1

Introducing logistics

1.1 Definition of logistics

According to a widespread definition, logistics (from the Greek term *lógos*, which means ‘order’, or from the French *loger*, which means ‘allocate’) is the discipline that studies the functional activities determining the flow of materials (and of the relative information) in a company, from their origin at the suppliers up to delivery of the finished products to the customers and to the post-sales service. The origins of logistics are of a strictly military nature. In fact, this discipline arose as the study of the methodologies employed to guarantee the correct supply of troops with victuals, ammunitions and fuel and, in general, to ensure armies the possibility of moving and fighting in the most efficient conditions. Indeed it was the Babylonians, in the distant 20th century BC, who first created a military corps specialized in the supply, storage, transport and distribution of soldiers’ equipment. Logistics was applied exclusively in a military context until the end of Second World War. Subsequently, it was extended to manufacturing companies in order to determine all the activities aimed at ensuring the correct purchasing, moving and managing of materials. Logistics problems are also increasingly present in the service sector, for example in the distribution of some services such as water and gas, in postal services, in urban solid waste collection, in the maintenance of road and electricity networks and in the post-sales activities of manufacturing companies (*service logistics*).

1.2 Logistics systems

From the point of view of companies, logistics is seen as a system (the logistics system), which includes not only all the functional activities determining the flow

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of materials and information, but also the infrastructures, means, equipment and resources that are indispensable to the execution of these activities.

A logistics system is made up of facilities, where one or more functional activities are carried out (e.g. storage and distribution). Figure 1.1 shows a schematic representation of a logistics system in which the manufacturing process of the finished goods is divided into a transformation phase and an assembly phase, performed in different centres. At the start are the suppliers of materials and components which feed the final manufacturing process. The end part represents a typical two-level distribution system with a tree structure. The Central Distribution Centres (CDCs) are directly supplied by the production plants, while each Regional Distribution Centre (RDC) is connected to a single CDC which has the task of serving the customer, who can also be dealers or retailers.

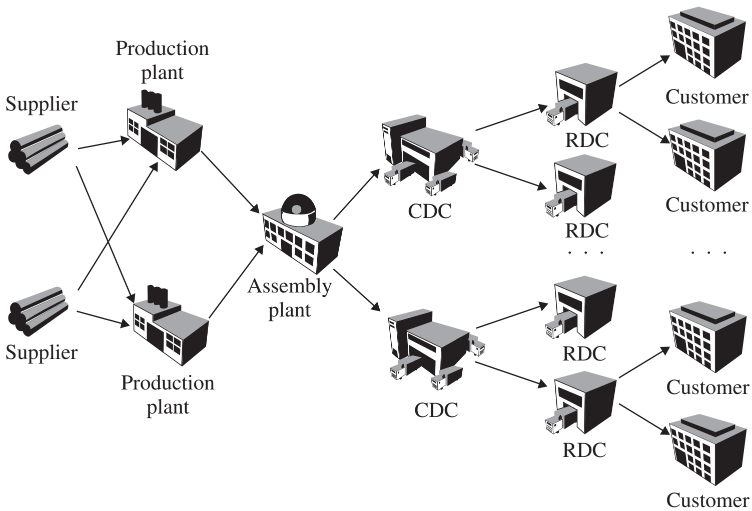

Figure 1.1 Example of a logistics system.

At each facility the flow of materials is temporarily interrupted, generally in order to change their physical-chemical composition, ownership or appearance. In all cases, each logistic activity carried out involves costs which affect the value of the product, constantly adding to it as it draws nearer the facilities closest to the final customer. This added value can be spatial (following e.g. distribution activities) or temporal (owing to storage activities).

Galbani is the Italian leader in the milk and dairy products sector and one of the main actors in the pressed pork market. The Galbani group is currently made up of three independent operational societies, one of them called biG Logistics. This company has the task of managing the logistics activities of the whole group. The logistics system is organized in such a way as to guarantee an efficient synchronization of the internal production and distribution processes of the products, both for the Great Organized Distribution (GOD) and for the channel represented by the traditional retail shops. The distribution network of the company is organized on two levels: there are, between the production plants and the destination markets, a central warehouse and 11 distribution platforms. This solution allows the minimization of the transport times and of the storage times of the goods in the warehouses. As a result, it favours a rapid delivery of the products, strictly respecting the refrigeration chain (deliveries within 12 hours for national distribution and 24 to 36 hours for abroad). The daily products are dispatched directly by the production plants to the central warehouse, located in the area of Ospedaletto Lodigiano, considered a barycentral position with respect to the national markets of the Galbani group. The central warehouse serves, in turn, the second-level platforms with the orders mixed according to their destination (see Figure 1.2). The platforms receive the entering flow of goods from the central warehouse and supply both the Distribution Centres of the GOD and the so-called satellites. The satellites are small-sized stores without stockpiles, with vans used for distribution to retailers. The van operates as a truly travelling store. There are 111 satellites distributed throughout the national territory, with a coverage radius on the provincial scale.

