms of the number of alternatives that need to be tested. This type of approach is often valid for DC location problems, because there are likely to be a number of potential DC locations that are totally inappropriate.
- *Simulation* is a widely used operational research technique, which is capable of representing complex problems and cost relationships. It is not an optimizing technique, so does not produce the 'best' answer, but it is descriptive of the different relationships and is used to evaluate any alternatives. The inability to produce optimal solutions has previously been seen as a drawback, but in fact a carefully derived simulation model, used with the practical expertise of a logistics specialist, is likely to result in realistic and acceptable solutions that can be readily implemented. Simulation models allow for various 'what if' questions to be asked to test alternative strategies.
- Certain *practical approaches* can also be used – particularly to help simplify the analytical approach. The most straightforward is map-based, whereby the

network is represented spatially on a map. Clustering techniques are used to reduce the complexity of the problem: that is, all customers in close geographic proximity are clustered together. This approach is relatively quick, if a little simplistic, and is made much easier because it is very visual, allowing for alternative configurations to be identified. The next level of sophistication is to use a spreadsheet-based approach. This allows for a much better level of analysis, enabling the quantification of the problem and potential solutions in fairly quick time. Spreadsheets can also be used to provide maps of the output.

The most common approach to determining DC location solutions is to use a logistics strategy simulation or optimization model. A variety of software programs has been developed. The common technique is to simulate the cost of operation for a particular configuration. As indicated, these methods are essentially 'what if' simulations that will always give best results in the hands of an experienced user. Recent innovations have included the use of high-resolution colour graphics to give a detailed representation of the geography and logistics involved.

## 11. Determine base case

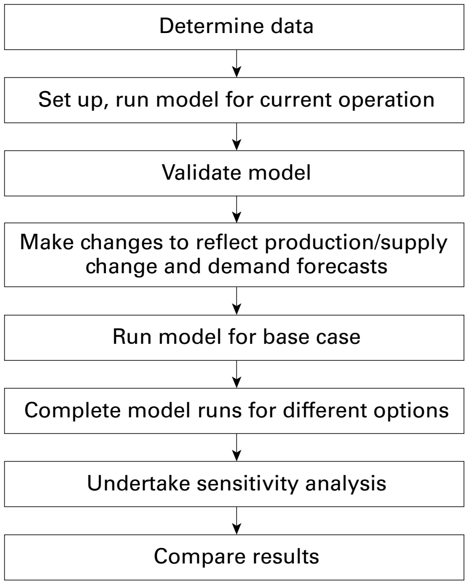
The main steps necessary for DC location modelling are outlined in Figure 10.4. An essential stage of logistics simulation is model validation. This involves the configuration and calibration of the model so that the current situation is accurately reflected in the baseline model that has been developed. The validation exercise involves taking a known situation and reproducing flows and customer service to test whether the costs are predicted with reasonable accuracy. It is essential to ensure that the model or method of analysis is truly representative of the system being investigated. Thus, there is a constant requirement during this part of the modelling process to check and test the appropriateness of the model and the results produced. When agreement has been achieved or variances have been understood, then a variety of alternative options can be tested against this 'base case'.

## 12. Analyse, cost and compare options

At this stage of the planning process, it becomes possible to start to test the key options that have been identified as feasible solutions. It should be noted that often the simulation of a future scenario will involve the synthesis of new databases of customer location and demand. This may require new costs and performance data to be identified – much of which may be outside the experience and data records of the company and so will necessitate supplementary data collection and evaluation.

Models will typically produce a great deal of cost and performance data as their output. It is also important to check the impacts on customer service with these option changes as this is key and may not be as clearly measured as some of the cost

**Figure 10.4** Logistics modelling: the main steps for a DC location study




implications. It is also important to be aware of the need to 'future-proof' the results by testing a range of options that test various growth implications to ensure that the 'new' logistics structure is able to cope with a varying degree of future growth scenarios. This may be with respect to elements such as different demand increases, customer location changes, cost variability and business strategy developments (such as more home delivery, new product developments, different sourcing implications).

An additional stage in the modelling process when sourcing models have been used is to rerun the allocation with the logistics costs that have been modified in the logistics simulation. This should not lead to major changes if the original cost estimates are realistic and robust solutions are obtained.

# Evaluate results, develop implementation plan

## *13. Evaluate results against logistics and business strategy*

Having modelled the logistics options and selected one or more that perform well when measured against service and cost, the impact of these on the total business strategy must be assessed. Three main areas where this will impact are:

1 *Capital costs:* if increased factory storage, new DCs, new equipment or new vehicles are required, then capital or leasing arrangements will be needed. In certain situations, capital constraints can exclude otherwise attractive options.

In other cases, an excessive increase in working capital (e.g. stockholding) may exclude an option.

2. *Operating costs:* the minimum operating cost is frequently the main criterion for selection between options. In some situations, increased operating costs can be accepted in the light of future flexibility.
3. *Customer service:* although options should have been developed based on customer service targets, the selected shortlist must be examined for the customer service level achieved. The balance of the mix might have changed in an effort to reduce costs. Stock held close to the customer might need to be increased to improve service reliability.

One means of matching logistics strategy to business strategy is to undertake some associated qualitative analysis. There are several reasons for doing this but the key ones are, first, to support the quantitative analysis and, second, to use qualitative analysis in place of quantitative analysis where it is impossible to derive good quantitative measures. A series of key assessment criteria can be developed and used to help in the comparison of the different strategic options identified. These can then be weighted according to their importance in the decision-making process, and scored according to how each particular option is thought to perform. As well as the more obvious cost indicators, there are other criteria that may also be important. Table 10.1 gives a partial example of this, showing the qualitative measures for 'service/marketing' (representing 25 per cent of the total assessment factors) and 'other' factors (25 per cent). The remaining 50 per cent (not shown) would be represented by cost factors.

Methods for the planning of the next level of distribution elements such as warehouse configuration, stock location and levels, vehicle fleet size and mix, and vehicle routeing and scheduling are covered in the appropriate chapters elsewhere in this book.

## 14. Implementation

When an appropriate option has been finally agreed and the remaining distribution requirements have been determined, then the process of implementation can start. This should follow the standard business practices used for any major project implementation plan. In addition, suitable cost and performance monitoring processes should be set up and used (see Chapter 38).

**Table 10.1** Example of part of a qualitative assessment used for a European study

| | Weighting % | Score 1 to 5 | Total |
|---|---|---|---|
| Service/marketing | 25% | | |
| Service – reliability | 8% | 4 | 32% |
| Service – response/speed | 4% | 4 | 16% |
| Complete order delivery | 1% | 5 | 5% |
| Market presence (ie stockholding) | 1% | 1 | 1% |
| Product quality | 3% | 3 | 9% |
| Company image | 4% | 1 | 4% |
| Flexibility of service | 4% | 1 | 4% |
| Total | 25% | | 71% |
| | | | |
| Others | 25% | | |
| Flexibility (for subsequent change) | 3% | 5 | 15% |
| Ease of management/control | 4% | 2 | 8% |
| Change from current – physical | 1% | 1 | 1% |
| Change from current – personnel | 1% | 2 | 2% |
| Risk (financial) | 4% | 4 | 16% |
| Risk (customer service) | 4% | 3 | 12% |
| Risk (loss of business) | 5% | 5 | 25% |
| Management of change | 3% | 4 | 12% |
| Total | 25% | | 91% |
| Overall total | | | 162% |

| | |
|---|---|
| Positive impact | 5 |
| No impact/no change | 3 |
| Large negative impact | 1 |

# Logistics management and organization

11

## Introduction

In this chapter, consideration is given to the way in which logistics and distribution are organized within a business. The importance of the integration of the logistics function into the business as a whole has been emphasized at various times throughout this book. There is a need for the organizational structure to reflect a similar form of integration. Thus, logistics organizational issues and human resource or 'people' aspects are addressed in this chapter.

There are several factors covered, the first being a brief summary of those aspects that concern the relationship of logistics and distribution with other corporate functions, introduced earlier in Chapter 2. Allied to this, a number of different organizational structures are discussed. These include traditional structures as well as those that provide more emphasis on logistics and those that allow for a process-oriented, cross-functional integrated approach to the organization.

The role of the logistics and distribution manager is considered – both with respect to his or her position within the company and also with respect to key functional responsibilities. A more 'grass-roots' view of logistics is taken, with a discussion on the payment systems used within the distribution and logistics environment.

## Logistics relationships with other corporate functions

In Chapters 1 and 2, logistics and the supply chain were considered in the context of business and the economy as a whole. In particular, the interfaces with other corporate functions were discussed, the major ones being with production, marketing and finance. There are many occasions when the importance of these corporate relationships has been emphasized, not least because of the move to a cross-functional, process-oriented view of the supply chain. This importance is particularly valid where the planning of corporate strategy is concerned. The need to adopt such a view was discussed in Chapter 6.

There are two key points that bear re-emphasis at this stage. First is the fact that logistics is, for many companies, already an integral part of the corporate being. Because of this, the second major point becomes apparent – the need for logistics planning and strategy to be recognized and used as a vital ingredient in the corporate plan.

The first point – that logistics is such an important element within a company's total business structure – can be illustrated using the interrelationships of logistics with other functions:

- with production: production scheduling, production sequencing, production control, plant warehouse design, raw material stocks
- with marketing: customer service, packaging, distribution centre location, inventory levels, order processing
- with finance: stockholding, stock control, equipment financing, distribution cost control, personnel costs

The need to include the planning of logistics and distribution in the overall corporate plan is thus self-evident. The business planning process was previously shown in Chapter 6, Figure 6.2. Even within this strategic framework it can be seen that distribution and logistics factors should provide a vital input. Within the strategic planning process, such elements as market analysis and policy determination cannot be derived without an understanding of customer service requirements and channel choice alternatives. With any policy assessment exercise and in any subsequent determination of competitive strategy, knowledge of key logistics elements is essential. Any factors related to the procurement, storage and movement of goods must, of necessity, be relevant to the determination of a company's business plan.

The reason that companies may fail to allow sufficient logistics input into the corporate planning process is probably due to the dynamic nature of the logistics environment and operation. Logistics is seen to be very much about doing and providing. As such, it can be viewed and treated as a short-term factor, with little direct relevance to long-term planning. Logistics is a function with both long- and short-term horizons. Its very dynamism tends to mould the one into the other, making it difficult at the operational level to distinguish between the two. In addition, the consequence of inappropriate planning is often seen as a short-term operational problem. In effect, the size and extent of financial and physical investment makes it imperative that the differentiation between the long and the short term is made and that, where necessary, the relevant elements of distribution and logistics are included in the overall business plan.

