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Stocks and Inventories

Aims of the chapter

In this chapter we introduce the ideas that lie behind inventory management. We define the terms used, describe the general features of stocks, their purpose, importance and use. We describe some changes that have affected inventory management in recent years. Our aim is to set the scene for later chapters, taking a broad overview before moving on to more detailed discussions.

After reading this chapter you should be able to do the following:

- define the main terms used for inventory management;
- describe the importance of stocks in an organization;
- discuss the reasons for holding stock;
- review the role of stocks in a supply chain;
- explain the benefits of co-ordinated stocks in a supply chain;
- describe some important business trends that affect stocks;
- say how views of stock have changed over time;
- describe the changing pattern of stocks at a national level.

This chapter discusses the following concepts:

- *Stocks*, which are stores of materials that are kept until needed.
- *Inventory*, which is a list of items held in stock.
- *Inventory management*, which is responsible for all aspects of stock control.

Stocks of materials

Definition of terms

All organizations hold stocks. These are the stores of materials they keep until needed. A shop, for example, buys goods from a wholesaler and keeps them in

stock until it sells them to customers; a factory keeps a stock of raw materials for its products; a television company has a stock of recorded programmes; a farmer stores hay to feed his animals over the winter; a research company has a stock of information; a bank holds cash for its day-to-day transactions. Whenever an organization has materials that it does not use immediately, it puts them into stock.

- *Stock* consists of all the goods and materials that are stored by an organization. It is a store of items that is kept for future use.
- An *inventory* is a list of the items held in stock.

An immediate problem is that people use these terms in different ways. In recent years it has become more common to use 'inventory' for both the list of items and the stock itself, and the two terms then become interchangeable. At the same time, organizations refer to their stock as stores, provisions, stockpiles, holdings, reserves, accumulated materials, banks, or a host of other names. To add to the confusion some groups put slightly different interpretations on the terms. Accountants, for example, view 'inventory' as the amount of money tied up in stocks, rather than the stocks themselves, or it might be the total value of an organization's assets. To finance people, 'stocks' are a way of raising capital – in the sense of 'stocks and shares' – and have nothing to do with stores of materials. Usually, these differences are fairly obvious and cause few problems, but sometimes you have to be a bit more careful. In this book we will stick to the standard definitions, where an inventory is a list of the items held in stock.

Each entry in the inventory is a distinct *item* that is held in stock. A supermarket, for example, has 'one-litre bottles of Diet Coke' as a distinct item. Other items in its inventory might be 'two-litre bottles of Diet Coke', 'half-litre bottles of Diet Coke', 'one-litre bottles of Diet Pepsi', and every other distinct product that it sells. A typical supermarket stocks about 30,000 items. Again, some people use different terms, with the most common alternative being *stock keeping unit* or *SKU*.

Each item is sold in standard quantities, or *units*. With our one-litre bottles of Diet Coke, the unit is clearly a bottle. Similarly, '500-gramme tins of Heinz baked beans' is an item in a supermarket, and each tin of beans is a unit; £1 stamps are an item in a post office, and each stamp is a unit; unleaded petrol is an item in a filling station, and each litre is a unit.

- An *item* is a distinct product that is kept in stock: it is one entry in the inventory.
- A *unit* is the standard size or quantity of an item.

Stocks are fairly obvious when you see a shop full of goods, or a warehouse of finished goods. These stocks are tangible and readily identifiable. Sometimes the stocks are a little less obvious, such as the reserves of cash held by a bank,

reservoirs used by a water company, substitutes available for a football team, or seats available in a theatre. An even broader view includes services with intangible stocks, such as the information that is held by research companies, the stock of expertise with consultants, and the store of knowledge in universities. In principle, all of these stocks need the same kinds of management. It is easier to imagine stocks of tangible goods, but remember that in different circumstances organizations can hold stocks of raw materials, components, finished products, people, information, paperwork, messages, knowledge, consumables, energy, money and anything else they need. For simplicity, we will use the general term 'material' for anything that is kept in stock. In the same way, we will always refer to 'organizations' holding stock to cover all types of company, whether it is a not-for-profit organization, a government body, a charity, a quango, a club, or any other body.

Stock cycles

Stocks are formed whenever an organization acquires materials that it does not use immediately. A common practice has a delivery of material arriving from a supplier, and this is kept in stock until needed. Sometimes it is easier to picture a specific operation, so you might imagine the stocks in a supermarket. Goods are delivered by lorry at night, these are checked, sorted and put onto shelves. Then they stay on the shelves until customers buy them. At some point stocks get low, and the supermarket arranges another delivery (as shown in Figure 1.1).

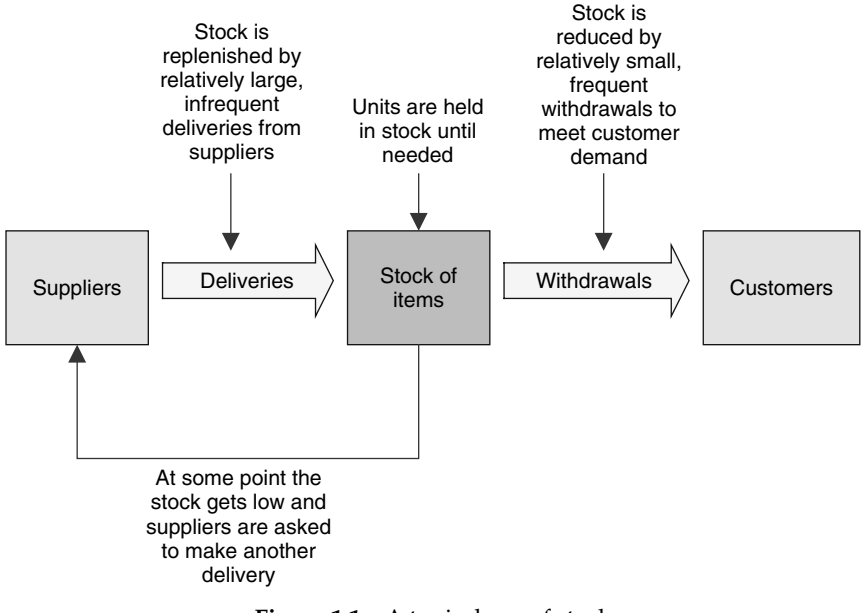

Figure 1.1 A typical use of stock

This sequence of stock replenishment and reduction to meet demand is repeated continuously in a *stock cycle*. Typically, each cycle has the following elements:

1. An organization buys a number of units of an item from a supplier.
2. At an arranged time, these units are delivered.
3. Unless they are needed immediately, the units are put into storage, replenishing the stock.
4. Customers, either internal or external, create demands for the item.
5. Units are removed from stock to meet these demands.
6. At some point, the stock gets low and it is time for the organization to place another order.