Figure 1.2 Geographical position of the central warehouse (in grey) and the 11 distribution platforms of the logistics system of Galbani.

A logistics system can be represented by means of a directed (multi)graph $G = (V, A)$, where V is the set of facilities, and A is the set of links existing among the facilities used for the flow of materials (see Figure 1.3). There can be several arcs between a pair of facilities, representative of alternative forms of transport services, different routes, or different products.

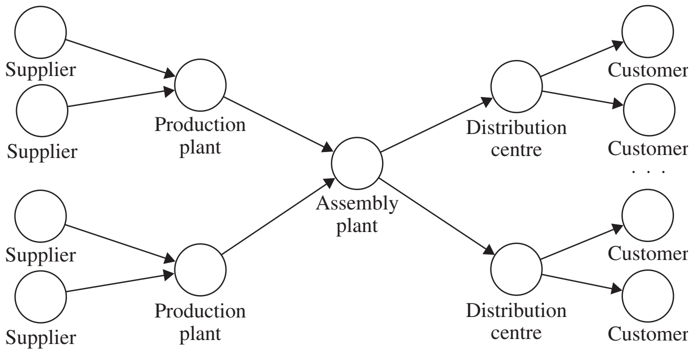

Figure 1.3 Representation of a logistics system system by a directed graph.

The logistics system of Galbani can be represented by the directed graph of Figure 1.4.

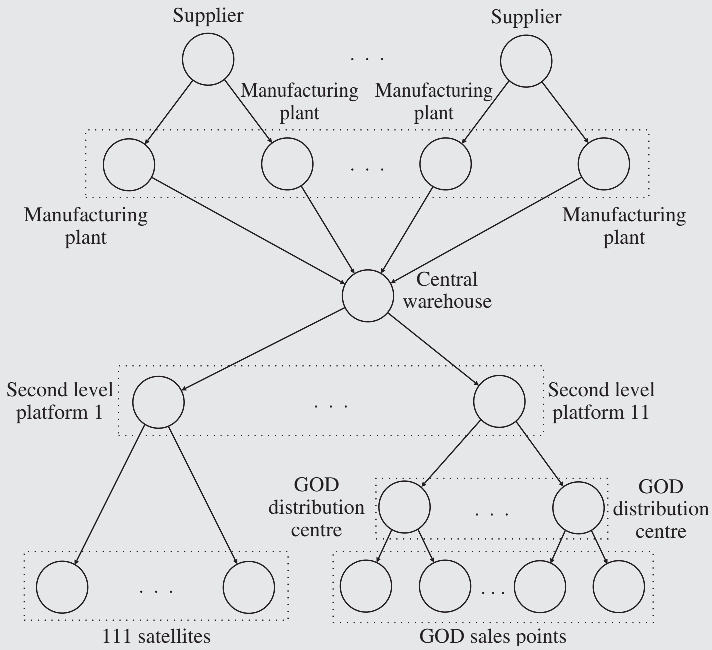

Figure 1.4 Representation by a directed graph of the logistics system of Galbani.

1.2.1 Logistics activities

Logistics activities are traditionally classified depending on their location with respect to the production and distribution process. In particular, *supply logistics* is carried out before the production plants and consists in the management of raw materials, materials and component parts supply as a function of the company's production plan. *Internal logistics* is carried out in the production plants and consists in receiving and storing materials, in picking them up from the warehouse to feed the production lines and in successively moving the semi-finished goods up to packaging and storing the finished product. Finally, the *distribution logistics* activities are carried out after the production plants and before the market. They supply the sales points or the customers. In this schematization, the supply logistics and the distribution logistics are collectively called *external logistics*.

Storage and *distribution* of the finished products are the primary logistics activities, and particular attention will be paid to them in this text. Logistics activities can be conducted by the company itself or can be entrusted to a third party (3PL, or *Third Party Logistics*). These choices are made by the company according to the same logic on which 'make or buy'-type decisions are based. They assume an in-depth knowledge of the nature of the costs that the company bears (fixed costs, variable costs, direct costs, and indirect costs).

When the multinational company Gillette decided to reorganize its logistics system in Turkey in 1999, it entrusted the Exel company with the execution of a series of logistics activities on its behalf, including distribution (both at national and international levels), customs issues, storage of finished products, and repackaging and labelling of the products.