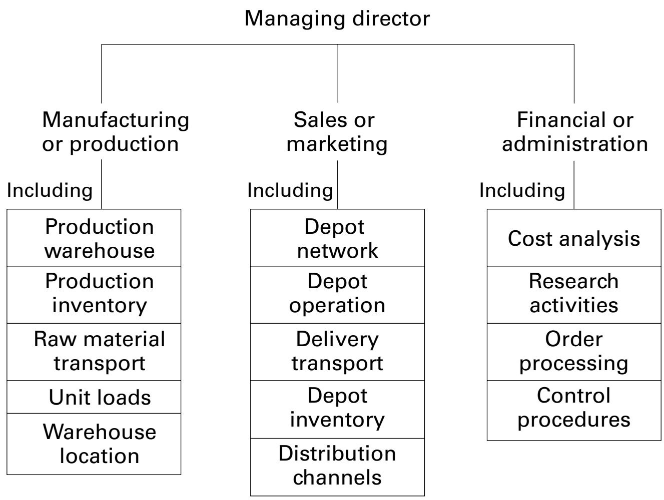
## Logistics organizational structures

Associated with the danger of not including relevant logistics factors within the corporate business plan is the need to recognize that the logistics function may also require a specific organizational structure. Logistics is sometimes not seen as a discrete function within the organizational structure of a company. Although distribution and logistics is generally recognized as an important element of many companies' operations, a number still fail to adapt their basic organizational structures to reflect this changing view.

Various different physical distribution functions may be allocated among several associated company functions. This failure to represent distribution and logistics positively within the organizational structure is often a result of historical arrangement rather than a specific desire to ignore the requirement for a positive logistics management structure. Clearly, some positive organizational structure is essential if the logistics function is to be planned and operated effectively.

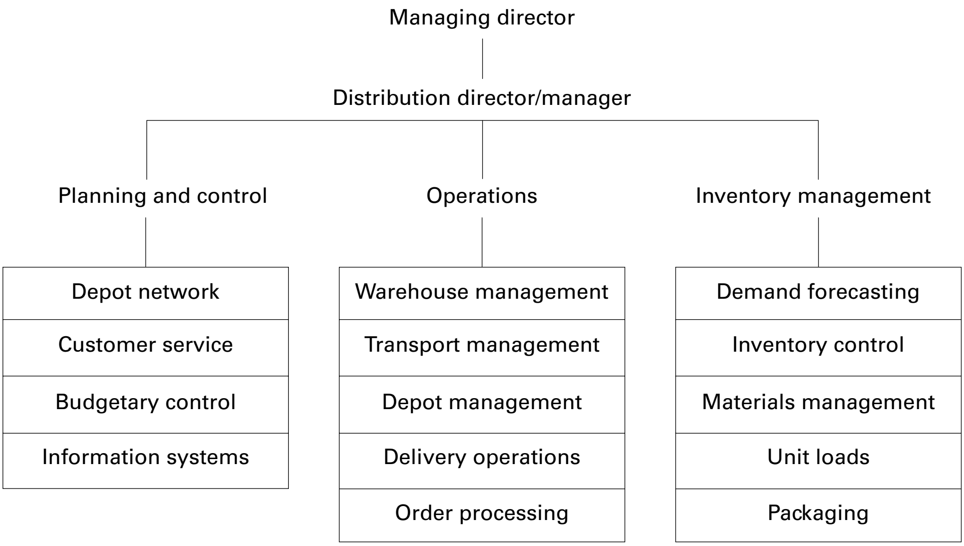
A typical traditional structure, showing key logistics and physical distribution elements spread among different corporate functions is illustrated in Figure 11.1. The problem with this type of organizational structure is that lines of communication are unclear from the logistics standpoint. Thus, it is often impossible to optimize the efficiency of the different logistics sub-functions, let alone create an overall logistics system that is both effective and efficient.

**Figure 11.1** A traditional organizational structure showing the positioning of key logistics functions




Most of the more forward-looking logistics-aware companies have seen the need for some form of organizational structure to reflect the recognition now being given to the importance of distribution and logistics activity. This new functional approach emphasizes the need for logistics to be planned, operated and controlled as one overall activity. The precise structure will obviously differ from one company to another. A typical structure might be as illustrated in Figure 11.2. This type of structure allows logistics to be managed as a function in its own right, although the need for close liaison with other company functions remains vital.

**Figure 11.2** A functional organizational structure showing logistics activities linked together



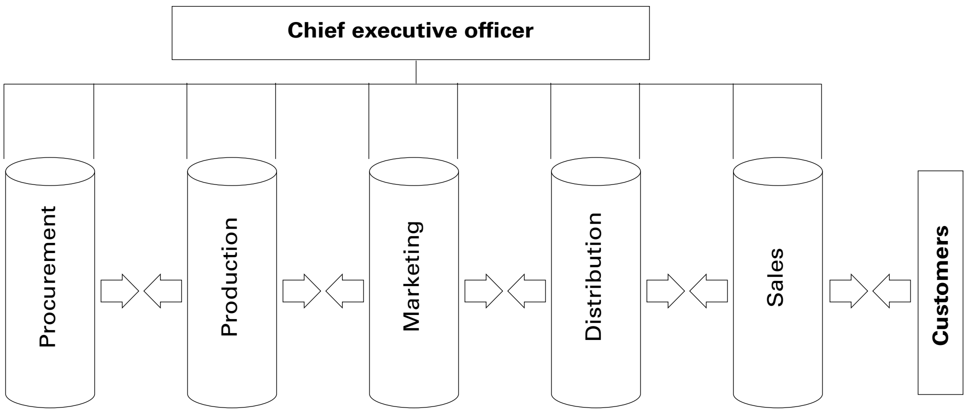

## Organizational integration

One important factor that has evolved with the move towards supply chain integration is the recognition of the need to rethink the way in which logistics operations are organized. This has led to a change in thinking in organizational terms away from functional structures and towards process-oriented structures. This is in many ways a reflection of the key changes that have been outlined in previous chapters:

- the emphasis on the customer, and the need to ensure that internal processes support the requirement to achieve customer satisfaction
- the concentration on time compression throughout the whole supply chain, and the need to identify and manage suitable trade-offs
- the move to globalization and the requirement to plan and manage the logistics network as a complete system

Traditional organizational structures do not really lend themselves to this way of thinking. They are essentially functional and inwardly focused, with their director reporting to a chief executive officer (see Figure 11.3). Each activity operates as a self-contained silo where there is a tendency for their functional boundaries to create barriers to integration – with the power barons at the head of each function perhaps fighting to protect their own power base, rather than pursuing overall company objectives.

**Figure 11.3** A traditional silo-based functional organizational structure

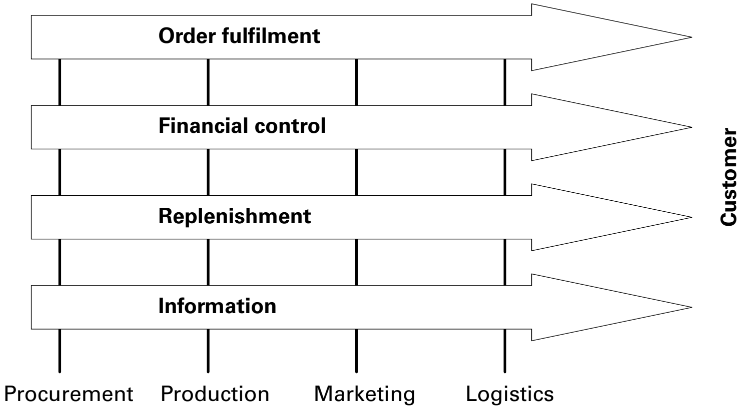



Thus, there has been a move away from these silo-based functional structures towards more process-oriented organizations. These are based on key business processes, such as those described in Chapter 7. They attempt to reflect the need to support, in particular, the customer-focused approach that many companies are trying to achieve. These new structures try to increase the visibility of market demand and enable an integrated supply chain response. An example of such an approach is shown in Figure 11.4.

This type of structure is known as mission management and is based on the concept of the management of systems or flows. This is undoubtedly relevant to logistics and distribution, which are concerned with material and monetary flows as well as the associated information flows often from raw material through various processes, storage and movement to the final customer.

Clearly the potential problems of mission management lie in the difficulty of managing and coordinating across functional boundaries. However, where good management practices are followed, and in the appropriate operational context, organizational structures such as these can work very effectively. They are particularly relevant for customer-service-oriented businesses. Some of the larger chemical companies, for example, adopt this type of management structure to provide coordination and control throughout the supply process of particular products.

**Figure 11.4** A customer-facing, process-driven organizational structure




Mission management is cross-functional, and as such can pose problems in a traditionally functional organization. For many companies, this type of mission management structure has not been an easy alternative, with traditional managers loath to make such a dramatic change to an approach that they have been familiar with for many years. Because of this, a further development, matrix management, has evolved. Here, the product or flow is planned and managed by a 'flow' or logistics manager, while the traditional functions provide the necessary inputs as they are required.

For some companies, a mixed or matrix approach seems to have been the most successful. This accepts that there is a need, at the planning level, to reorganize on a process basis, which crosses traditional boundaries, but recognizes that it is important to retain specialists at an operational level to ensure the efficient running of operational functions such as transport and warehousing. The different emphasis in these two approaches is demonstrated by comparing Figures 11.5 and 11.6.

As well as changes to process-oriented management structures, there have been broader supply chain initiatives, in particular the need to rethink buyer–supplier relationships. A major aim is to move away from the traditional, somewhat combative arrangements that have occurred with buyer/seller price-led relationships towards the building of stronger and more positive partnerships that reflect the need for companies, within a supply chain, to work together to achieve commercial success. This involves the development of a structure where the link is not merely between the sales team on the one hand and the buying team on the other. The new structures are designed to promote coordination and cooperation with other relevant groups across company boundaries. This might include research and development, marketing, distribution and any other functions that, with a suitable link, can benefit from such a partnership approach. Figure 11.7 demonstrates the change in approach from a traditional single point ('bow-tie') to a coordinated multiple approach ('diamond').