Usually deliveries from suppliers are relatively large and infrequent, while demands from customers are smaller and more numerous, giving the typical

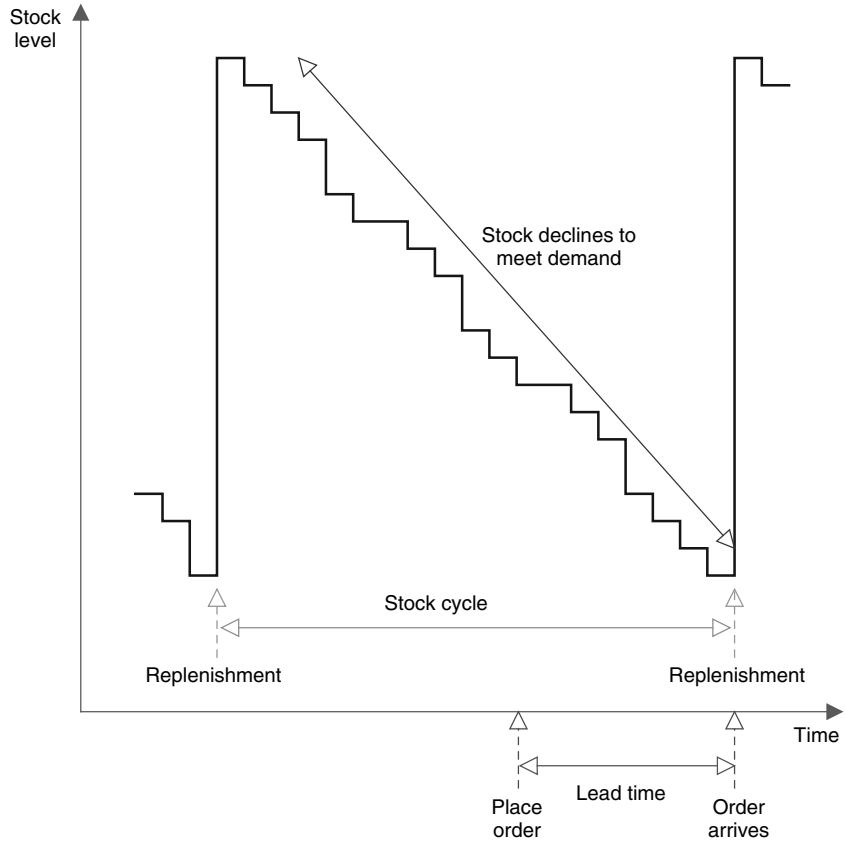

Figure 1.2 Stock levels in a typical cycle

pattern shown in Figure 1.2. Remember that in this broad sense, a *customer* is anyone or anything whose demand is met by removing units from stock. The customer can be internal, when they are someone else within the same organization, or external, when they come from outside the organization. A *supplier* is anyone or anything that replenishes or adds to stock, and again it can be either internal or external. The length of a stock cycle can vary between a few hours (like newspapers and milk which have frequent deliveries) and decades (like gold in Fort Knox that is rarely passed on to customers).

As materials move through the stock cycle, there are many different arrangements for purchasing, storage and delivery. One common feature, however, is that holding stock is surprisingly expensive. We will look at costs in the next chapter, but a rule of thumb says that the cost of holding stock is about 20 per cent of its value a year. If you keep £500 of food in a freezer, it costs about £100 a year. To appreciate the scale of these costs to industry, you only have to look at a big logistics centre, watch convoys of delivery lorries moving along motorways, or realize that Tesco keeps a billion pounds of stock in its shops. Not surprisingly, organizations put a lot of effort into controlling these costs through careful *inventory management*. This function is also called *stock control* or *inventory control*.

- *Inventory management* is the function responsible for all decisions about stock in an organization.
- It makes decisions for policies, activities and procedures to make sure the right amount of each item is held in stock at any time.

Summary

Every organization holds stocks of materials. These are the stores of items – listed in an inventory – that are kept until needed. Stocks are replenished by deliveries from suppliers and reduced to meet demands from customers. Inventory management is responsible for all aspects of stock control.

Review questions

1.1 What is the difference between stock and inventory?

1.2 If a stock item is 'Everyperson's Encyclopaedia', what is a unit?

1.3 How would you define 'suppliers' and 'customers'?

Reasons for holding stocks

Giving a buffer

Stocks are expensive, because of the costs of tied-up capital, warehousing, protection, deterioration, loss, insurance, packaging, administration, and so on. An obvious question, then, is, 'Why do organizations hold stock?' There are several

answers to this, all based on the need for a buffer, or cushion, between supply and demand.

We can illustrate the need for a buffer by considering the stock of bread at Angela's Bakery Shop. It takes some time to make bread, but customers will not wait this time and want a loaf available as soon as they enter the shop. Angela clearly has to plan her baking in advance. If she knows exactly when customers want bread, she can schedule the baking so that loaves are ready at exactly the right time. This would have the advantages of eliminating stock, giving customers the freshest possible bread, and having no leftovers to go stale. In practice, of course, she does not know exactly when customers will buy bread, or how much they want. There is always some variation and uncertainty in the timing and size of customer purchases, and to allow for this Angela bakes loaves in advance and keep a stock on her shelves. Another important concern is that each customer only buys a small amount, but the most efficient way of making bread is in batches of an oven-full at a time. The stock allows for this mismatch between the best rate of supply and actual demand.

Now consider another example with two consecutive operations on an assembly line. Ideally, the first operation finishes a unit, and passes it to the second operation, which starts work immediately. But if the first operation develops a fault, or there is something wrong with the unit, or there is some other reason for a delay in passing the unit forward, the second operation has nothing to work on and it sits idly waiting. The way to avoid this loss of production is to have a small stock of work in progress between the operations. When there are problems with moving a unit forward, the second operation continues working on this stock, and the buffer 'decouples' their operations.

These two examples show how stock gives a buffer between supply and demand. It allows for variation and uncertainty in both supply and demand, and lets operations continue smoothly when there are problems (see Figure 1.3). We can add some details to this idea of a buffer and say that organizations hold stocks to do the following:

- allow for demands that are larger than expected, or at unexpected times;
- allow for deliveries that are delayed or too small;
- allow for mismatches between the best rate of supply and actual rate of demand;
- decouple adjacent operations;
- avoid delays in passing products to customers;
- take advantage of price discounts on large orders;
- allow the purchase of items when the price is low and expected to rise;
- allow the purchase of items that are going out of production or are difficult to find;
- make full loads for delivery and reduce transport costs;
- give cover for emergencies.

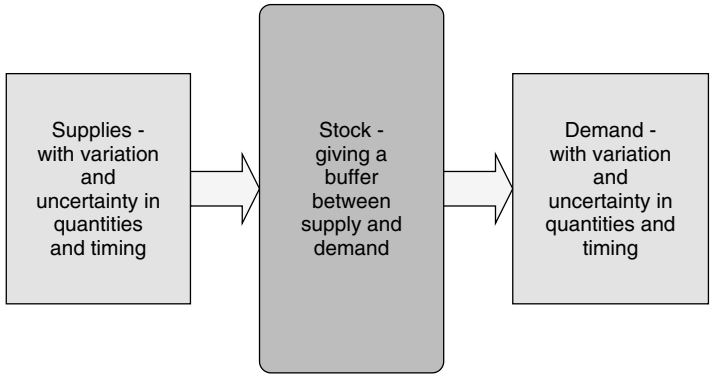

Figure 1.3 Stock gives a buffer between supply and demand

Types of stocks

To achieve these purposes, organizations hold different types of stock. A useful classification has:

- *raw materials*, which have arrived from suppliers and are kept until needed for operations;
- *work in progress*, which are units currently being worked on;
- *finished goods*, which are waiting to be shipped to customers.

This is a fairly arbitrary classification, as one organization's finished goods are another organization's raw materials. Some organizations (notably retailers and wholesalers) have stocks of finished goods only, while others (manufacturers, say) have all three types. Some stock items do not fall easily into these categories, so we can define two additional types as:

- *spare parts*, for machinery, equipment, etc.,
- *consumables*, such as oil, paper, cleaners, etc.

These are needed to support operations, but they do not form a part of the final product (shown in Figure 1.4).

To take a specific example, GlenMorray Knitwear make a range of golf clothes, and their raw materials are wool, cotton, fabrics and other materials waiting to be made into articles; work in progress is the articles being worked on at the moment; finished goods are articles waiting to be delivered to customers; spare parts are kept for the knitting machines and other equipment; and consumables include cleaners, stationery and other material to keep the operations going.