1.2.2 Information flows and logistics networks

Within a logistics system, with the exception of the cases where recycling of product wrapping is provided or where defective components or products are returned, the flow of materials typically moves from the suppliers to the processing and assembly plants, thence to the sales points and finally to the customers. The flow of materials is integrated with an information flow which follows the opposite direction: in the logistics systems of the MTO-type (*Make to Order*), for example, customers' orders influence the production plan and the latter determines the demand for materials and components of the processing and assembly plants. Analogously, in MTS-type (*Make to Stock*) logistics systems, market information (demand recorded in the past, results of possible market surveys etc.) is used to forecast the sales and therefore affects the mode of distribution, as well as the production and supply plans.

The production centres of the Galbani group determine the daily production plan on the basis of recorded predictive data, among others, from the volumes distributed the previous working day. In this case, the 11 logistics platforms gather the sales data recorded both at the GOD and at the satellites, and this information is transmitted to the central warehouse and from there to the production plants.

Hellena is a Dutch company that produces biscuits. The ordering of raw wheat flour is done by fax. Once an order is received and the goods prepared, the supplier provides for the dispatch of the product which must be accompanied by the delivery note. This document must therefore be issued before delivery or dispatch of the goods with specifications of the main elements of the operation (serial number, date, quantity and description of the goods transported etc.) and issued with a minimum of two copies (one must be retained and filed by the supplier and the other must be consigned to the customer together with the transported goods). In this context, two information flows are activated. The first, relative to the sending of the fax, travels in the opposite direction from the transport of the order (from the customer to the supplier) and also uses a different channel. The second, the delivery note, accompanies the consignment, using the same channel as the goods and travelling in the same direction.

An existing information flow (created through fax, email etc.) between a pair of facilities can be represented by an arc. This means that the information network, that is, the set of information flows, can also be represented by a directed (multi)graph, analogously to the network of materials flow.

Networks of materials flow and information networks give rise to *logistics networks* (see Figure 1.5).

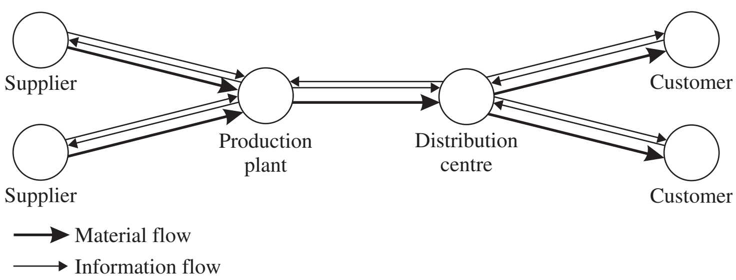

Figure 1.5 Representation of a logistics network.

1.2.3 Case of more products

When a company has to simultaneously handle several products, the logistics system inevitably becomes more complex. It is convenient to group the products into *classes* of different importance, so that the logistics activities can be organized for each class of product and not for each single product.

The ABC classification, which is the most widespread method for this purpose, allows the goods to be subdivided into three classes, called A, B and C, on the basis of the value of the products. The value of the products is typically measurable by means of the revenue generated by them in a reference time span (e.g. a year). In this way, class A is made up of the set of products achieving a corresponding high percentage (e.g. 80%) of the overall annual revenue. Class B is made up of the set of articles associated with the following 15% of the revenue, whereas class C is made up of the remaining articles. The classification is achieved by ordering the list of products in non-increasing values, and successively selecting the articles in the resulting order, up to a predetermined cumulated value.

On the basis of the so-called 80–20 principle, or Pareto principle, founded on the observation that, in 19th-century Italy, 20% of the population possessed 80% of the wealth, class A will account for a modest fraction of the products. In contrast, class C, despite affecting overall revenue only slightly, could be made up of numerous products.

This observation suggests different operating modes with regard to logistics. For example, it is convenient to adopt a distribution over large geographical areas for products of class A, using more CDCs and RDCs, with high stock levels of the products. On the other hand, the distribution of class C products can be made by using a single CDC and reducing the stocked quantity of products to a minimum.

Blucker is the owner of an Irish plant manufacturing products for the building industry. The Cork warehouse is for the storage and distribution to wholesalers of products in the water-based dispersion adhesives category. There are a total of 15 products. Information about the revenue and the annual amounts sold to wholesalers is provided in Table 1.1. The ABC (80–15–5) classification of the products by annual revenue can be deduced from Table 1.2, obtained by ordering the products on the basis of non-increasing revenue value. Class A products make up 78.42% of the annual revenue, whereas they represent only 40.66% of the overall weight of products sold. Class B products represent 15.15% of the annual revenue and have a relative weight of 32.22%, whereas class C products make up only 6.43% of annual revenue; the weight of these products is equal to 27.12% of the overall weight of all products sold in the year. The cumulative percentages of the annual

Table 1.1 Annual revenue and amounts sold of Blucker products.