**Figure 11.5** Mission management, which acts directly across traditional functional boundaries

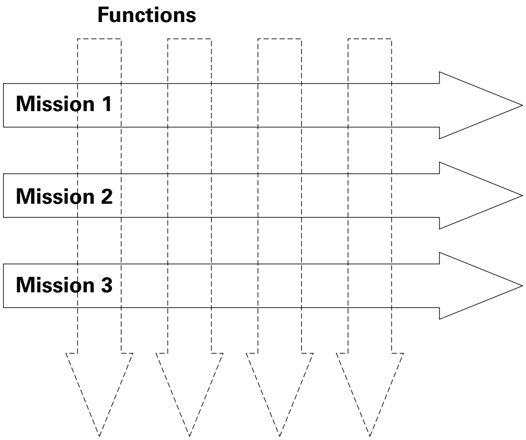
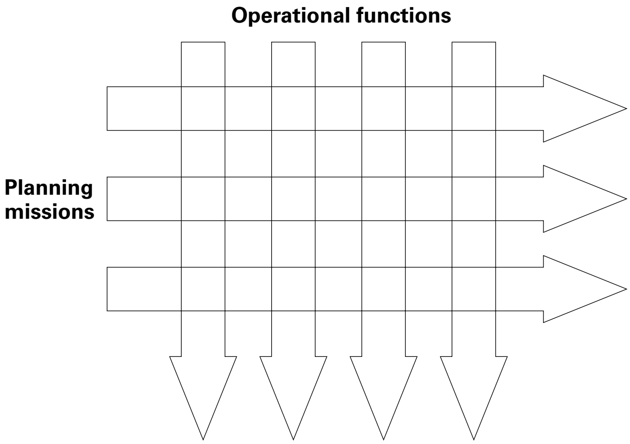


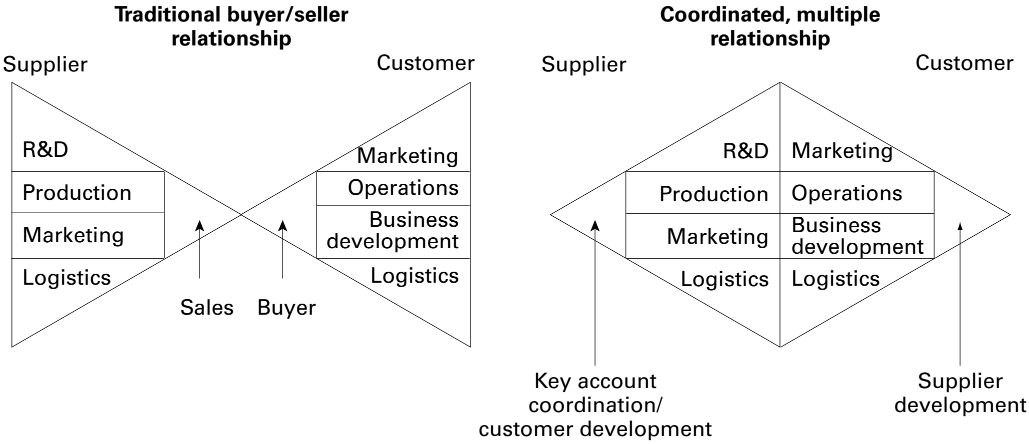

**Figure 11.6** Matrix management, which emphasizes both planning and operational elements




# The role of the logistics or distribution manager

The role of the logistics or distribution manager can vary considerably from one company to another, dependent on the internal organizational structure, the channel type (own account, third party, etc), the industry or product, and the customer profile. Factors such as these will certainly affect the extent of the operational role and

**Figure 11.7** Buyer/seller relationships: a single versus a multiple linked approach




**SOURCE** Christopher and Peck, 2003

the nature of the planning role. It is useful here to consider the part that the logistics or distribution manager can play in both the planning and the operational processes.

With respect to the *planning process*, in an earlier section of this chapter, the need for companies to include the planning of logistics and distribution in the overall corporate strategy was emphasized. It is possible to identify several key factors in which the logistics manager can contribute to and benefit from an involvement in the planning process. These include:

- providing a positive input into corporate strategic planning
- gaining a better understanding of the company and its business
- the potential for improving the effectiveness of the logistics operation the company is providing

These factors include both the physical and the information systems and requirements of the operation.

More detailed points for each of these three elements include:

1 *Providing an input into corporate strategic planning*:
  - a an understanding of the functional interfaces
  - b full involvement with distribution's activities
  - c familiarity with the external environment as it relates to distribution
  - d insights regarding competitor distribution strategies
  - e familiarity with customer distribution needs
  - f knowledge of channels of distribution
  - g distribution data

2 *A better understanding of the company and its business*:
   a appreciating the company and its strategic goals
   b a clearer knowledge of other functional activities
   c clarification of the impact of corporate strategy on distribution activities
   d increased sensitivity to the distribution environment
   e a greater awareness and appreciation of integrated information systems
3 *Improving the effectiveness of the logistics operation*:
   a developing a broader perspective of distribution
   b increased delivery responsiveness
   c improving rapport/liaison with others
   d identifying distribution opportunities
   e recognizing customer needs
   f improving communication between functions

Logistics-related planning activities are a vital input in the overall business strategy. The more specific elements were outlined in the early chapters of this book. They involve a medium- to long-term planning horizon and will include aspects such as the number of facilities, their size and location, transport networks, fleet size and mix of vehicles, stock levels, information systems, etc.

As already indicated, the *operational role* for managers can vary significantly according to the size and nature of the business, the product, the channel type and the customer profile, among other factors. Also, there are a number of different job titles and job functions that exist. These range from the distribution or logistics manager, who might have overall responsibility for an entire distribution network, including central distribution centres, regional distribution centres, primary transport (line-haul) and delivery vehicles, stock location and control, computer systems, etc, to a shift manager or supervisor who might, for example, be concerned with the detailed performance and control of an order-picking operation on a night shift.

Traditionally, the three main operational areas of responsibility are related to:

1 *transport:* primary transport (line-haul), delivery operations, vehicle routeing and scheduling, vehicle procurement, etc
2 *warehousing:* goods inward, bulk storage, order picking, marshalling, materials handling equipment, etc
3 *information:* stock location, stock control, order processing, budgeting, monitoring and control, etc

For many logistics managers, these areas may be expanded to cover other aspects such as procurement, inbound logistics, inventory levels, forecasting, telesales, production planning, reverse logistics, packaging, etc. In addition to these broad functional areas, there is a staff role concerning the management of human resources, union negotiation, health and safety, and the linkage to other corporate interfaces such as production, supply, marketing, sales and finance. Over and above all of these aspects of the operational role, and probably common to all types of distribution organizations, is the responsibility for, and the need to control, the balance between the service to the customer and the cost of providing this service.

Some logistics managers may have an even broader remit that covers key elements of *supply chain planning*. These might be summarized as:

- to lead the design, creation, configuration and parameter setting of the entire supply chain
- to create the framework and the dialogue that determine the performance targets along the whole chain
- to drive the systems and monitor and report the entire logistics operational performance against agreed targets
- to review how problems can be solved and performance improved

## Payment systems

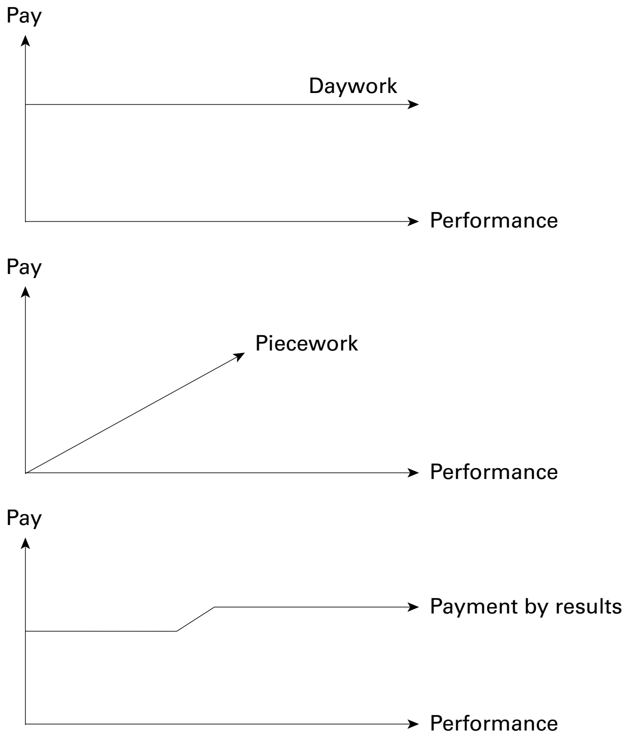
One relatively neglected area in the literature on logistics and distribution concerns the various payment mechanisms and incentive schemes that are used within the industry. Having looked at the broad roles and responsibilities of the distribution or logistics manager, it is interesting to gain a better understanding of the grass-roots position related to the type of payment systems that are commonly in use.

There are a number of different types of payment system. These can be broadly divided into the three main systems of daywork, piecework and payment by results. These are illustrated in Figure 11.8. Daywork is a method of payment based entirely on the hours attended at work; piecework is payment entirely related to the amount of work undertaken; and payment by results is a mixture of these, providing a basic wage plus a bonus based on work undertaken.

There are a number of variations of these systems:

- *Daywork* (also known as graded hours, fixed day, etc): this is based entirely on the hours worked.
- *Measured daywork*: this consists of a basic attendance wage plus a bonus for achieving a given level of work performance.
- *Stepped measured daywork* (stabilized incentive scheme, premium payment plan): this introduces ‘steps’ in the measured daywork scheme, so providing additional incentive.

**Figure 11.8** The main types of payment system, showing the relationship between performance and pay




- *Merit-rated bonus scheme* (incentive bonus scheme): this is a bonus scheme on top of a basic wage, but it is not productivity-related. It might be related to attendance, achievement of performance targets, etc.
- *Piecework:* payment is entirely based on the amount of work completed.
- *Payment by results*: in its purest form this is piecework, but usually it is a results-based payment on top of a basic wage.
- *Commission:* this is a piecework or payment-by-results scheme, but is based on effort and achievement (e.g. sales, cost savings); this is a common type of management bonus scheme.
- *Group* or *plant-wide schemes*: these are collective bonus schemes based on collective performance, which could be related to costs versus sales, increased output or improved efficiency.
- *Fringe benefits*: these are various non-performance-related add-ons covering such items as Christmas bonus, subsidized canteen, clothing allowance, etc; eventually, these types of benefit can become taken for granted.

- *Profit-sharing scheme*: this is related to the company profit, and is aimed at fostering employee interest in the company.
- *Share schemes*: these are usually limited to managers and directors, though there are some notable company-wide share schemes.
- *Team working*: these are rewards for small groups, usually used for management teams.
- *Annualized hours*: these are formalized systems that treat working time on the basis of a number of hours per year rather than hours per week; they have become recognized as useful schemes where there is a distinct seasonal or peak nature to the work and thus are matched to the needs of the business to meet customer requirements and are popular in warehouse operations.