Another less widely used classification of stock describes its overall purpose:

- *Cycle stock* is the normal stock used during operations.
- *Safety stock* is a reserve of materials that is held for emergencies.

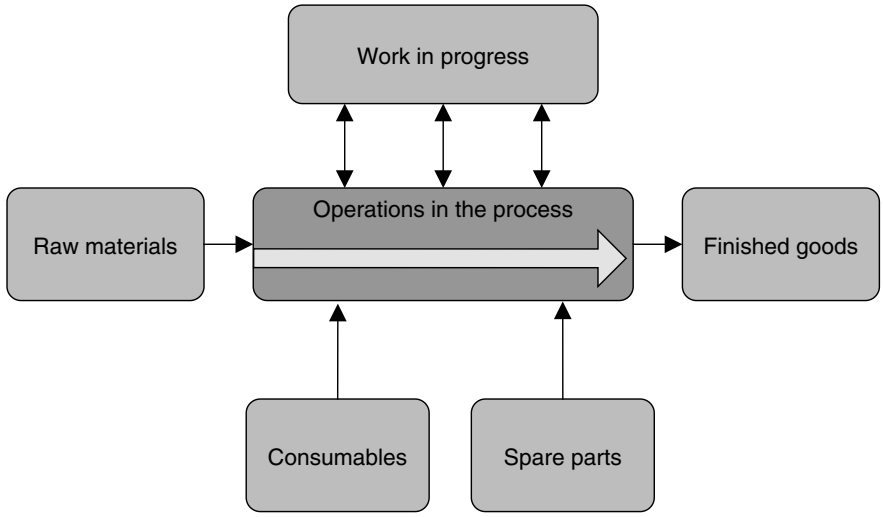

Figure 1.4 Different types of stock

- *Seasonal stock* is used to maintain stable operations through seasonal variations in demand.
- *Pipeline stock* is currently being moved from one location to another.
- *Other stock* consists of all the stocks that are held for some other reason.

Importance of stock

There is a huge variation in the stockholdings of different industries and organizations. Building materials, such as sand and gravel, need fairly large storage areas, but virtually no special attention; expensive items, such as gold and diamonds, need small storage areas, but with high security; perishable goods, such as frozen foods, need special types of storage; information can be stored in huge quantities, but it must allow rapid searching, sorting and retrieval. Despite these differences, you can see that stocks play an important – and even essential – role in every organization. Without stocks most operations are simply impossible. At the very least, stocks allow operations to become more efficient and productive. Stocks affect lead times and availability of materials – thereby affecting customer service, satisfaction, and the perceived value of products. They affect operating costs – and hence profit, return on assets, return on investment and just about every other measure of financial performance. They affect broader operations, by determining the best size, location and type of facilities; they can be risky, because of storage requirements, safety, health and environmental concerns; they can encourage growth of other organizations, such as suppliers and intermediaries offering specialized services

To put it simply, without stocks, organizations could not work. The important question, then, is not whether to hold stocks, but how to manage the stocks that must be held.

Summary

The main purpose of stock is to give a buffer between supply and demand. This safety cushion is essential to ensure the smooth running of operations. Stocks can be raw materials, work in progress, finished goods, spare parts or consumables. The amounts held have widespread effects on the performance of an organization.

Review questions

1.4 How do stocks act as a buffer between operations?

1.5 If suppliers were reliable, there would be no need for stock. Do you think this is true?

1.6 How would you classify lubricating oil for an engine?

Stocks in the supply chain

Shape of supply chains

We have talked about stocks in a single organization, but no organization works in isolation. Each becomes a customer (when buying materials from suppliers) and a supplier (when delivering materials to customers). A wholesaler, for example, acts as a customer when buying goods from manufacturers, and then as a supplier when selling goods to retail shops. Products move through a series of organizations and operations as they travel between original suppliers and final customers. Milk moves through a farm, tanker collection, dairy, bottling plant, distributor and supermarket before we buy it. A toothbrush starts its journey with a company extracting crude oil, and then it passes through pipelines, refineries, chemical works, plastics companies, manufacturers, importers, wholesalers and retailers before finishing up in your bathroom. This series of activities and organizations forms the product's *supply chain*. The function that has overall responsibility for moving materials through the supply chain is *logistics* or *supply chain management*.

- A *supply chain* consists of the series of activities and organizations that materials move through on their journey from initial suppliers to final customers.
- *Logistics* or *supply chain management* is the function responsible for this flow of materials.

As logistics has overall responsibility for the movement – and storage – of materials, inventory management becomes one of the tasks of this broader function.

It is certainly impossible to separate inventory management from other decisions about the supply chain. When we talk about controlling the stock of, say, raw materials, we have to consider the transport of materials, warehousing, purchasing and other activities of supply chain management.

Every product has its own unique supply chain, with materials moving through raw materials suppliers, manufacturers, finishing operations, logistics centres, warehouses, third party operators, transport companies, wholesalers, retailers and a whole range of other operations. In a simplified view, the supply chain for a product consists of tiers of suppliers feeding materials from original sources into its operations, and then tiers of customers moving materials out to the final customers (as shown in Figure 1.5).

There are many variations on this basic model, but the two main features are the supply chain's length and breadth. Here the length refers to the number of tiers, or intermediaries, that materials flow through between source and destination. When farmers sell their produce directly to final customers there is a very short supply chain; on the other hand, computers combine parts from around the world and have long chains. Supply chain breadth is the number of parallel routes that materials can move through on their way to final customers. Cadbury's has a broad supply chain, which means you can buy their chocolate in a huge number of retailers; Pigalle et Fils has a very narrow chain and they only sell their chocolate in two shops in Belgium.

A key point is that every organization on a supply chain holds its own stocks. If the supply chain is very long, or very broad, there is a lot of material held in storage and this is likely to move slowly towards final customers. So one factor in the design of a supply chain is the total amount of stock held. An empirical

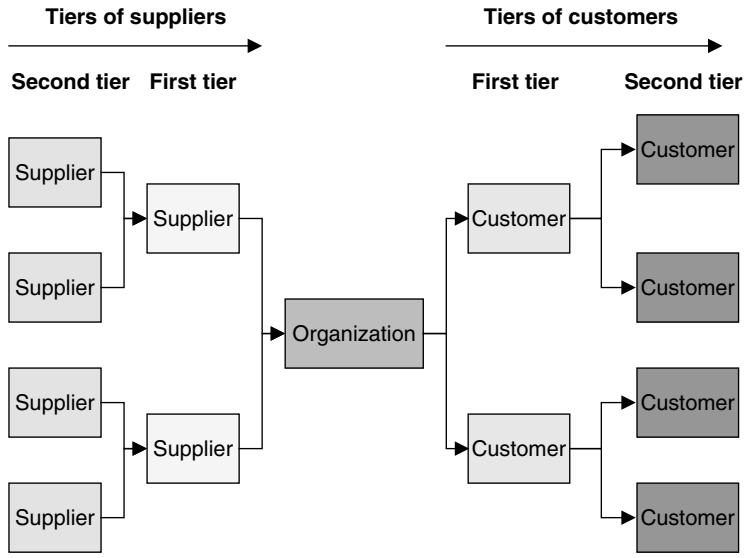

Figure 1.5 A simplified supply chain

observation suggests that the aggregate amount of stock held in a number of locations is:

$$AS(N_2) = AS(N_1) \times \sqrt{\frac{N_2}{N_1}}$$

where:

N_2 = number of planned future facilities
N_1 = number of existing facilities
$AS(N_i)$ = aggregate stock with N_i facilities

Worked example

AJT Transport of Manchester is planning to increase its services to mainland Europe. It currently has 12 depots with aggregate stock valued at £12 million and plans to expand to 16 depots. With a carrying cost is 20 per cent of value a year, what is the likely cost of this change?