ID	Article	Revenue [€]	Quantity [kg]
1	FIL12	324 764	38 614
2	BG1	109 000	33 452
3	BG2	959 800	24 522
4	BG3	86 540	25 545
5	P	341 280	24 767
6	TX	156 984	19 768
7	K0	762 250	32 234
8	K1	119 150	17 669
9	K2	51 206	22 600
10	K3	80 596	32 574
11	P-L1	144 625	30 578
12	P-L2	553 600	31 400
13	P-L3	35 608	33 560
14	P-L4	123 720	18 768
15	P-L5	102 300	35 287

Table 1.2 *ABC* classification of Blucker products.

ID	Article	Annual revenue (€)	Annual amounts sold (kg)	Cumulated annual amounts sold (%)	Cumulated annual revenue (%)	Class
3	BG2	959 800	24 522	5.82	24.29	*A*
7	K0	762 250	32 234	13.47	43.58	*A*
12	P-L2	553 600	31 400	20.92	57.59	*A*
5	P	341 280	24 767	26.80	66.23	*A*
1	FIL12	324 764	38 614	35.97	74.45	*A*
6	TX	156 984	19 768	40.66	78.42	*A*
11	P-L1	144 625	30 578	47.91	82.08	*B*
14	P-L4	123 720	18 768	52.37	85.21	*B*
8	K1	119 150	17 669	56.56	88.23	*B*
2	BG1	109 000	33 452	64.50	90.98	*B*
15	P-L5	102 300	35 287	72.88	93.57	*B*
4	BG3	86 540	25 545	78.94	95.76	*C*
10	K3	80 596	32 574	86.67	97.80	*C*
9	K2	51 206	22 600	92.03	99.10	*C*
13	P-L3	35 608	33 560	100.00	100.00	*C*
	Total	3 951 423	421 338			

amounts sold and of the annual revenue for each of the 15 products are plotted in Figure 1.6. The same figure exhibits the 80–20 curve of equation $y = [(1+\alpha)x]/(\alpha + x)$, which best fits the plotted values (y is the cumulative percentage of the annual revenue, x is the cumulative percentage of the amounts sold and $\alpha = 0.238$ is obtained by using the least squares method, see Exercise 1.5).

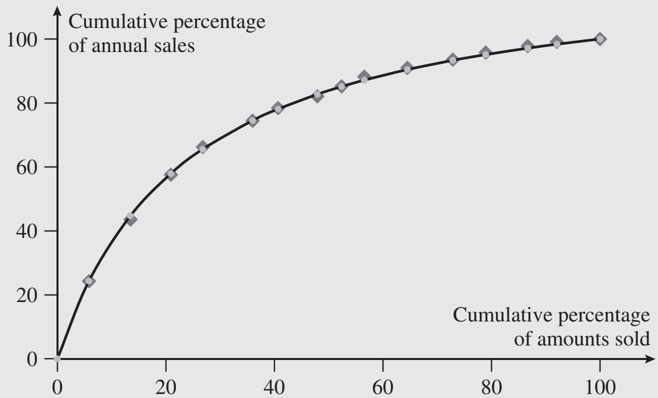

Figure 1.6 80–20 curve for Blucker products.

1.3 Reverse logistics

The life cycle of a product does not finish with its delivery to the end consumer. In fact, it is possible that the product can become obsolete, damaged or otherwise nonfunctional, and must therefore be discarded or sent back to its origin for possible repair.

Reverse logistics is the sector of logistics dealing with product flows (unsold items or returns) from their final destination to the initial producer, or to a facility dedicated to their treatment. Examples of reverse logistics' functional activities include control in the facilities to avoid the unjustified return of products which are only apparently nonfunctional, recovering and collecting unsold items, transporting returns in dumps or disposal centres, or operating in secondary markets. A possible schematization of the flows of materials in a logistics system both direct and reverse is shown in Figure 1.7.

As can be seen from the figure, to effectively and efficiently manage the flows of materials and related information from the point of consumption to the point of origin, reverse logistics may require connections of the original network and the use of specific reverse links. This kind of approach is oriented toward the possibility of regaining value from products that have exhausted their life cycle.