For motivational financial schemes it is important to distinguish between schemes that provide an incentive, reward or bonus, because they can have a varying impact on workforces. The main differences are:

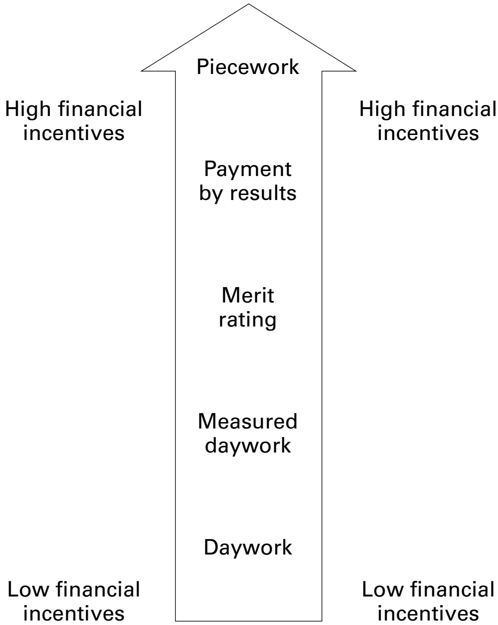
- Incentives: these stimulate better performance in the future because they are payments for the achievement of previously set and agreed targets. Incentives tend to have the most direct impact on employee behaviour and motivation because the conditions of payment are known in advance.
- Rewards: these recognize good performance in the past. They are likely to have a less direct impact on behaviour and motivation due to the level of uncertainty of the amount of the payout.
- Bonuses: these are rewards linked to performance but paid out in a lump sum.

Clearly, the applicability of these methods of payment varies considerably from one type of distribution operation to another, and from one type of distribution job to another. Productivity-related incentive schemes are only valid in operations that will benefit from schemes of this nature, i.e. where increased worker effort will mean an increase in output. For many distribution operations, the need for accurate, timely order picking may far outweigh the number of picks made per picker per hour. Additionally, it is likely to be both dangerous and illegal to propose a driver incentive scheme that gives additional payment for the speed with which the work is completed!

It is interesting to consider two particular aspects related to payment schemes, and to show how these vary according to the type of scheme operated.

The first is the relationship between different schemes and *financial incentives*. This is illustrated in Figure 11.9, which demonstrates how piecework, for example, at one end of the payment scheme spectrum, requires high financial incentives to operate effectively. The other extreme, daywork, can operate with low financial incentives.

**Figure 11.9** Hierarchy of payment schemes in relation to financial incentives




In contrast, Figure 11.10 shows the extent of *supervision* required for the different payment schemes. Here it is daywork that requires the most amount of supervision and piecework the least.

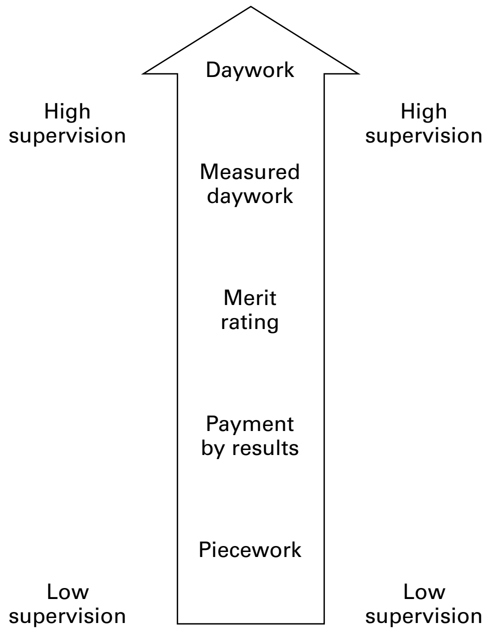
It can be seen from the two figures that one is the direct converse of the other. This demonstrates that, in general, high levels of supervision are required to support payment schemes that offer low financial incentives. Conversely, in general, payment schemes with high financial incentives require the least amount of supervision.

The relevance of these different schemes for distribution is best summarized according to the main breakdown of distribution personnel – drivers and warehouse staff.

Drivers are most likely to be paid on hours worked or hours guaranteed – some form of daywork. There may also be a special rate for the job, based on work experience or driving qualifications. In terms of incentive, a form of 'job and finish' might be operated, giving extra leisure rather than extra cash as the incentive. Financial bonuses might be offered as a form of payment by results based on such things as miles/kilometres run, cases delivered, etc. Once again it must be emphasized that any bonus payments are prohibited if they endanger road safety.

Warehouse staff are also likely to receive remuneration based on hours worked or guaranteed. In the more controlled environment of a warehouse, daywork is likely to be measured. Additionally, there are likely to be different rates according to different job functions (fork-lift truck drivers, pickers, etc). Merit-rated bonuses

**Figure 11.10** The extent of supervision required for different payment schemes




based perhaps on attendance might be offered, and certainly productivity-related bonuses are likely to be very common, based on cases picked, pallets moved, etc. Measured performance schemes are operated based on work study standards for specific tasks. In addition, as already indicated, many companies are now introducing annualized hours because it can lead to a much more efficient use of the labour force.

# Omnichannel fulfilment 12

## Introduction

With the mix of store and internet shopping continually evolving the subject of omnichannel fulfilment provides logistics managers with a considerable challenge. In this chapter, the main issues posed by omnichannel fulfilment are explored, together with alternative supply chain structures both for food and non-food retailing. Finally, an approach to implementation is examined.

Most large retailers sell their products through a mix of different distribution channels, particularly via 'bricks-and-mortar' stores and over the web. The latter is often referred to as 'e-commerce' and may be accessed by personal computers or by mobile phones/tablets (known as 'm-commerce'). When buying goods, consumers may interact with retailers through these and other communication channels:

- *initial awareness of the product*: television, magazines, internet advertising, store displays
- *information about the product*: website, telephone, email, mobile 'apps', store salesperson
- *purchase of the product*: via website, by telephone, by mail, at store
- *delivery*: home delivery, collection from drop-point, collection from store
- *returns*: by mail/parcel, collection by van, return to store

A consumer may thus use a variety of these channels in relation to a single purchase. For example, he or she may see something in a magazine, find out more details while visiting a store, purchase on the website, collect from the store and arrange to return it to a distribution centre by post. This potential mix of channels presents a number of challenges with regard to marketing, sales and physical distribution. It is important in this context that a consistent brand experience is provided to consumers across these channels at each stage of the transaction. This mix of channels in the same transaction, together with a consistent brand experience across channels, are the essential characteristics of 'omnichannel' retailing, as opposed to the term 'multichannel' retailing, which may just be regarded as selling through different channels. The interaction between channels can be positively promoted by retailers, for example by positioning computer screens in-store so that shoppers can browse the online range of goods or by offering next-day delivery from a distribution centre for any items out of stock in the stores. Various terms are used to describe these interactions, for example:

- *BORIS:* buy online, return in-store
- *BOPIS/BOPUS:* buy online, pick-up in-store (also known as *click-and-collect*)
- *BODFS:* Buy Online, Deliver From Store where orders are fulfilled from the nearest store rather than a central warehouse to speed up delivery.
- *BOPIL:* Buy Online, Pick Up In Locker (orders are delivered to automated lockers in-store, at malls, petrol stations etc).
- *BOPIP:* Buy Online, Pick Up at Partner location (for example post office, convenience store).
- *STOS:* Ship To Store when customers order items not in stock locally, which are then shipped from another store or distribution centre for later pick up.

Previous chapters have noted the various channels of distribution, how the supply chain may be segmented and how logistics networks may be planned. This chapter now brings together these different aspects in relation to how retailers serving consumers through multiple channels may segment, design and manage their supply chains.

## Issues

There are a number of issues faced in omnichannel fulfilment. First of all, *different order profiles* tend to occur in each channel. Most retailers serve stores from their own distribution centres, supplemented by some direct delivery to the stores by manufacturers of specific goods (e.g. high-volume and fresh products). Stores tend to order in reasonably large quantities and therefore full-case or pallet quantities are normally required. However, the order profile is quite different for internet shopping which involves direct-to-consumer (D2C/DTC) orders typically of very small quantities: for example, an order for photographic products may be one digital camera and one carrying case. Thus, whereas store deliveries tend to comprise a small number of orders, with many order lines (i.e. many different product lines on an order) and many items per line, the internet channel is normally characterized by many individual consumer orders, with few order lines and few items per line. This profile also occurs for automated home ordering, where appliances such as refrigerators, coffee machines and printers order new items immediately home stocks become low; this type of connectivity between devices and the web is known as the Internet of Things

(IoT). In addition, direct-to-consumer orders normally need to be individually packed ready for home delivery.

The *service expectations* of the retail store and the internet customer may be significantly different. Consumers ordering on the internet often expect rapid home delivery (or a fixed time delivery), regular updates on the order status, and for the whole order to be 100 per cent accurate and damage free. Stores hold a small buffer stock of different items, so traditionally the service level expectations for store deliveries have not been quite so demanding. A further consideration is the *product range* offered through each channel. Retailers may decide to offer the same range on the internet as they offer in their stores, a restricted range or an extended range of products.

*Seasonal peaks* are often more accentuated in the case of internet sales, particularly for non-food items. Thus, some retailers experience internet sales during the seasonal peak that are a few hundred per cent higher than normal sales levels. This causes severe logistics challenges, including finding space within the warehouse for inventory in the build-up to the peak, hiring and training seasonal workers and handling the sheer throughput of goods at peak within the advertised service levels.

The percentage of *returns* by consumers is often higher for internet orders than for store orders, particularly in the case of non-food (e.g. fashion) retailing. Peak returns have traditionally occurred after the peak sales season, but there is now a trend towards price reductions during the peak sales season (e.g. 'Black Friday' and 'Cyber Monday' during the UK Christmas period) and therefore high levels of returns now often have to be handled at the same time as continuing peak sales levels. In certain market segments the level of returns can be over half of the goods dispatched so this can be a major issue. In addition, some retailers actively encourage returns of old items (e.g. previously bought clothing) as part of their environmental credentials.

These contrasting characteristics have *implications* for supply chain design. Thus, different types of distribution centre operation may be required (e.g. case picking to low-level order picking truck for store orders and item picking from conveyors for internet orders), as well as different vehicle types (e.g. articulated trailers or large rigid vehicles for store deliveries and small vans for home delivery). In addition, there may be implications for the disposition of inventory. For example, if different distribution centres are set up to handle each channel then this would involve separate stockholdings of each product line. Also, pack sizes may be different for each channel and this would necessitate separate stockholdings.

It should be noted that within each of the two main channels described above (i.e. store and internet channels), there may be numerous sub-channels, each with its own characteristics. For example, the store channel may include own stores, franchise stores, in-store kiosks, discount stores and pop-up stores. These often have different order characteristics and therefore may need to be segregated in terms of distribution networks or operations.

# Food retailing

Food retail stores are normally served by regional distribution centres (RDCs) from where vehicles deliver to stores in a specific geographical area. In order to minimize the duplication of stocks across the regions, slow-moving goods are often stocked at national slow-moving goods centres (SMCs) from where products are transported overnight and cross-docked at the RDCs to merge in with the store deliveries of fast-moving and medium-moving goods.