Solution

We know that:

$$N_1 = 12 \text{ depots}$$

$$N_2 = 16 \text{ depots}$$

$$AS(N_1) = £12 \text{ million}$$

Then we can substitute these values to get:

$$AS(N_2) = AS(N_1) \times \sqrt{\frac{N_2}{N_1}} = 12 \times \sqrt{16/12} = £13.9 \text{ million}$$

The additional depots will raise stock holding costs by:

$$(13.9 - 12) \times 0.2 = 0.38 \text{ million or £380,000 a year}$$

The best shape for a supply chain depends on many factors, such as the product's value, bulk, perishability, availability, profitability, and so on. It also depends on the organization's aims and business strategy. As a rule, a short, narrow supply chain gives an organization a lot of control over its logistics, but with a few, scattered intermediaries it is difficult to achieve either high customer service or low costs. Broadening the chain and adding more intermediaries gives higher customer service, but increases costs and reduces the organization's control. Making the supply chain long and narrow can reduce costs, but the organization loses some control and the customer service does not improve. Making the supply chain both

long and broad removes most control from the organization and raises costs, but gives good customer service. As you can see, organizations often have to find the best balance between costs and customer service. This is a common theme in inventory management, and we will return to it several times in the book.

Unfortunately, there is never a single 'best' shape for a supply chain, and managers have to look for designs that come closest to achieving their aims. One approach to doing this takes the following steps:

1. The logistics strategy sets the overall direction of logistics (as we shall see in the next chapter) so analyse this and find the aims of the supply chain.
2. Examine current operations, identify their failings and look for ways of overcoming these.
3. Design an outline structure for logistics, finding the number of facilities, best locations, modes of transport, investment in stocks, etc.
4. Make detailed plans, setting the size of each facility, stock holdings, material handling equipment, systems to develop, people to employ, transport needs, etc.
5. Get final approval from senior managers and agree the funding.
6. Finalize building designs, purchase land, choose contractors and build.
7. Finalize equipment design, choose equipment, suppliers and purchase.
8. Finalize systems design, for ordering, inventory control, billing, goods location, monitoring and all other systems.
9. Fit out facilities, install all equipment, systems, staff and test operations.
10. Open and receive stock, run final tests of all systems, finish training and begin operations.
11. Sort out teething problems and get things running smoothly.
12. Monitor and control, ensuring that everything works as planned, measure performance, revise targets, etc.

This is, of course, only a guideline to suggest the decisions in designing a supply chain. You can clearly see how decisions about the broader supply chain affect the stocks by, for example, setting the location, space available, handling facilities, systems and investment. You can also see how, conversely, attitudes towards stocks affect the design of the supply chain. If, for example, organizations accept that large stocks of finished goods must be kept near to customers, they will design supply chains to feed into these stocks. We will return to this theme in the next chapter.

Supply chain management is going through a period of rapid change. One clear trend is towards shorter chains, as organizations realize that they can both reduce costs and increase customer service by moving materials quickly through short chains. To achieve this, they remove layers of intermediaries and hold stocks in

fewer, larger facilities. Within the European Union, for example, efficient transport links mean that companies can replace a series of national warehouses by a single European logistics centre. Finding the best locations for these centralized stores can be very difficult. They might be near to factories, customers, transport, other facilities – or in areas with development grants. If an organization wants fast delivery, it has warehouses close to final customers; if it wants the lowest costs, it concentrates stocks in very large, centralized warehouses that are inevitably some distance from customers; if it imports and exports a lot of materials it might use warehouses near to ports, airports or rail terminals; if it manufactures goods, it has a stock of finished products near the factory. Here we cannot deal with details of the design of supply chain, but you should remember that these decisions include some of the key issues for inventory management. Again, we will discuss some of these in the next chapter.

Co-operation within a supply chain

A traditional view has each organization in a supply chain working largely in isolation and concerned only with its immediate suppliers and customers. This short-sighted view ignores the obvious point that the success – and survival – of the whole supply chain depend on its ability to satisfy final customers. Organizations in a supply chain increasingly recognize that they share a common overall objective, and should not compete with each other, but should co-operate to get final customer satisfaction. Competitors are not other organizations within the same supply chain, but are organizations in other supply chains. As Christopher (1996) says, 'supply chains compete, not companies'.

We can easily demonstrate the kind of problem that arises if organizations in a supply chain do not co-operate. Imagine a retailer who notices that demand for a product rises by 10 units in a week. When it is time to place the next order, the retailer assumes that demand is rising, and orders 20 extra units to make sure it has enough. The local wholesaler sees demand rise by 20 units, so it orders an extra 30 units to meet the growth. The regional wholesaler sees demand rise by 30 units, so it orders another 40 units. As this movement travels back through the supply chain, a relatively small change in final demand is amplified into a major variation for early suppliers. When demand from final customers moves down a bit, this is amplified into a collapse in demand for early suppliers.

Worked example

A simple supply chain has a manufacturer, regional and local wholesalers, a retailer and final customer. Each organization holds its own stock of one week's demand. In other words, each buys enough materials from its suppliers to make its closing stock at the end of the week equal to the demand during the week. Demand for a product is steady at 10 units a week. One week, however, demand from final customers rises to 20 units. Assuming that deliveries are very fast, how does this affect stocks in the supply chain?

Solution

The spreadsheet in Figure 1.6 shows these results. For each tier you can see:

- demand – which equals the amount bought by the following tier of customers;
- opening stock at the beginning of the week – which equals its closing stock in the previous week;
- closing stock at the end of the week – which must equal demand in the week;
- number of units bought – which equals demand plus any change in stock:

$$\text{buys} = \text{demand} + (\text{closing stock} - \text{opening stock})$$

In week 1 everything is going smoothly, with the usual 10 units flowing through the supply chain. Then in week 2 customer demand goes up to 20 units. The retailer must buy 20 units to meet this demand, plus an additional 10 units to raise its closing stock to 20 – so it buys 30 units from the local wholesaler. The local wholesaler has to supply this 30 units, plus an additional 20 units to raise its closing stock to 30 units – so it buys 50 units from the regional wholesaler.

	A	B	C	D	E	F	G	H	I	J
1	**Week**		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
2										
3	**Customer**									
4		Demand	10	20	10	10	10	10	10	10
5										
6	**Retailer**									
7		Demand	10	20	10	10	10	10	10	10
8		Opening stock	10	10	20	10	10	10	10	10
9		Closing stock	10	20	10	10	10	10	10	10
10		Buys	10	30	0	10	10	10	10	10
11										
12	**Local wholesaler**									
13		Demand	10	30	0	10	10	10	10	10
14		Opening stock	10	10	30	30	20	10	10	10
15		Closing stock	10	30	30	20	10	10	10	10
16		Buys	10	50	0	0	0	10	10	10
17										
18	**Regional wholesaler**									
19		Demand	10	50	0	0	0	10	10	10
20		Opening stock	10	10	50	50	50	50	40	30
21		Closing stock	10	50	50	50	50	40	30	20
22		Buys	10	90	0	0	0	0	0	0
23										
24	**Manufacturer**									
25		Demand	10	90	0	0	0	0	0	0
26		Opening stock	10	10	90	90	90	90	90	90
27		Closing stock	10	90	90	90	90	90	90	90
28		Makes	10	170	0	0	0	0	0	0

Figure 1.6 Effect of varying demand in worked example

The regional wholesaler has to supply this 50 units, plus another 40 units to raise its closing stock to 50 units – so it buys 90 units from the manufacturer.