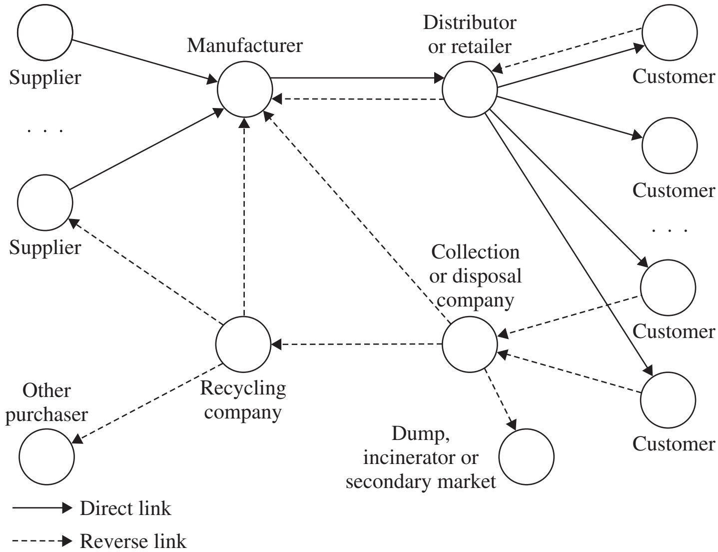

Figure 1.7 Example of a reverse logistics system.

A customer buys a lemon squeezer from a sales point of the German chain MediaMarkt which he subsequently finds to be defective. The customer takes it back to the sales point, which verifies the real defect of the lemon squeezer and then substitutes it with a new, functioning one. The retailer returns the defective lemon squeezer to the appropriate collection centre. This centre credits the sales point with a lemon squeezer, and therefore a debit to the manufacturer is created. The lemon squeezer is sent to the manufacturer who repairs it and sends it to a secondary market. In this way, the manufacturer obtains an added value on the defective product.

1.4 Integrated logistics

Until now logistics has been discussed as an operational tool within a company. It is indeed in this direction that many companies have operated until the 1980s. At that time, however, the increase in competition at all levels (raw materials, finished products, high consumption goods, capital equipment etc.) and a marked reduction in product lifespan have translated into a greater flexibility for the companies, that is, into an increased capacity to adapt more rapidly to the needs of a market in evolution. It is in this economic context that *integrated logistics* arose, that is, the coordinated management, according to a systemic vision, of the logistics activities of different companies involved in the management of the materials and information flows, with the aim of maximizing the overall profitability.

The management of an integrated logistics system yields an increase of the relationships not just among the various functions of a company (marketing, production and logistics) but also in the interactions among different partner companies, which yields an overall competitive advantage.

Integrated logistics can be realized in two different alternative forms.

The first case (*efficiency approach*) relies on so-called *intelligent relations*, that is, on the stipulation of contracts of a strictly operative nature that do not modify the company's own strategies but tend to speed up exchanges with the partners and lead to a reduction of waste and of activities that do not provide an added value.

In the second case (*differentiation approach*), the company tries to forge exclusive alliances with the partners, thus generating unique and privileged relationships that are not replicable by competitors and generate an added value with respect to the competition.

A case of intelligent relations is that of Calzedonia, which uses an ERP software. The system is available on a web portal for the person in charge of purchasing, and provides all the information about orders in real time. When the company decided to adopt this system, it notified its suppliers that orders would no longer be placed by fax, but rather by email. All the confirmations or changes to orders made by email are integrated within the ERP software of the company and flow together into the portal. Thanks to this software, the users of the purchasing office can dedicate their time to activities that generate added value (identify the best prices, create a climate of mutual interests with the suppliers, coordinate themselves etc.) and concentrate on problems of delays to supplies. The suppliers feel more controlled (the delivery date of materials is a precise date) and also more responsible with regard to respecting deadlines. All this leads to a better planning of production by the company and, in general, to a greater competitiveness of the integrated logistics system.

An example of a differentiation strategy is the alliance between Nokia, a Finnish company specializing in the manufacture of cellular telephones, and Yahoo!, an American company supplying broadband services, electronic mail etc. The agreement is not only about mutual support and market share increase but also a challenge to rival companies, such as Apple and Google, which offer wireless services. By making available the integration of its OVI Maps, Nokia has become an exclusive global supplier for the navigation services and maps of Yahoo! On the other hand, Yahoo! made its own messaging technology available to Nokia exclusively. Yahoo! has therefore become the official supplier of Ovi Mail and Ovi Chat. To guarantee a maximum quality service for its own customers, the two companies benefit from advantages relative to their respective global distribution structures and the joint strength of their own brands.

1.5 Objectives of logistics

In this chapter, logistics has been introduced without mention of the objectives to be pursued. These can be characterized by three variables: costs, profits and service level.

Costs. The costs of logistics activities are the financial resources consumed by the company when carrying out these activities. They are divided into fixed and variable costs. The main cost categories of a logistics system are summarized in Table 1.3.

Table 1.3 Main cost categories of a logistics system.