Retail food products may require frozen (i.e. about –18°C to –25°C), chilled (i.e. about +2°C to +5°C) or ambient (i.e. normal) temperatures. Therefore, the warehouses and vehicles must be multi-temperature (i.e. with separate zones or compartments for each temperature range) or different distribution networks need to be established for each temperature regime. For example, a retailer may have a separate network of frozen warehouses, from where refrigerated vehicles deliver the products at frozen temperatures to the stores.

In order to serve the internet channel for home delivery or store collection, food retailers have a number of distribution options:

- *Regional distribution centres:* one option is to serve the internet orders from the existing RDCs. This may reduce the need for extra warehouse infrastructure and it also facilitates the options of either delivering to the consumers' homes or delivering to the stores for the consumers to collect. However, the geographic areas to be covered by vans based at the RDCs for home delivery tend to be very large and this makes multi-drop transport to homes fairly inefficient. Another disadvantage is that the RDCs have been set up for pallet and case picking and may not be suited to handling a multitude of small orders that require item picking. If there are different existing networks for frozen, chilled and ambient goods, then there is the added complication (and cost and time delay) of consolidating loads together for single deliveries to consumers' homes.
- *Stores:* a second option is to pick the orders at the stores and deliver the goods on vans based at the stores. This utilizes an existing network of locations close to the consumers, thus being suitable for multi-drop home deliveries. This is a commonly used option, but does have the disadvantages of possible interference with shoppers (i.e. by the internet pickers who would be traversing the same aisles as consumers in the stores) and potential conflict between car and van parking. In addition, it is not possible to guarantee a particular product line to a consumer at the time of ordering on the web, as the product may be out of stock on the shelf by the time it is picked.
- *E-fulfilment centres (eFCs):* a third option is to establish specialist e-fulfilment centres (or dark stores or micro-fulfilment centres – MFCs). These can be specifically designed for the efficient picking of internet orders and stock can be

reserved for consumers at the time of ordering. If items are out of stock at the e-fulfilment centre, then this is known at the time of receiving the internet order and substitutes can be offered to the consumer. This option is also suited to 'pure-play' internet food retailers who do not have an existing RDC or store network. However, distances to consumers can be lengthy, making efficient multi-drop home deliveries difficult to achieve. A network of e-fulfilment centres is therefore one option. Some omnichannel retailers use a combination of options, such as e-fulfilment centres in major centres of population (where vehicle drop densities can be high) and the store option in rural areas. Small e-fulfilment centres in towns and cities are often known as urban fulfilment centres (UFCs), micro-fulfilment centres (MFCs) or 'dark stores'. These require sites that are close to residential areas, have planning permission to operate 24 hours per day, and have large yards to accommodate the delivery vans. Such sites can be difficult to locate in some geographic regions. In some urban areas retail parks have been repurposed to provide land for UFCs. Also, UFCs may be set up at the back of (or above) existing stores and micro-fulfilment systems are available to provide automated solutions for storage and order picking. These micro-fulfilment solutions may utilize 'goods to picker' technologies such as conveyors or autonomous mobile robots (AMRs) bringing goods to pickers from miniloads (see Chapter 21 for details).

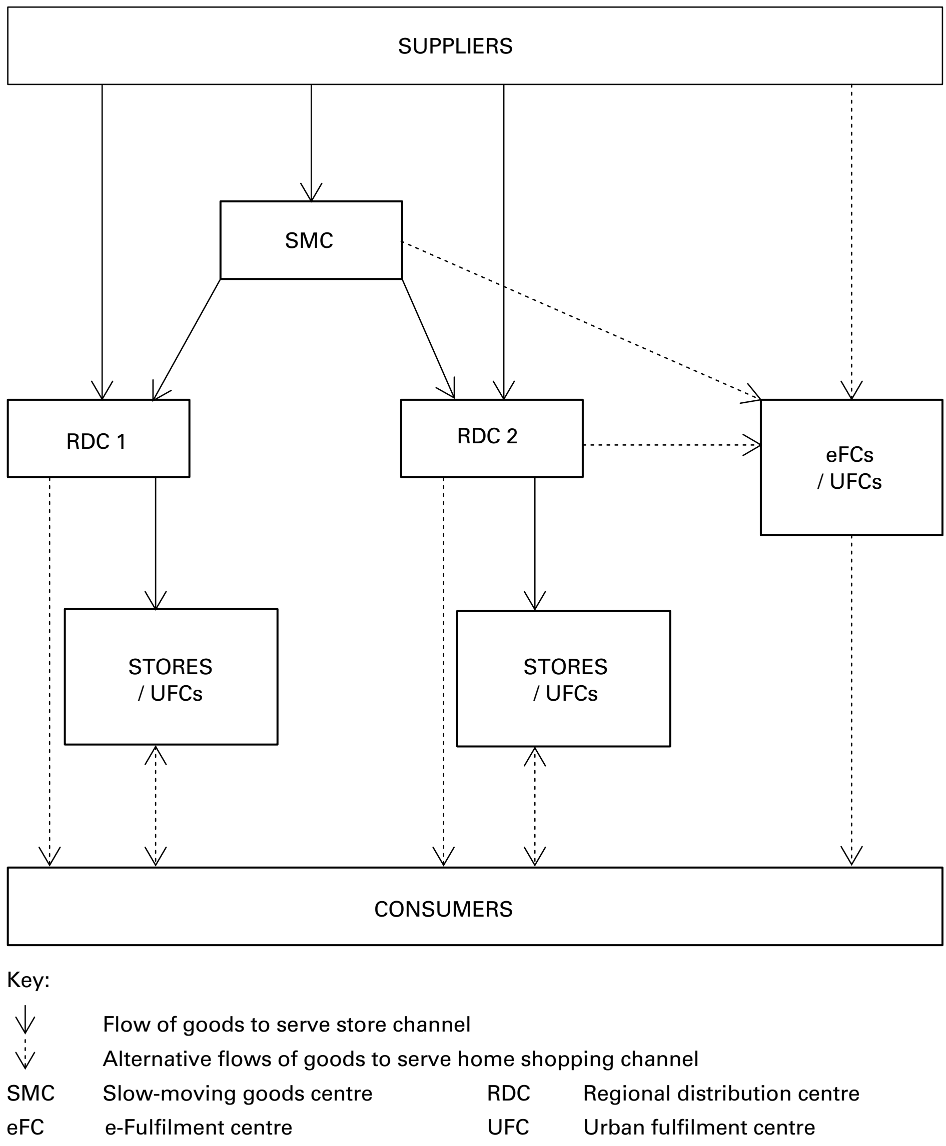
These distribution options are shown diagrammatically in Figure 12.1.

The actual delivery of products to the consumers' homes (or workplaces, pick-up points, secure boxes, etc) was discussed in Chapter 5 under 'The consumer'. These deliveries often have to be made to fixed time slots agreed with the consumer at the time of order so as to ensure that someone is at home to receive the goods. This is not only important for consumers but also for cost efficiency – further attempts at delivery add to the transport cost and may also necessitate new perishable items being picked for the consumer, with the consequent difficulties of recycling the old items that have begun to perish. One option is to arrange to deliver directly to consumers' refrigerators and freezers located in the house or outside, based on suitable access arrangements.

## Non-food retailing

Non-food retailing includes goods such as clothes, electrical appliances, books, toys and beauty products. Traditionally, the distribution networks serving *retail stores* comprise one or more national distribution centres (NDCs). This is because the cost trade-off, described in the analysis of logistics networks in Chapter 9, is greatly influenced by the high inventory-holding costs. With non-food goods there are often a large number of stock-keeping units (SKUs), with a long tail of fairly slow-moving

**Figure 12.1** Potential omnichannel fulfilment options for food retailing




goods. It is frequently not cost-effective to replicate these stocks across regions. There are exceptions, and where there is sufficient volume through a large number of stores then regional distribution centres may sometimes be found. In the case of NDC structures, there may be just one NDC or, if this would be too large, then there may be a number of NDCs each holding a specific product group. Where this occurs, there is a need for the consolidation of goods from different NDCs prior to dispatch to the stores (or sending separate vehicles from each NDC to the stores).

In the case of *'pure-play' internet retailers* (i.e. retailers that only sell over the internet and do not have any stores), then these often have a single NDC, normally located near the hubs of the parcel carriers. This is so that they can offer a late cut-off time in the evening to consumers and still have time to pick and deliver parcels to the hub ready for overnight distribution and delivery the following day. In the UK, for example, these hubs are generally located centrally in the Midlands region. However, if the NDC feeds chiefly into the postal service then it may be located away from the Midlands, as the postal service has multiple hubs around the country. For large 'pure-play' internet retailers, it may not be practical to have a single excessively large NDC (for reasons such as site availability, staff availability, effective management or business resilience) and therefore separate NDCs for each product group may again be required. Where internet retailers grow even larger then they may eventually have sufficient drop density from their own deliveries to make it cost-effective to set up their own network of local depots, at which vans are based for final delivery or from which local couriers collect. Where throughput volumes are sufficiently high then it may also be worthwhile to hold fast-moving lines at these local depots so that same-day, even within-the-hour, services can be offered (although a large number of stocking points are required to provide national within-the-hour services). In addition to these networks, internet retailers may arrange for suppliers to send goods directly to consumers' homes, thus bypassing their own warehouse networks. Some internet retailers have started in this way and then as they have become larger have switched to their own warehouse networks so as to gain closer control over service levels, perhaps maintaining direct supplier delivery channel for slower-moving goods or large items.

For *omnichannel retailers*, it is necessary to provide high service levels to both their store and internet/catalogue channels while taking advantage of any synergies that may be possible. The choice of how to segment markets, products or geographical areas between the distribution centres (DCs) is therefore very important in terms of how to structure the overall distribution network. There are several different forms of segmentation that might be used:

- If the supply chains are *segmented* in terms of *store and internet channels*, then this has the advantage of providing focus to the often rapidly growing internet channel. As noted earlier, the types of orders tend to be quite different for these two channels and therefore separate DCs can be designed to fit the requirements of each. For example, a case picking operation may be suited to the store orders (e.g. picking from pallets onto trolleys or low-level order-picking trucks) while an item-picking operation may be more suited to internet orders (e.g. picking items from tote bins transported from a miniload system by conveyor to a picking station, followed by transfer to parcel-packing stations). However, this segmentation has the distinct disadvantage of increasing overall inventory levels, as safety stocks will be needed for both store and internet channels (see the 'square root rule' in Chapter 15). The decision as to whether to have separate inventory, common inventory or some form of hybrid 'ring-fenced' inventory (which allows inventory transfer between channels, but may incur inter-NDC transport costs) is a key factor in the distribution network strategy. Another disadvantage of segmenting by store and internet channels is that the collection/delivery interface with the customer may not be completely separate. If internet orders are to be delivered to consumers' homes (or drop points, such as petrol or train stations), then it makes sense from a transport viewpoint to serve this channel from a separate DC. However, many omnichannel retailers have found that 'click-and-collect' has become increasingly popular. This is where consumers order on the internet but wish to collect from a store. In this case, the goods then need to be transferred back to the store delivery network, thus incurring transport costs (and a time delay) between the different NDCs. In addition, there may be a need to transfer returns between the store and internet supply chains – for example, goods with slightly damaged packaging may be returned by a consumer who bought them on the internet and it may then be decided to sell these at a discount in a store sale. Similarly, it may be decided to sell off overstocked internet items through store sales.