In week 3 we get the reverse effect as customer demand returns to 10 units. The retailer now reduces closing stock to 10 units, so it can meet all demand from stock and does not have to buy anything from the local wholesaler. This gives a demand of zero for all other tiers of suppliers. The stocks slowly returns to normal over following weeks, but a variation in customer demand of 10 units in one week, makes manufacturing jump by 160 units. The total amount of stock in the supply chain rises from 40 units to 190 units, and this will take 15 weeks to return to normal. Of course, we could criticize the inventory control policies here, but we will return to this theme in later chapters.

Any uncertainty in the supply chain – such as the jump in demand seen in the worked example – encourages organizations to hold higher stocks to give themselves a margin of safety. These extra stocks clearly increase costs. They also make the chain slow to react to changing conditions – when, for example, final customers start demanding a new product, all the stocks of old products in the supply chain have to be sold before the new ones appear. The way to avoid such problems is to co-ordinate the stocks and flow of materials. This brings a series of benefits, which include:

- lower costs – with lower stocks, less expediting, balanced operations, economies of scale, etc.;
- improved performance – with more stable operations, better planning, higher productivity of resources, etc.;
- improved material flow, with co-ordination giving faster and more reliable movements;
- better customer service, with shorter lead times and faster deliveries;
- more flexibility, with organizations reacting faster to changing conditions.

Christopher (1999) again summarizes the situation by saying that, 'Most opportunities for cost reduction and/or value enhancement lie at the interface between supply chain partners'.

Achieving co-operation in the supply chain

As you would imagine, there are many practical difficulties with achieving this co-operation. Many organizations simply do not trust other members of the supply chain, and they are reluctant to share information. Even with sufficient trust, there can be problems with different priorities, competition, data exchange, appropriate systems, skills, security, the complexity of systems, and so on. This raises the obvious question of how to achieve integration.

The first problem is overcoming the traditional view of organizations as adversaries. When an organization pays money to its suppliers, people assume that one

can only benefit at the expense of the other. If the organization gets a good deal, it automatically means that the supplier is losing out; if the supplier makes a good profit, it means that the organization pays too much. This adversarial attitude has major drawbacks. Suppliers set rigid conditions and, as they have no guarantee of repeat business, they see no point in co-operation and try to make as much profit from each sale as possible. At the same time, organizations have no loyalty, and they shop around to get the best deal and remind suppliers of the competition. Each is concerned only with their own objectives and will – when convenient to themselves – change specifications and conditions at short notice. The result is uncertainty about the number and size of orders, constantly changing suppliers and customers, changing products and conditions, different times between orders, no guarantee of repeat orders and changing costs.

To avoid these problems, organizations have to recognize that it is in their own long-term interest to replace conflict by co-operation. There are several ways of organizing this. The simplest appears when an organization has a good experience with a supplier and continues working with them over some period, developing a valuable working relationship. The key point with such informal arrangements is that there is no commitment. This has the advantage of being flexible and non-binding, but it has the disadvantage that either party can end the co-operation without warning and at any time that suits them.

Many organizations prefer a more formal arrangement, with a written contract setting out the obligations of each party. These are common when organizations see themselves as working together for some time, such as an electricity company agreeing to supply power at a fixed price for the next three years, provided a customer buys some minimum quantity. More formal agreements have the advantage of showing the details of the commitment, so that each side knows exactly what it has to do. On the other hand, they have the disadvantage of losing flexibility and imposing rigid conditions.

When an organization and a supplier are working well together, they may both feel that they are getting the best possible results and neither could benefit from trading with other partners. Then they might look for a long-term relationship that will guarantee their mutual benefits continue. This is the basis of a *strategic alliance* or *partnership*. Ellram and Krause (1994) prefer the term *supplier partnering* which they define as 'an ongoing relationship between firms, which involves a commitment over an extended time period, and a mutual sharing of information and the risks and rewards of the relationship'.

With such alliances, the supplier knows that it has repeat business for a long time, and can invest in improvements to products and operations; the organization knows that it has guaranteed – and continually improving – supplies. This often encourages suppliers to specialize in one type of product. They give such a commitment to the alliance that they reduce their product range, make these as efficiently as possible, and concentrate on giving a small number of customers a very high quality service. At the same time, customers reduce their number of suppliers, as they no longer need to look around to get the best deals. Japanese companies were among the first to develop strategic alliances, and at the time

when Toyota had formed partnerships with its 250 suppliers, General Motors was still working separately with 4,000.

Despite the clear evidence of benefits from co-operation in the supply chain, some people are not convinced, and say that each organization should independently pursue its own aims. You can imagine these different views in an example. Suppose a supplier has been delivering a product to an organization for some time, and has recently improved its operations to reduce the cost by 2 per cent. When it is time to negotiate this year's deliveries, what price should it quote? At one extreme is the view that the supplier has been working happily with the old level of profit, and should pass on all the savings in a lower price to make sure that it remains competitive and keeps the organization's custom. At the other extreme is the view that the supplier should maximize its own profits by keeping all the savings and increasing the price by (at least) the rate of inflation. In the middle is a compromise view which says the supplier should somehow share the benefits of lower costs with the organization. The final decision depends on aims, competition, power in the supply chain, and so on. Some formula for sharing the benefits is likely to give the best long-term results.

Summary

Inventory management can be viewed as one of the tasks of logistics. It is very closely related to other activities in the supply chain. As materials move through a supply chain, stocks are held at various points. The best results come when organizations within the same supply chain co-operate to ensure final customer satisfaction. There are several ways of achieving this co-operation, ranging from informal trading relationships through to partnerships.

Review questions

1.7 What is a supply chain?

1.8 Good customer service comes when stocks of finished goods are as close as possible to final customers. Do you agree with this?

1.9 Why should organizations within the same supply chain work together?

1.10 A company can only increase its profits by paying its suppliers less or charging its customers more. Do you think this is true?

Trends affecting stock

Organizations are constantly looking for ways of improving their operations and gaining a competitive advantage. We have seen how this encourages co-operation within a supply chain, and we mentioned some other issues, such as shorter supply chains, lower stocks, increasing customer service, and so on. In reality, these changes are taking place very quickly, and organizations are going through a period of rapid adjustment to the way they work. New practices and developments are making fundamental changes to operations, and many of these affect the role

and management of stock. We cannot look at all of these changes in detail, but will mention some of the most significant. The following list is, of course, nowhere near exhaustive and all kinds of changes are now affecting stocks.

Improving communications

Organizations are always introducing more sophisticated technology. Much of this affects the movement and storage of materials – with electronic identification of packages, satellite tracking of deliveries, automatic systems for moving goods, and so on. However, the greatest impact in recent years has come from improved communications. Consider, for example, the effect on purchasing materials. When a company wanted to buy something, it traditionally had to generate a description of the item, request for price, purchase order, order confirmation, contract terms, shipping papers, financial arrangements, delivery details, special conditions, invoices, and so on. All of these – and mountains of other paperwork – had to be printed and posted between organizations. By the 1990s technology had revolutionized these communications, with *electronic data interchange* or *EDI* allowing the direct exchange of data between remote computers. Supermarkets were among the first users of EDI, when they linked their stock control systems directly to suppliers' order processing systems. Then supermarket checkouts could record sales of each item, and when stocks got low the system automatically sent a message asking for another delivery. This use of *EPOS* – electronic point-of-sales – data gave less paperwork, lower transaction costs, faster communications, fewer errors, more integrated systems and closer business relations.