Main cost categories	Fixed costs	Variable costs
Storage costs	Administrative costs Running costs of storage centres	Insurance policies Financial burdens and opportunities costs Deterioration costs Obsolescence costs
Operational management costs	Administrative costs of issuing and computing orders	Loading and unloading goods costs Movement costs Stock control and management costs Packaging costs Deferment of takings Forfeits
Stockout costs		Lost sale Loss of customer Loss of image
Transport costs	Devaluation of means of transport Rental of means of transport	Insurance costs Variable transport costs
Plant and equipment costs	Rates of plant devaluation	Rental fees (variable according to volume)

Profits. Logistics activities affect company profits, even though, contrary to costs, the impact of logistics operations on sales is difficult to quantify. For this reason, the sole objective of profit maximization is not very practical from the point of view of logistics.

Service level. The service level encompasses the overall degree of customer satisfaction and depends on numerous factors (indicated collectively as *marketing* *mix*), connected to the product characteristics, price, promotional offers and mode of distribution. It is possible to quantify the service level, as will be shown in this chapter, by using suitable indicators.

Company profits are directly connected to the service level offered to customers. For example, it has been experimentally tested that an effective and efficient organization of the distribution service yields a direct increase in market share.

One possible objective of logistics is to minimize costs in a reference time horizon (e.g. a year), while keeping the service level unchanged. Alternatively, the objective could be to determine the optimal service level for maximum profit (difference between revenues and costs) in a reference period. In general, the maximization of profit is obtained for high (but less than maximum) values of service level.

Ecopaper is a Turkish company producing various kinds of paper (glossy, chemical, adhesive etc.) as well as derivative products (e.g. gift-wrapping paper). It distributes them to various kinds of customers (specialized shops, GOD, advertising agencies etc.). The market in which it operates is highly competitive, and delivery time is seen to be a key factor for the company's success.

Ecopaper can act on the distribution system, in particular on the number and location of the distribution centres, guaranteeing different delivery times. The logistician has made available the following estimates about the annual costs of distribution and the relative sales, as a function of different levels of logistic service (see Table 1.4).

Table 1.4 Annual estimate of sales, costs and profits (in M€) of Ecopaper.

	Orders dispatched within 3 days [%]				
	60	70	80	90	95
Sales	4.00	5.00	7.00	9.00	10.50
Costs	1.80	3.00	3.50	6.00	7.10
Profits	2.20	2.00	3.50	3.00	3.40

As can be seen from the table, organizing the distribution system so as to guarantee 80% of deliveries within three days of issuing an order leads to a maximization of profits. This is due to the savings that can be generated by optimizing the number of distribution centres.

1.5.1 Measures of the service level

The most widespread way of measuring the service level of a logistics system is through the quantification of the *order-cycle time*, defined as the time interval from the issuing of an order (or request of service) to the delivery of the product (or completion of the service). The main logistical components of the order-cycle time are the order processing time (checking for errors in the order, preparation of the shipping documents, updating of the store inventory etc.), the availability of the products in the warehouse, the assembly time of the products making up the order (withdrawal from a storage point or creation of packaging for transport) and the shipping time (movement of products from the storage point to delivery point, including loading and unloading of the goods).

In general, it is not possible to know a priori with certainty the duration for each of these operations, given that several internal and external random factors affect the company's logistics system. For this reason, each component of the order-cycle time can be formally represented only by a continuous random variable, which has an unknown probability distribution but can be estimated on the basis of historical data gathered within the company. The two most significant quantities used to characterize a random variable are the mean and the standard deviation. These can be estimated by the sample mean and the sample standard deviation.

Consequently, the order-cycle time can also be represented by a continuous random variable, whose probability distribution is obtained from the probability distributions of the individual time components.

The English company MobilTrust has an order-cycle time for its products which essentially depends on two elements: the assembly time and the transport time. Five hundred observations on assembly time and 252 recorded transport times are available. The minimum observed value of assembly time is 2.3 days and the maximum is 15.9 days, whereas the minimum transport value is 6.9 days and the maximum is 13.2 days. For simplicity, it is convenient to express the available historical values in integer numbers of days. Table 1.5 shows the number of observations and the related discretized time values.

Let X and Y be the independent continuous random variables associated, respectively, with the assembly time and with transport time. The set of values observed for the assembly time is indicated by Ω_X ($\Omega_X = \{2, 3, \dots, 16\}$). Let h_i be the number of observations recorded for every value $x_i \in \Omega_X$ (e.g. $h_3 = 4$). Analogously, let Ω_Y be the set of values observed for the transport time and k_j the number of observations recorded for every value $y_j \in \Omega_Y$.

Table 1.5 Historical data of assembly time and transport time (in days) of MobilTrust.