- An alternative *segmentation* is by *product group* (i.e. having a network of NDCs each holding a different product group). This would solve the problem of additional safety stocks and the unnecessary movements of goods between NDCs in relation to 'click-and-collect' and returns. However, there would generally need to be a consolidation of loads between the NDCs so that a single delivery can be made to each store (i.e. containing goods from all product groups). This again would incur inter-NDC transport costs. Consumers may also have a preference for receiving all the items ordered in one delivery, rather than receiving multiple packages on different days.
- A similar *segmentation* would be by the *storage and handling characteristic* of each product (e.g. one NDC holding small items, one holding medium-size items and one holding oversize items that may require two people to handle). This type of segmentation may benefit the warehousing element as appropriate specialist storage and materials handling equipment could be installed in each NDC. The difficulty of consolidating loads would still arise, unless separate transport networks are necessary for each grouping (e.g. large household items may require specialist vehicles or may be delivered directly to consumers using two-man delivery vehicles). One option is to locate the NDCs close to each other on the same distribution park (sometimes referred to as creating a warehouse 'campus'). If there are a large number of NDCs it may even be worthwhile to have a dedicated sortation centre on the 'campus' to consolidate loads.

- A further *segmentation* could be by *geographical region*. There would be a network of RDCs, each serving stores and consumers in their region. This would provide short delivery distances to the stores, potentially improving store replenishment times and reducing secondary transport costs on multi-drop trips to stores within each region. However, safety stocks would be increased as separate stocks of each SKU would need to be held at each RDC. The transport costs for the internet orders would depend on exactly how these are to be delivered. If internet orders are delivered by parcel carrier then they would be sent to a parcel hub, frequently located in the centre of a country, and therefore an RDC network may not be suitable. However, if they are sent by post then the goods could be fed into multiple hubs and, in this case, an RDC network may be suitable. For direct delivery by van to consumers, note that a large number of stockholding depots (e.g. e-fulfilment centres) are required to provide high service levels (e.g. within-the-hour delivery). Such depots may be able to provide 3D printing capabilities for suitable items.
- Where large quantities of goods are *purchased from overseas*, then warehouses known as import centres may be set up in or close to ports in order to postpone the decision as to which region of the country to send the goods. This is referred to as 'distribution postponement' and has the benefit of allowing the supplier to forward the goods to meet known demands at RDCs in specific regions. This concept is often known as 'port-centric logistics' whereby ports set up distribution parks within their boundaries to facilitate the establishment of such import centres. These may also have the benefit of enabling the use of greater weight shipping containers (as they may not be restricted by weight regulations affecting national road networks) and may also reduce the amount of vehicle mileage running with empty containers, as the containers can be unloaded immediately at the port. There is, however, a danger of this approach creating an extra 'decoupling point' in the supply chain (see Chapter 16), with the possibility of extra stockholding. The total supply chain therefore needs to be planned with care.

The choice of segmentation is therefore fairly complex and, in addition to the distribution network structure, retailers need to decide whether to manage the warehouses themselves or use third-party operators, and whether to use dedicated or shared-user facilities – the latter often providing flexibility for evolving requirements, particularly for smaller retailers (see Chapter 35). One common trend is for small internet retailers to use the web and/or warehousing services of a very large internet retailer so as to gain economies of scale.

# Implementation

For omnichannel fulfilment, it is important to meet the service level expectations of each channel while minimizing operational costs. In order to achieve the latter, synergies need to be achieved wherever possible between the distribution operations of each channel. However, as described in this chapter, it can be difficult to find a solution that can take full advantage of all the potential synergies between inventory-holding, warehousing and transport costs. Often solutions that provide synergies in terms of one aspect of costs involve higher costs elsewhere (e.g. having separate warehouses for case picking for stores and item picking for home shopping may lead to efficient warehouse operations but will involve higher inventory costs, as separate safety stocks will be needed for each). This is complicated further by the crossover of flows between channels (e.g. consumers ordering items on the internet for collection at stores, known as 'click-and-collect'). Thus, while multiple channels may complement each other and help drive overall sales, it is necessary for omnichannel fulfilment to be able to support this mix fully.

A total-cost approach is therefore needed, analysing what type of distribution network would provide the required service levels at the lowest cost (as described in Chapter 10). There is also a difficulty in formulating a future planning base, as requirements for the fulfilment of orders are continually changing (e.g. some stores are replenished in item quantities for certain product groups resulting in order picking, although not packing, being similar to internet orders). Flexibility is important, although this can be difficult to build into fixed assets such as warehousing, and therefore planning for different likely scenarios is one useful approach. The whole supply chain needs to be built with flexibility in mind – including decisions as to product sourcing (e.g. domestic, 'onshore' or 'offshore' sourcing), transport mode (e.g. road, rail, sea or air freight), distribution network infrastructure (e.g. how to segment the warehouses), inventory positioning (e.g. where to locate the 'decoupling point' – see Chapter 16) and final delivery (e.g. own or third-party carrier).

Once implemented, a large multi-tiered distribution network requires advanced management techniques, such as the use of distributed order management (DOM) systems, to optimize the location and movement of inventory.

# Manufacturing logistics 13

## Introduction

This chapter aims to provide the reader with an overview of the processes involved in the production of goods and services. These processes are known under various names, including manufacturing logistics and operations management (OM). The logic behind OM is based on systems thinking with a system defined as:

> A collection of interrelated components that work together towards a collective goal. A system receives inputs and converts them into outputs via a transformation process.

This is most obvious in a manufacturing context where raw materials and labour play the part of inputs that are transformed by the production process into outputs in the form of finished products.

We need to place this system mentally into the wider supply chain context and understand that OM deals with the conversion process between procurement and finished product storage and distribution. This chapter also aims to give the reader an overview of some of the most common forms of manufacturing planning and control techniques. It is not intended to examine these systems in great depth but rather to explain the basic principles of the various approaches and explain some of the terminology.

The following approaches are covered:

- just-in-time
- material requirements planning (MRP) and manufacturing resource planning (MRPII)
- flexible fulfilment or, as it has come to be known, postponement
- distribution requirements planning (DRP) and demand-driven material requirements planning (DDMRP)

As a further aid to understanding the parameters of OM a basic input–output transformation diagram is included here (Figure 13.1). OM covers all the activities encompassed by the transformation process. These may include designing processes,

**Figure 13.1** A basic input–output (I/O) transformation diagram


organizing human resources, scheduling and sequencing production, quality control, performance management and execution of the organization's strategy.

## Typology of operations

The means of production of the goods or services may take many different forms. One way of classifying them is through a system known as the four Vs:

- *volume:* the amount of goods and/or services produced
- *variety:* how many different products and/or services are offered
- *variability:* to what extent the demand for the goods and/or services fluctuates
- *visibility:* how much of the process of delivering the product and/or service is revealed to the customer – face-to-face services where the customer interacts directly with the provider have a high level of visibility, whereas the consumer of a mass-produced item purchased from a third party will have a low level of visibility

Each of the four Vs is measured on a spectrum from high to low and compared with the other Vs to create a picture of the operation in question. Once this classification is understood it will indicate certain strategies and operational tactics that may be appropriately used in managing them. For example, a consultant may be described as having low volume, high variety, moderate variation in demand and high visibility – whereas a manufacturing plant that only makes three products is likely to have high volume, low variety, moderate variation in demand and low visibility. The factory in question would seek to lower unit costs of production and would be a candidate for high capital investment in machinery to automate the process. By comparison, the consultant will have high unit costs that reflect the high level of flexibility and complexity associated with his service. Automation and systemization would be virtually impossible in such a service-oriented operation.

These four Vs are also complemented by three more, colloquially defined as the seven Vs or the SCM Extended Vs. These include:

- *velocity:* speed of supply chain flows, especially in fast fashion, perishable goods and e-commerce
- *variation:* differences in supply or production processes, beyond just demand variation
- *value:* cost–benefit balance delivered to the customer, including perceived quality

In Supply Chain 5.0, the 7Vs take on a more strategic, human-centric meaning. Volume is managed for both efficiency and resilience, while variety caters to personalized customer needs without overcomplication. Variation in demand is addressed through AI forecasts enhanced by human judgment, and visibility ensures full transparency from source to customer. Velocity is redefined as responsiveness, and variability is leveraged as an advantage through flexible systems. Above all, value is measured in financial, social and environmental terms, aligning performance with long-term sustainability goals.

## Manufacturing process types

The volume of product to be produced and the variety of products will dictate the most appropriate process type to use. Process types for products may be categorized as follows:

1. Project: very low volume (one-off) and high variety. For example, building a ship. Usually large-scale, complex, and the product is stationary.
2. Jobbing: low volume and high variety such as building a customized product for a customer. For example, custom-made furniture.
3. Batch: medium volume and medium variety. The classic example is the small bakery that produces several types of bread in batches to serve the local community.
4. Mass: high volume and low variety. A car assembly plant is a good example of a mass production process.
5. Continuous: very high volume and very low variety. An oil refinery would be a good example.

## Service process types

The equivalent process classification for service processes based on volume and variety are as follows:

1. Professional services: low volume and high variety. A good example would be a business consultant service.

2 Service shops: medium variety and volume. The services delivered by a high-street bank fit this category.
3 Mass service: high volume and low variety. Rail services and airports would be classified as mass service.

## *Production facilities and layouts*

The design of production facilities should reflect the manufacturing process type chosen. Layouts are closely correlated with the volume and variety of products being produced and are classified in the following way:

1 Fixed position: all the required resources are moved to the point of production, as in the case of shipbuilding above and a project process.
2 Process or functional: this is where the production resources have similar functions and are therefore grouped together and the products are moved between them. This is an appropriate layout for a high variety of products with similar requirements. For example, a factory that is divided into functional areas such as machining, painting and assembly.
3 Cellular: a work cell is more than a single machine location but smaller than a manufacturing department. A small group of workers are brought together in one part of the factory to produce a certain product or range of products. In their cell they will have all the machines, resources and materials available to produce these products. Production workers in the cell produce the product in a mini production line, ideally passing the product progressively from one worker to the next. This system speeds up processing time, while quality, coordination, communication and teamwork between workers are all improved by this technique. The travel distance and travel time in the factory are also reduced by this system of cellular working.
4 Product: an assembly line is the best example of this layout. All the resources for producing the product are arranged and dedicated to a particular product. Often these are automated to some degree.