By 1997 about 2000 companies in the UK were using EDI (Stafford-Jones, 1997), and over the next few years electronic trading became more sophisticated and widespread. The mushrooming of e-mail was followed by all kinds of e-business, e-commerce – and soon 'e-anything'. The efficient transfer of information has been particularly useful for purchasing, which has developed into *e-purchasing* or *e-procurement*. This comes in many forms, with the two main versions based on *B2B* (business-to-business, where one business buys materials from another business) and *B2C* (business-to-customer, where a final customer buys from a business). By 2002 around 83 per cent of UK suppliers were using B2B (MRO Software, 2001), and the worldwide value of B2B trade was over US$2 trillion (The Gartner Group, 2002).

Two associated technologies supported EDI. The first is *item coding*, which gives every package of material moved an identifying tag. The tag is usually a bar code or magnetic stripe that can be read automatically as the package moves through the supply chain. Then stock control systems know where every package is at any time, and automatic materials handling can move, sort, consolidate, pack and deliver materials as needed. The second technology is *electronic fund transfer* or *EFT*, which automatically debits a customer's bank account and credits the supplier's. This completes a loop, with EDI to place orders, item coding to track the movement, and EFT to arrange payment.

Improved communications, together with better transport, mean that physical distances are becoming less significant. Organizations can become global in

outlook, buying, storing, manufacturing, moving and distributing materials in a single, world-wide market. As a result, international trade and competition continue to rise. Organizations used to look for competitors in the same town, but now they are just as likely to come from another continent. This trend is encouraged by free trade areas such as the European Union and the North American Free Trade Agreement.

Improving customer service

Customers have become increasingly knowledgeable about products and suppliers, and demand lower costs, higher quality and better service. In the past we might have gone to a local retailer to see what they were selling, but now we can surf the Web to compare the products offered by any company in the world.

To offset the increasing demands from customers, organizations are becoming more competitive. They might simply keep prices down, or they might find some other way of improving customer service. Both of these depend on the management of stocks. Low prices, for example, can only be achieved with low costs, and one significant factor here can be the cost of holding stock. It is normally in everyone's interests to make this as low as possible, so that customers pay as little as possible and the organization remains competitive. However, we cannot view the stockholding costs in isolation, as it is frequently linked to customer service. If an organization tries to reduce costs by holding less stock, it might find that there are more frequent shortages; or if it closes down a warehouse, the delivery time might rise. Although there is a continuing trend towards better customer service, we have to balance the gains this brings against the cost. As you will see in the rest of this book, finding the best balance between costs and service is a recurring theme in inventory management.

Concentration of ownership

Large companies can find economies of scale, and they have come to dominate many operations. There are, for example, many shops and transport companies, but the biggest ones continue to grow at the expense of small ones. The result is that most industries are dominated by a handful of major companies. This concentration is accompanied by changing power in the supply chain, with very large retail chains, such as Wal-Mart, Tesco, and Toys-Я-Us, demanding customized services from their suppliers.

At the same time there is concentration among suppliers, with fewer major companies. However, the effects are less clear here, as each customer is likely to work with a broader range of suppliers. The trend, though, is towards fewer suppliers with long-term commitments.

Outsourcing inventory management

Traditionally, each organization looked after its own logistics. Now, though, more organizations realize that they can benefit from using specialized companies

to take over part, or all, of their logistics, leaving them free to concentrate on their core activities. This is called *outsourcing* with the specialized companies being *third party operators*. A common starting point is to outsource transport to a specialized company. Next steps are to outsource warehousing, purchase of materials, materials handling, and other aspects of inventory management. This can bring significant benefits, which include the following:

- lower fixed costs, with organizations only paying for services they use;
- specialist suppliers who have expertise and use the best systems and practices;
- third parties can combine work from several customers to get economies of scale;
- guaranteed high, and agreed, levels of customer service;
- flexible capacity, dealing effectively with peaks and troughs in demand;
- lower exposure to risk from, say, varying demand;
- increased geographical cover and local knowledge;
- a convenient way of working in new markets.

Of course, there are disadvantages of outsourced inventory management, including reduced control, inability to respond to unusual circumstances, more complicated communications, conflicting objectives, less control over costs, and so on. Nonetheless, the advantages of third party operations are becoming clearer, with more organizations moving in this direction.

A variation on outsourcing has *vendor managed inventory* or *VMI* where suppliers manage both their own stocks and those held further down the supply chain. In this case the third party operator is an organization higher up the supply chain. This brings the usual benefits of outsourcing, together with much closer co-ordination and control of stocks. A slight variation on this has *co-managed inventory* where an organization and supplier somehow co-operate to manage stocks jointly.

Cross-docking

A traditional warehouse has materials delivered, it moves them into stock, keeps them until needed, and then delivers them to customers. *Cross-docking* co-ordinates the supply and delivery, so that materials arrive at the receiving area and are transferred straight away to the loading area where they are put onto delivery vehicles for customers. Ideally individual packages arrive and are passed on for delivery, but sometimes there is a limited amount of sorting, perhaps breaking down larger deliveries into smaller amounts for each customer. Some people prefer the term *flow through stock* when there is this kind of sorting.

A related arrangement uses *drop-shipping*, where materials do not actually go to the warehouse, but are delivered directly from upstream suppliers to downstream customers. If, for example, you buy a Hotpoint washing machine from a Dixon's store, you will probably find that the machine is delivered directly

from Hotpoint without ever visiting a Dixon's warehouse. Methods like this are becoming increasingly common, as more customers buy through the Web, or find other ways of trading with earlier parts of the supply chain, such as mail order, telephone shopping or buying directly from manufacturers. This has the benefits of reducing lead times, reducing costs to customers, having manufacturers talking directly to their final customers, allowing customers access to a wider range of products, and so on.

Any method that avoids putting materials into stock at a warehouse can dramatically reduce stock levels and associated administration. In the extreme, the only stock is within delivery vehicles, giving *stock on wheels*. This is not, however, a solution for all problems, as the co-ordination can be difficult, and this needs a certain volume of trade to stop the small, frequent deliveries becoming prohibitively expensive. Many parcel delivery services such as FedEx, UPS, Omega and DHL have grown as a way of giving rapid delivery of small amounts of materials at reasonable cost.

Postponement

Manufacturers typically move finished goods out of production and keep them in a store of finished goods until needed. When there are many variations on a basic product, this can give high stocks of similar products. Postponement moves almost finished products into stock, and delays final modifications or customization until the last possible moment. You can imagine this with 'package-to-order', where a company keeps a product in stock, but only puts it in a box written in the appropriate language when it is about to ship an order.

Manufacturers of electrical equipment, such as Phillips and Hewlett-Packard, used to build into their products the transformers and plugs needed for different markets. Then they had to keep separate stocks of products destined for each country. Now they make the transformer and cables as separate, external units. They only keep stocks of the basic, standard products, and customize them for different markets by adding the proper transformers and plugs at the last minute. The result, of course, is much lower stocks.

Increasing environmental concerns

One cultural trend that is affecting inventory management is the growing concern about air pollution, water pollution, energy consumption, urban development and waste disposal. It is fair to say that the whole area of logistics does not have a very good reputation for environmental protection – demonstrated by the emissions from heavy lorries, use of greenfield sites for warehouses, calls for new road building, use of extensive packaging, ships illegally flushing their fuel tanks, oil spillages from tanker accidents, and so on. On the positive side, though, logistics is moving towards 'greener' practices, with more energy-efficient vehicles, control of exhaust emissions, reuse of packaging, switching to environmentally friendly modes of transport, increasing recycling through reverse logistics, added safety features to ships, development on brown-field sites, and so on. There is increasing

recognition that careful management can bring both environmental protection and lower costs.