Assembly		Transport	
Number of observations	Time	Number of observations	Time
1	2	19	7
4	3	27	8
4	4	54	9
18	5	65	10
38	6	48	11
56	7	25	12
69	8	14	13
96	9		
72	10		
68	11		
41	12		
18	13		
12	14		
2	15		
1	16		

The sample mean $\bar{X}$ and the sample standard deviation S_X of X are obtained in the following way:

$$\bar{X} = \frac{\sum_{i=1}^{|\Omega_X|} h_i x_i}{\sum_{i=1}^{|\Omega_X|} h_i} = 9.13 \text{ days};$$

$$S_X = \sqrt{\frac{\sum_{i=1}^{|\Omega_X|} h_i (x_i - \bar{X})^2}{\sum_{i=1}^{|\Omega_X|} h_i - 1}} = 2.3 \text{ days}.$$

Similarly, the sample mean and the sample standard deviation of the transport time ($\bar{Y}$ and S_Y) can be calculated:

$$\bar{Y} = 9.9 \text{ days};$$

$$S_Y = 1.55 \text{ days}.$$

Using a simple hypothesis test, it can be verified that the two random variables can be assumed to be normally distributed with a mean and standard deviation equal to the sample values.

The random variable Z associated with order-cycle time is, therefore, the sum of the independent random variables X and Y. Since X and Y are normally distributed, Z is also a normal random variable, with mean and standard deviation estimated by the sample values:

$$\bar{Z} = \bar{X} + \bar{Y} = 19.03 \text{ days};$$

$$S_Z = \sqrt{S_X^2 + S_Y^2} = 2.77 \text{ days}.$$

Figure 1.8 shows the probability density functions corresponding to the observed values of the random variables associated with assembly time, transport time and overall supply time.

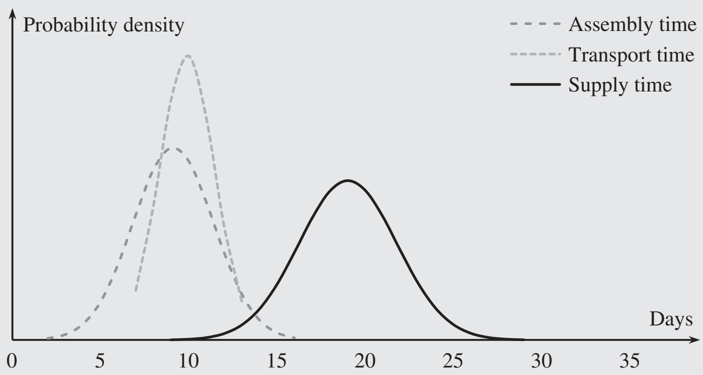

Figure 1.8 Density probability functions of assembly time, transport time and supply time for the problem of MobilTrust.

The coefficient of variation, which is defined as the ratio of the standard deviation and mean of the order-cycle time, can be used as a measure of the *reliability* of the service offered to the customers. The lower the value of this index, the greater the reliability.

Lugan is a Chilean chain of supermarkets which entrusts the task of supplying all its sales points to a transport company. Since the key factor for being competitive in the reference market is punctuality with the deliveries, the choice must be in favour of the most reliable operator. Two transport companies (A and B) were tested, to carry out the deliveries starting from the same distribution centre to the same sales point. The sales point was chosen among

Table 1.6 Historical data of service times (in hours) of operator *A* in the problem of Lugan.

Number of observations	Loading time	Journey time	Unloading time	Overall time
7	0.20	2.08	0.11	2.39
8	0.22	2.09	0.10	2.41
11	0.22	2.13	0.07	2.42
19	0.22	2.18	0.13	2.53
32	0.19	2.38	0.10	2.67
19	0.24	2.40	0.07	2.71
10	0.17	2.69	0.12	2.98
8	0.17	2.78	0.09	3.04

Table 1.7 Historical data of service times (in hours) of operator *B* in the problem of Lugan.

Number of observations	Loading time	Journey time	Unloading time	Overall time
32	0.23	1.50	0.60	2.33
7	0.25	1.50	0.10	1.85
10	0.19	1.30	0.50	1.99
8	0.20	1.50	0.78	2.48
8	0.13	1.55	0.05	1.73
7	0.36	2.30	0.07	2.73
32	0.25	1.35	0.75	2.35
10	0.17	1.20	0.09	1.46

those whose product demand, in value, has maintained unchanged levels over time. The data shown in Tables 1.6 and 1.7 were obtained from observations in the field.