## *Operations management performance objectives*

These have been defined as encompassing five crucial areas of producing goods and/or services (adapted from Slack et al, 2009):

- quality: right first time, fit for purpose
- cost: minimizing cost without compromising quality, and making a profit
- speed: delivering as fast as practicable

- dependability: delivering on promises made to the customer in full
- flexibility: adapting what you do or how you do it to reflect changes in customer or market requirements

## Push and pull systems

A 'push' system of manufacturing is one where goods are produced against the expectation of demand, which includes both known demand in the form of existing orders and forecast demand. In other words, goods are not produced specifically to order but are produced against a forecast demand. One fundamental issue relates to the lead time gap: where the amount of time it takes to source and manufacture goods is longer than the customer's willingness to wait, especially in today's world of internet retailing. This gap has to be reduced, eliminated or filled with finished goods inventory in order to satisfy customer demand in an acceptable timescale. In other words, the lead time gap is the gap between the customer's expectation and tolerance for waiting for fulfilment of their order and the company's ability to source, manufacture and deliver the order.

Demand forecasting has to be carried out where raw material suppliers' lead times for delivery and customer delivery requirements have to be considered. If there is a one-month lead time for a given raw material then it will be necessary to estimate what the level of production will be in one month's time in order to satisfy forecast demand for the product. These forecasts are usually based on historical sales information. The difficulty arises when either there is a higher level of demand than expected and sales are lost, or there is a lower level of demand and finished product stocks grow too large. Lost revenue from missed sales opportunities is the result on the one hand, and higher inventory carrying costs or product obsolescence costs are the result on the other. MRP and MRPII (described later in this chapter) are 'push' systems.

A 'pull' system of manufacturing is one where goods are only produced against known customer orders. This is because only actual orders from customers are being produced on the production line. None of the goods are being made to keep as finished product stocks that may be sold at a later date. Therefore, firm customer orders are 'pulling' all the materials through the process from the material suppliers and culminating in the delivery to the final customer. Just-in-time is a 'pull' system.

## Dependent and independent demand

Once a decision has been made to manufacture a given product either to fulfil a customer's order or for stock, a requirement is created for the constituent parts of this product. This requirement, which is contingent on the production of the product in question, is known as dependent demand. In other words, because it is planned to make a given finished product, this decision triggers the demand for all the constituent parts of that product. In this situation there is no uncertainty and activities may be planned accordingly. Therefore, when the production scheduling activity is taking place, the quantity and required delivery dates of the constituent parts are known to the schedulers.

Independent demand is quite the opposite. In this situation the schedulers do not have a clear view of customer demand and are therefore forced to forecast demand in the best way they can. The demand for spare parts for products sold in the past is a good example of this type of demand. This is a very difficult situation, which is full of uncertainty. The schedulers must try to ensure goods and services are available when the customers require them. Almost by definition in this situation there will always be a state of imbalance between supplies of the goods and services and the demand for those same goods and services.

## Just-in-time

This approach was first developed in Japan by Toyota, the automobile manufacturer, in the 1970s. In its early days it was known as the 'Toyota manufacturing system' or 'Toyotarism'. The label 'just-in-time' was applied later. It is basically a set of management philosophies that work together as a 'pull' system with the intention of meeting demand as it occurs.

One of the central ideas of this system is the elimination of waste (*muda* in Japanese) from the manufacturing process. In this context, 'waste' does not refer simply to reworking or scrapping substandard products. Waste within the just-in-time environment means waste in all its manifestations. It seeks to reduce what is known as 'the seven wastes':

1. overproduction
2. waiting
3. transporting
4. inappropriate processing
5. unnecessary inventory
6. unnecessary motions
7. defects

## *Elimination of wasted time*

Because only customers' orders are being produced and the speed of the production process is known, it is possible to synchronize deliveries of raw materials to the end of the production line (or to the precise point on the production line in some cases) with little time to spare before use. The whole purpose of this exercise is to reduce the working capital used in the overall manufacturing system. In turn, this produces a better return on capital employed. The other benefits are that there is little or no requirement for factory space to be used for storage, and a reduced requirement for labour to manage the stock. This is the origin of the name 'just-in-time'.

## *Movement through the manufacturing process*

If materials move through the system in a straight line it is reasonable to suppose that the minimum distance has been covered. In many manufacturing systems this is not always possible. In fact it has been identified in some manufacturing processes that components and sub-assemblies are moved around the factory in a very erratic pattern before they all come together in the finished product. Attempting to minimize the overall distance that materials have to travel through the system helps avoid wasted travelling time and effort.

## *Kanban*

The word *kanban* (the signal) refers to a system of cards (other methods such as marked squares on the floor or balls are used in some cases), which is used to organize the progress of materials through the manufacturing process. It may be easier to understand the system if one imagines squares marked on the floor of the factory. The squares contain work-in-progress required by the next step in the manufacturing process. The squares become empty as the materials are used. The next batch of materials may only move into a square when the square is empty. This approach is replicated as materials move progressively from one step to the next. Thus no build-up of goods occurs, and materials move through the system in an orderly fashion.

The problem is that goods will have to move through the system at the speed of the slowest element in the chain. However, large online work-in-progress stocks will be eliminated. This too contributes to the reduction of working capital being used by the system.

### *Right first time*

Quality problems in the form of scrapped or reworked products are waste of the first order. The Japanese developed several strategies to counter this problem. In one case they built their factory with no area to store scrap, on the principle that having an area for scrap encouraged its production. Quality circles were created, where workers were allocated time specifically given over to discussing quality issues and their elimination, the target being zero defects. The philosophy of *kaizen*, or continuous improvement, was engendered as a working culture in these organizations, with support at the very top. Systems of quality management such as total quality management (TQM) and ISO 900X seek to achieve the same ends.

The causes of scrapped or reworked production may not originate in the factory itself and may be caused by substandard raw materials being supplied to the process. Increasingly, suppliers' performance is critically appraised and measured in defective parts per million or in some other way. The preferred approach is working in a positive environment with suppliers to eliminate problems quickly. Involving suppliers in new product development helps eliminate potential problems before they are translated into the production process (see Chapter 14).

Many companies have now adopted Six Sigma as a formal process improvement technique. Literally, this aims to control a process to the point of ± six sigma (i.e. standard deviations), which equates to 3.4 defects per million. The processes in this technique normally consist of DMAIC (define, measure, analyse, improve and control).

### *Finished product stocks*

Under just-in-time (JIT), these stocks only contain goods produced to a specific customer order. This too contributes to a reduction in working capital.

Because of the needs of brevity it has only been possible to skim the surface of the JIT philosophy. Subjects such as the reduction of set-up and changeover times, team working and empowerment, total productive maintenance, levelled production schedules and many more are arguably no less important.

## Material requirements planning (MRP)

This principle of production scheduling is based on the premise that if one knows what product needs to be produced then one should also know how many constituent parts are required in order to make the product. It is basically a 'push' system based on forecasted demand for the overall product. A useful analogy is the preparation of a meal. Let us say that the meal in question is a traditional UK cooked breakfast.

Depending on taste you may choose two rashers of bacon, a fried egg, some mushrooms, tomatoes and toast. While describing the contents of the breakfast, we have also prepared a list of the constituent parts. If we needed more than one single breakfast then we would simply multiply the quantities of ingredients by the number of breakfasts required. We now have our 'bill of requirements'. This would allow us to go shopping for the ingredients and also allow us to purchase accurately only the ingredients required to avoid wastage through having too many ingredients or disappointment through not having enough ingredients to meet the demand. The success of this system relies on us knowing how many breakfasts are required and how many diners actually turn up for the meal. In other words, success relies on matching the forecast with actual demand.

If we were building a complex piece of machinery rather than our meal then we could apply the same principles. The numbers of different machines could be broken down into the numbers of sub-assemblies required, which in turn could be further broken down into components. Orders could be placed with suppliers for the required quantities and delivery times agreed. These orders would be made in the light of any existing stock of parts already available for use. This sounds very simple but in practice is an enormously complicated process.

The situation is further complicated when orders are cancelled at short notice or increased without warning. The adjustments will need to be made quickly in order to avoid failing to meet customer requirements or conversely being left with an excessive amount of component stock.

The following is a simple explanation of the basic structure of an MRP system.

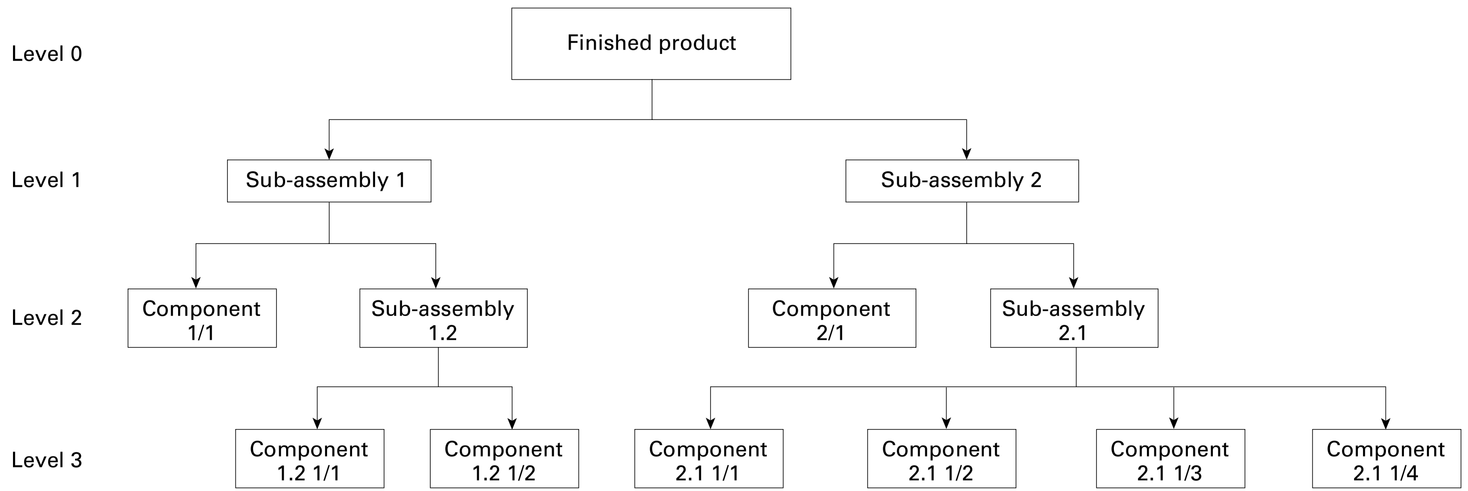
## *The master production schedule (MPS)*

The MPS is a list of all the products or services to be supplied within a specific period of time. This period of time must be sufficiently long to allow for the ordering and delivery of required sub-assemblies and parts, as well as allowing sufficient time for manufacturing the product in question. The schedule may be made up of both forecast and known demand, i.e. customers' orders. It also lists all the required outputs from the system and when the goods and services are required, through the use of a 'due date'. Therefore, the contents of the schedule will dictate the contents of the bill of requirements.