Summary

Organizations are continually looking for ways to improve their operations. The results have created a series of trends that affect inventory management. Among these are increasing use of technology, improved customer service, global operations, outsourcing, new arrangements for stock management, and so on.

Review questions

1.11 Why do you think that there are currently such rapid changes affecting inventory management?

1.12 Are the effects of these trends independent of each other?

1.13 Several trends in operations are leading to lower stocks. Is it inevitable that stocks will continue to decrease?

Changes to aggregate stocks

Changing views of stock

The trends outlined in the last section show that organizations are changing their attitudes towards stock. This is not new, but is part of a continuing pattern. For most of history, stocks have been considered measures of wealth or well-being and were, therefore, beneficial. The family with the biggest store of food was least likely to starve, the company with most raw materials was insulated from shortages, and the business with most money in the bank was most secure. The obvious conclusion was that stocks should be maximized, as this gives the greatest benefit.

At times when the production and distribution of any material are uncertain, it certainly makes sense to avoid problems by collecting as much stock as possible. However, by the turn of the twentieth century industrialized countries had more or less secure supplies of most materials. The uncertainty in supply was greatly reduced, and this brought a new attitude towards stock. Organizations could now buy materials when they were needed – rather than when they were available – and they looked for more rational ways of controlling stock levels. This new outlook suggested that stocks were expensive and needed formal management. In particular, organizations should look for ways of minimizing some aspect of cost. Sometimes people were sidetracked from this aim and in the 1920s, for example, there was a craze for minimizing stocks rather than costs. Unfortunately, many companies hit problems when they reduced stocks to levels that made it impossible to work effectively or maintain any kind of customer service.

In the late 1920s *scientific inventory control* became the main approach to inventory management, using mathematical models to find optimal stock levels. As

you can imagine, a continuing problem has been to find agreement about what 'optimal' levels might really be. Are these the levels that minimize total cost, or some aspect of cost, or give high customer service, or minimize stock-outs and disruptions, or give highest return on investment, or maximize stock turnover, or achieve one of dozens of other measures of performance?

For some time, it was felt that a 'fixed accelerator' could define an optimal stock level as some fixed proportion of sales (for example, Abramovitz, 1950). In practice, this proved ineffective and there was a move towards a 'flexible accelerator' to allow for differences between aims and actualities, time delays, and so on (for example, Lovell, 1961, 1964). Unfortunately, this approach also had its failings, and a more flexible approach was developed, which used a range of models to deal with different circumstances. These models grew increasingly sophisticated, and remained the main approach to inventory management for most of the last century. We will describe some of these models in Chapters 3 to 5.

More recently, new ideas have emerged about inventory management. These do not look for the best policy for dealing with uncertainty in supply and demand, but look for ways of removing the uncertainty. When there is no uncertainty, the stocks can be eliminated, or at least minimized. We will describe approaches of this kind in Chapters 9 and 10.

To summarize this brief review, for most of history, stocks were seen as beneficial and organizations attempted to maximize their holdings; in the last century, organizations realized that stocks were expensive and looked for policies that defined optimal stock levels; most recently organizations have looked for ways of eliminating stocks. This is, of course, only a broad overview and you can find many organizations that work with very high stocks. Shops, for example, keep high stocks so that customers can see a range of goods and do not have to wait for deliveries. In the same way, there are many parts of the world where supplies are still not reliable and when materials become available, organizations buy as much as possible.

Aggregate national stocks

In recent years, organizations have been working to lower stocks without affecting either their own efficiency or customer service. Perhaps we should look for some broad evidence to see how successful they have been. Surveys give some evidence for success, with the Institute of Grocery Distribution finding that stock levels in retail distribution centres fell by 8.5 per cent in the year to 1998 (Institute of Grocery Distribution, 1998), and the Institute of Logistics finding that some UK companies had 'managed to almost halve the stockholding requirements since the 1995 survey' (Institute of Logistics, 1998).

More general evidence comes from government statistics. In the UK aggregate stock holdings are about £100,000 million, divided roughly equally between raw materials, work in progress and finished goods (Office of National Statistics, 2002). There are surprisingly wide changes in this aggregate national stock. Some changes are planned, as organizations adjust their stocks, while others are a consequence of broader economic influences, when, for example, the economy

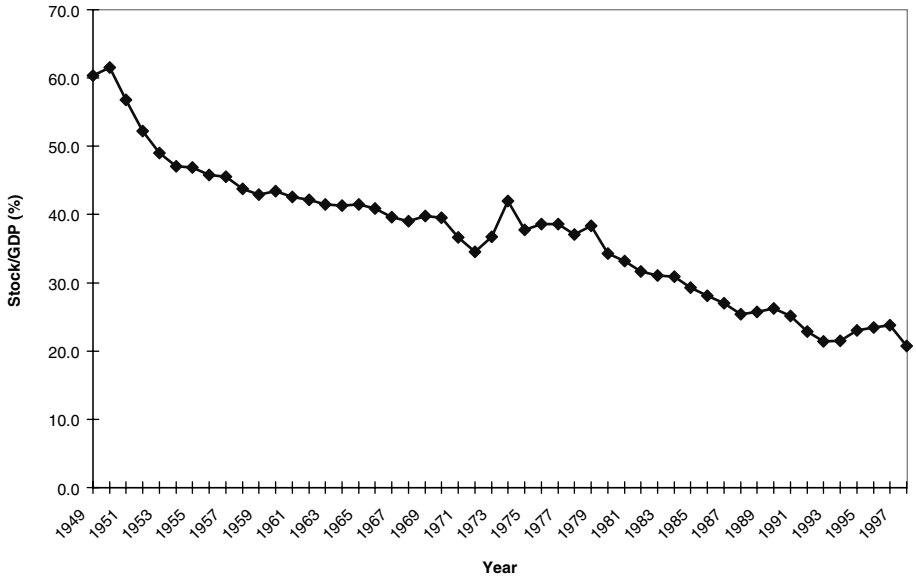

Figure 1.7 Aggregate stock as a percentage of GDP for the UK

declines, sales fall and organizations are left with higher than expected stocks of unsold products. If we consider the aggregate national stock as a proportion of gross domestic product, we get a useful measure that overcomes some effects of changing economic conditions and focuses on the changes which are positively planned. Figure 1.7 shows this result for the second half of the last century (Central Statistics Office, 1966–1983, and 1984–1996).

The figures show a clear pattern. At the end of the 1940s and into the early 1950s there was a rapid decline in stocks as the economy returned to normal after the Second World War. From the early 1950s to the early 1970s there was a steady decline, which gives evidence for improving inventory management. In the early 1970s there was some disturbance caused by a rapid increase in the price of oil, and the economic disruption that followed. At this time, the costs of raw materials rose sharply and there were frequent shortages, while declining sales left finished goods unsold. After this disturbance, the long-term trend continued, with organizations improving their operations and working with ever-lower stocks.

Effects of the business cycle

Aggregate stock holdings are clearly influenced by general economic conditions over which individual organizations have no control. We can illustrate one aspect of this by business cycles. A traditional view of business cycles starts with industry being optimistic about the future. Sales are expected to rise, so production increases to match perceived future demand and the economy expands. Actual sales lag behind this increased production, so there is a build-up of

stock. At some point, industry loses confidence and cuts back on production to reduce the excessive stocks, and the economy contracts. This recession – or at best stagnation – continues until stocks are lower, production is not meeting expected demand, and industry again expands (as shown in Figure 1.8).

Nobody has found a precise cause or explanation for business cycles, and there is a general belief that each cycle is in some ways unique. It is, however, widely accepted that long-term business cycles and stocks are closely related, and that stock levels – as one of the easiest factors to change – tend to fluctuate more than the business cycle itself. One view has variations in stocks as actually causing business cycles. Klein and Popkin (1961) suggest that controlling 75 per cent of the variation in stock levels in the United States between the World Wars would have avoided all recessions. Such findings might encourage governments to prohibit wide fluctuations in stocks by taxes or other means. In practice, such measures have never been tried, mainly because of the difficulties in defining 'excessive' fluctuations and finding a reasonable way of preventing them.

As well as the general economic climate, there are specific reasons for aggregate stock to vary. It is, for example, sometimes suggested that high interest rates should lead to low stocks, as it becomes more expensive to finance them. This argument is not really convincing, as finance is only one of the costs of inventory

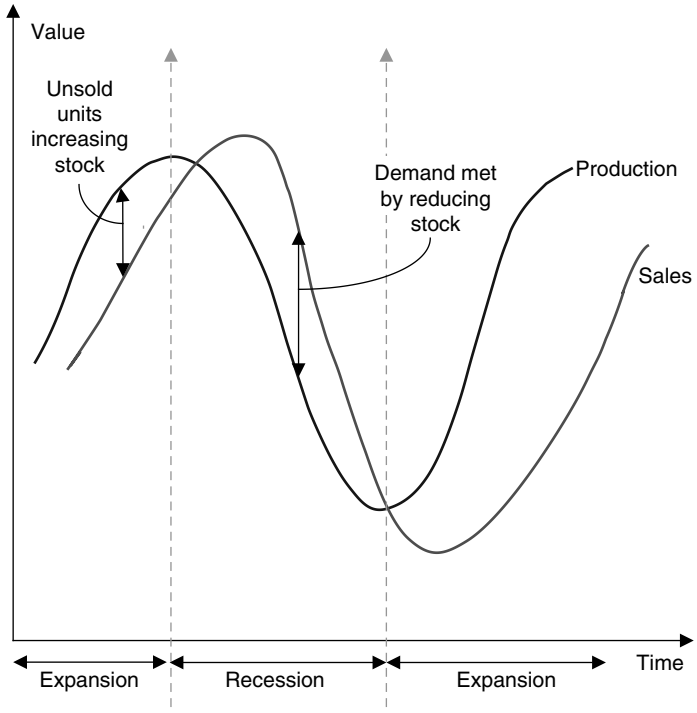

Figure 1.8 Stock levels in a business cycle

and the other costs are so high that a small variation in interest rates should have little effect. More significantly, an organization that can work with lower stocks when interest rates are high should always work with lower stocks and reduce its on-going costs.

A more convincing argument shows the effect of inflation. At times of high inflation stock levels rise as organizations buy more materials at the current lower prices to avoid the higher prices that are likely with future orders. At the same time, the book value of stocks increases, raising the value of assets and making stocks more attractive.

Summary

Attitudes to stocks have changed over time. The current trend is towards lower stocks. This can be seen at a national level, where aggregate stocks show a long-term decline as a proportion of Gross National Product. National stock levels are also affected by business cycles, but the details of this relationship are unclear.

Review questions

1.14 Why are organizations moving towards lower stocks?

1.15 Is the objective of minimizing the costs of stock holding the same as minimizing stock?

1.16 Why do stock levels tend to fall during periods of recession?

1.17 On a national scale, reducing variations in stock levels would reduce the severity of business cycles. Do you think this is true?

Chapter review

- This chapter introduced the ideas behind inventory management, laying the foundations for later chapters. It started by defining some important terms.
- Every organization holds stock of some kind. There are many different materials held and arrangements for storage, but they all need careful inventory management.
- The main purpose of stocks is to act as a buffer between operations. They allow operations to continue normally through variations and uncertainty in supply and demand.
- Stocks are held at various points in their supply chains. In the past these stocks have largely been considered as independent, but there are clear advantages in co-ordinated management.
- Organizations are going through a period of considerable change. Many of these changes have direct effects on stocks. These include trends towards higher technology, improved customer service, global operations, and so on.

- Partly as a result of changing operations, organizations have changed their view of stocks. The current view is that they are expensive and should be reduced to the minimum level that can give acceptable customer service.
- This view has had an effect on aggregate, national stocks, which have been in a long-term decline.

Project

The purpose of this project is to get a view of stock holdings at a national level. Figure 1.7 showed the ratio of aggregate stocks to GDP for the UK during the second half of the twentieth century. Do these figures really show that organizations are deciding to work with lower stock levels or are there other explanations?

Update the figures and see if the trend is continuing. Are there any other factors that could be influencing recent figures? Find comparable figures for other countries. How do these compare with the UK? How can you explain any significant differences?

Discussion questions

1.1 Is it true that every organization holds stock?

1.2 Organizations hold stock to give a cushion between operations. But this stock is expensive, so a better approach would solve any problems and do away with the need for this buffering. Does this seem a reasonable suggestion? If it is, how could we do away with the need for buffers?

1.3 Organizations in a supply chain can never really co-operate, as they compete for available money. Customers should use every available means to pay the lowest price for materials; suppliers should charge the highest prices they can. Is this a more realistic view of relationships in a supply chain?

1.4 Many trends in business have a direct impact on stock management. What do you think are the most important trends at the moment?

1.5 Stock levels are inevitably declining. Eventually we will be able to work without any stock at all. Do you think this is true?

1.6 Why have the stocks in some countries fallen faster than in other countries?

References and further reading

Abramovitz, M. (1950) *Inventories and Business Cycles*. New York: The National Bureau of Economic Research.

Central Statistics Office (1966–1983) *National Income and Expenditure*. London: HMSO.

Central Statistics Office (1984–1996) *United Kingdom National Accounts*. London: HMSO.

Christopher, M. (1996) Emerging issues in supply chain management, *Proceedings of the Logistics Academic Network Inaugural Workshop*, Warwick.
Christopher, M. (1999) Global logistics: the role of agility, *Logistics and Transport Focus* 1(1).
Ellram, L.M. and Krause, D.R. (1994) Supplier partnerships in manufacturing versus non-manufacturing firms, *The International Journal of Logistics Management*, 5(1), 43–53.
The Gartner Group (2002) website at *www.gartner.com.*
Institute of Grocery Distribution (1998) *Retail Distribution 1998*. Herts: IGD.
Institute of Logistics (1998) *European Logistics: Comparative Survey*. Corby: Institute of Logistics.
Klein, L.R. and Popkin, J. (1961) An economic analysis of the post war relationship between inventory fluctuation and change in aggregate economic activity, in *Inventory Fluctuation and Economic Stabilization*. Washington, DC: The Joint Economic Committee.
Lovell, M.C. (1961) Manufacturers' inventories, sales expectations and the accelerator principle, *Econometrica*, 29, 293–314.
Lovell, M.C. (1964) Determinants of inventory investment, in I. Friend (ed.). *Models of Income Distribution*. Princeton, NJ: Princeton University Press.
MRO Software (2001) *Supplying the Goods*. London: MRO Software.
Office of National Statistics (2002) *UK Economic Accounts*. London: HMSO.
Stafford-Jones, A. (1997) Electronic commerce: the future with EDI, *Logistics Focus*, 5(9), 9–10.
Waters, D. (ed.) (2003) *Global Logistics and Distribution Planning*, London: Kogan Page.

Websites

Many websites describe some aspects of inventory management, with the following giving useful starting points

www.apics.org American Production and Inventory Control Society
www.inventorymanagement.com Centre for Inventory
www.cris.com Inventory Control Forum
www.poms.org Production and Operations Management Society
www.iomnet.org.uk Institute of Operations Management
www.theorsociety.com Operational Research Society