## *The bill of requirements*

This is also referred to as the bill of materials (BOM). As explained earlier, this will list all the sub-assemblies, components and parts required in total to produce all the goods listed in the master schedule. It will also show the different levels at which these constituent parts are put together in order to produce the finished goods.

**Figure 13.2** A bill of requirements for one product



For example, the finished product may contain two sub-assemblies that together complete the product (see Figure 13.2). The finished product is said to be at Level 0. These assemblies will be numbered sub-assembly 1 and sub-assembly 2. Together these sub-assemblies are said to be at Level 1. Both sub-assemblies are made up of one component and one further sub-assembly each. This level is described as Level 2. Owing to the fact that the two major sub-assemblies at Level 1 contain one further sub-assembly each at Level 2 then a further level is created at Level 3. At Level 3 it can be seen that one of the sub-assemblies at Level 2 contains two components and the other contains four components.

This process (sometimes referred to as 'netting') is continued until all the constituent parts are broken down and listed at different levels. It can be quickly seen that, if the bill of requirements for each product is viewed from the opposite direction to the finished product, i.e. the highest-level number first, then one is looking at a sequence for assembly. The components are put together to form sub-assemblies, which in turn are put together to form the finished product.

This bill of requirements, having detailed all the required parts and sub-assemblies, will allow the MRP program to create the required orders to be placed with suppliers. One important thing to remember is that it also lists in detail the order and timing for when these parts are required.

Noting the level of detail in the bill of requirements for just one product described above, it may be easier to understand the level of complexity involved in scheduling many different products that may contain many more components. It will also underline the complexity involved in changing the master schedule due to cancellations or additional orders.

## *Opening stock*

The master schedule and the bill of requirements together form the framework of what is required and when it is required, but two other factors must be fed into the computer program at the same time. The first of these is the current level of unallocated stocks of parts, components and sub-assemblies available for immediate use. There may be in total larger stocks on hand but these may already have been allocated to production via the system and are therefore unavailable. This information will, of course, modify any orders for raw materials placed on suppliers.

## *Opening capacity*

The final fundamental factor required by the MRP program is the current level of available unallocated production capacity for not only the finished product but any components or sub-assemblies that are manufactured in-house.

All of the above information – the master schedule, the bill of requirements, the opening stock and the opening capacity – will be fed into the MRP computer program. The program will then produce, as required, the following:

- a list of purchase requirements, which lists what needs to be purchased and when
- a manufacturing schedule, which lists what will be made and when it will be made
- the closing stock of parts, components and sub-assemblies after the master schedule has been completed
- the closing capacity available after the master schedule has been completed
- a list of anticipated shortfalls in production – these may be due to shortages of parts or capacity

The whole MRP process is iterative and therefore must be repeated periodically. This may be done on what is known as a 'regenerative' basis or a 'net change' basis. The 'regenerative' basis involves assuming that no previous MRP calculation has taken place. Therefore, known or forecast demand is used to create a new bill of requirements, with available parts of stock and available production capacity being allocated disregarding any previous calculations. For the purposes of this approach, all parts and capacity are assumed to be unallocated, as existing orders and work-in-progress will be covered by the new master schedule. This approach tends to be used where demand and, therefore, output are fairly consistent. This method also has the advantage of not perpetuating any previous computation errors as each new calculation starts from fresh current data.

The 'net change' approach concentrates on changing only those parts of the production plan that have changed rather than recalculating the whole plan. Thus, if changes are made to the master schedule then only those parts of the plan that are affected will be changed. This method tends to be used more in situations where demand is more volatile and so changes are more frequently needed.

## Manufacturing resource planning (MRPII) and further developments

As the name implies, manufacturing resource planning (MRPII) deals with more than simply production scheduling. While the basic material requirements planning (MRP) is incorporated into MRPII, the wider system brings other activities into the picture. The objective is to harmonize and control more of the activities within the production plant. Areas outside an MRP system but included in an MRPII system usually are: maintenance management; cost accounting; stock management; sales orders; procurement; personnel levels.

MRPII systems themselves are often incorporated into much wider enterprise resource planning (ERP) systems which also include the company's financial and transaction systems. In addition, these systems normally link to manufacturing execution systems (MES) which control the activities on the shop floor. While the MRPII schedule provides the information of what needs to be produced when, the MES actively controls the flow of orders through the production process, taking into account factors such as machine breakdowns and maintenance, staff absenteeism, variations in set-up times and quality problems. This combination can therefore provide real-time adaptive production scheduling.

This ability to adapt manufacturing plans in real-time requires information provided by technologies such as the Internet of Things (to provide immediate updates on orders, work-in-progress movements, manufacturing resources and inventory levels), artificial intelligence (to be able to plan and learn from the complexities of the operations) and Big Data (to provide the necessary analytics). Robotic process automation (RPA) can be used to bring together and automate the end-to-end supply chain, so that for example the detection of a low stock level of an item at a customer's premises could instantly feed into the manufacturing plan and operations.

## Flexible fulfilment (postponement)

Flexible fulfilment is a method of manufacturing that attempts to delay the final definition of a product to the last possible stage in the supply chain – hence the popular description of 'postponement' for this system.

The advantages gained from this method can be dramatic, especially where companies trade on a global scale. Consider the problems raised by the different voltages available around the world for the use of portable electrical goods. If the manufacturer supplies goods around the globe, then stocks of finished products might have to be kept for each different type of power supply, very likely in or close to the particular market in question. This will increase inventory carrying and, especially in the electronics business, the possibility of product obsolescence. However, if it were possible to have a number of different power supply packs that all fitted the same product then it would be necessary to have only one 'global' product, which could be quickly adapted by changing the power module alone to suit the market concerned. This would mean that there would no longer be country- or market-specific products, and products could be transported and sold anywhere in the world at short notice.

This method has considerable implications for product design in that products need to be designed so that any variations dictated by markets can be adapted by changing modules only. Different keyboards for laptop computers are required to allow for the different alphabets to be found around the world. Manufacturing a laptop with a keyboard that is not easily substituted for another creates large inventories of language- or alphabet-specific stocks in those countries. Postponement means that the bulk of the laptop is produced and shipped around the world, but the final definition of the product only takes place when the alphabet-specific keyboard is attached.

Other examples of postponement can be seen when promotions of a product such as 'Buy product A and get product B free' occur. The attachment of product A to product B creates a third product, C. This product can be produced by wrapping the two products, A and B, together in some form of outer. This operation can be undertaken in the distribution centre prior to final delivery, which will avoid the necessity of forecasting and shipping stocks from further up the supply chain. The product C could almost be made to order via the wrapping process. If the promotion goes well then only increased levels of products A and B need be shipped.

## The effects on distribution activities

These developments in manufacturing planning and control systems have had a significant impact in the management of traditional distribution activities. In the case of flexible fulfilment, where final modifications to products are taking place in distribution centres, this has caused traditional distribution managers and companies to redefine their role and approach. Distribution companies have had to start offering these services as part of their portfolio of services. Distribution managers have had to create the working environment for these activities to take place as well as providing a suitably trained workforce to deal with the new requirements.

The effects on distribution systems of just-in-time (JIT) deliveries have led to more frequent deliveries of smaller quantities to stringent delivery timetables. This has had effects on vehicle fleets and scheduling as well as developments in linked information systems between manufacturer, supplier and transport provider. Without these developments, JIT would be virtually impossible.

Distribution requirements planning (DRP) systems were developed as a logical extension of MRP systems. The principles have simply been extended into a forward distribution planning system so that orders pass through the distribution network and arrive with the customer at the required time. DRP can act as a 'push' or a 'pull' system depending on whether they are triggered by forecasts or actual orders.

Demand-driven material requirements planning (DDMRP) systems, on the other hand, are specifically designed to 'pull' orders through multi-echelon supply chains. These can plan activities at each echelon, from raw materials through manufacturing to final distribution, based on final demand so as to overcome the 'bullwhip' effect (described in Chapter 15).

# Additive manufacturing

Additive manufacturing or 3D printing covers all products that are produced by a 3D printer. Materials such as metal, plastic, ceramics, rubber and even chocolate may be used to manufacture a product by spraying the material and building up layers in three dimensions.

3D printers already produce items such as dental crowns and specialized spare parts. The implications of this method of manufacturing on logistics are considerable. It has become possible for a customer with a 3D printer in a remote location to download design instructions from the internet and, providing the right materials are to hand, he or she may manufacture the spare part on site without any need for delivery. Of course, the implications may be more profound and not limited to the field of logistics. During and after the 2020–21 Covid-19 pandemic there occurred a lot of supply chain disruption. As a consequence, many organizations are considering improved supply resilience by increasing inventories, and 3D printers are very likely to have a role in this regard.

With the continuing growth in the use of robotics, the human labour content will reduce even further. The competitive advantage of cheap labour will be eroded and industries that have moved offshore may start to return to their home countries. There is already some evidence of this happening and it is called reshoring. Shop-floor jobs will require high levels of technical skills in the future.

**Table 13.1** Additive manufacturing benefits

| Benefit | Impact on supply chains | Example application |
|---|---|---|
| Shorter lead times | On-demand production reduces time from order to delivery. | Printing spare parts locally for immediate use. |
| Lower inventory costs | Shift from make-to-stock to make-to-order models. | Printing components only when needed. |
| Greater customization | Enables mass customization without costly retooling. | Tailoring product designs for specific customers. |
| Reduced supply risk | Decentralized production mitigates global disruptions. | Regional printing hubs during shipping delays. |
| Sustainability gains | Less material waste, lighter products, recycled feedstock. | Lightweight components reducing transport emissions. |
| Extended product lifecycle | On-demand spare parts keep products in service longer. | Printing discontinued machine parts for maintenance. |
| Faster innovation | Rapid prototyping accelerates product development. | Quickly iterating on new product designs. |

Materials such as carbon fibre and graphene are replacing steel and aluminium. Graphene has an astonishing array of properties, including electrical and thermal conductivity, as well as mechanical strength. Nanotechnology, where measurements of a billionth of a metre are used, baffle the mind but open up amazing possibilities in pharmaceutical manufacturing. The thought of viruses being used to make batteries seems impossible but is actually happening.

Many, if not all, of these developments will impact directly on how we organize and execute manufacturing and distribution logistics activities in the near future. The benefits of additive manufacturing are detailed in Table 13.1.

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