The overall service times of the two suppliers can be represented by means of normally distributed independent random variables T_A and T_B normally distributed, with a mean and a standard deviation estimated by the sample values:

$$\bar{T}_A = 2.65\,\text{hours};$$

$$S_{T_A} = 0.19\,\text{hours};$$

$$\bar{T}_B = 2.19\,\text{hours};$$

$$S_{T_B} = 0.33\,\text{hours}.$$

On the basis of the mean value of the overall service time of the two operators, the company would tend to choose operator B ($\bar{T}_B < \bar{T}_A$). However, the values of the coefficients of variation of the two variables, equal respectively to $V_{T_A} = S_{T_A}/\bar{T}_A = 0.073$ and $V_{T_B} = S_{T_B}/\bar{T}_B = 0.151$, suggest, in contrast, choosing operator A, who proves to be the most reliable of the two.

Other possible measures of service level can be ascribed to the level of transport efficiency (e.g. the percentage of dispatches completed within a prescribed time) and to the integrity, precision and completeness of the orders (e.g. the percentage of orders dispatched within a prescribed time).

1.6 Management of the logistics system

Within a company, the management of the logistics system is the transverse process of planning, organizing and controlling the logistics system.

Planning means taking the best decisions possible, according to the predetermined objectives of the logistics system.

Organizing refers to organizing the human resources directly involved in logistics activities within a company organizational chart, so as to attain the company's objectives, effectively and efficiently.

Control means measuring the performances of the logistics system according to the qualitative and quantitative standards requested by the company management, and possibly initiate corrective actions when the results are not in line with the objectives.

The planning, organization and control phases of the logistics system arise in sequence: planning human resources involved in logistics can occur only after the planning phase of the logistics system. In the same way, it is not thinkable to measure to which extent the objectives of the logistics activities have been attained if the company organizational chart is not first defined in terms of human resources assigned to these activities.

1.6.1 Planning phase

The planning of the logistics system prevalently considers the following *decision-making areas*: forecasting, location, supply, storage and distribution.

Forecasting is the process of estimating the uncertain parameters that characterize the logistics system. The forecasts serve to correctly size the logistics system, to define the production capacity and the correct stock level, to work out plans and production programmes, to organize transport and so on. Chapter 2 will be dedicated to forecasting methods in logistics.

Location is the activity by which the optimal location of the facilities is determined, both in the planning phase of a logistics system and in the reorganization of an existing one. The main problems of location in the logistics context will be illustrated in Chapter 3.

Supply is the decision-making area that concerns all the logistics activities relative to the purchasing of raw materials, semi-finished goods or supply services. The decisions regarding this area largely depend on the specific company context. Chapter 4 will deal with the main decision-making problems regarding management of the suppliers.

Storage and distribution are decision-making areas for which logistics activities are of primary importance.

In these contexts, but not exclusively, logistics planning can be organized at three different decision-making levels: strategic, tactical and operational.

Strategic decisions, or long-term choices, have a long-term effect (more than a year) on the logistics system and typically involve major financial investments; therefore, these decisions are unlikely to be reversible in the short term. They are generally based on forecasts relative to aggregated data (e.g. regional demand for families of similar products). *Tactical decisions*, or medium-term choices, refer to the use of available resources and are usually based on forecasts. They are carried out with an annual, seasonal or monthly frequency. *Operational decisions*, or short-term choices, concern the definition of weekly or daily work plans for the staff and for the material resources. They use data from the surrounding environment (orders issued by customers, information on the state of the warehouses and on the availability of vehicles, news of strikes in the transport sector etc.) and the results of forecasts. Logistics planning relative to the areas of storage and distribution will be dealt with specifically in Chapters 5 and 6. Table 1.8 classifies logistics decisions depending on the strategic, tactical or operational level, which will be discussed in the following chapters.

The organizational and control activities of the logistics system will be the object of a deeper examination in Sections 1.6.2 and 1.6.3.

1.6.2 Organizational phase

The various organizational decisions made by a company determine its distribution of responsibilities and tasks. These are influenced by different factors, such as the sector in which it operates, the culture of the company (beliefs, values and expectations shared by the members of the organization), the technology employed (the greater the use of advanced technology, the slimmer the organizational structure) and the company size (small companies typically have a sole decision maker, whereas in medium-large ones power must be delegated and functions must be created to establish the relationships of authority).

Logistics in a company is a primary activity which can be illustrated by adopting a traditional mode of presentation of organizational structures: *functional*, *divisional* and *matricial*.

Table 1.8 Examples of strategic, tactical and operational decisions within the decision-making area of storage and distribution.

Decision-making area	Planning level		
	Strategic	Tactical	Operational
Storage	Warehouse planning Selection of warehouse equipment Choice of warehouse layout	Allocation of the products at storage points Choice of inventory policies for the products in stock in the warehouse	Pickup of products from the storage area Consolidation of products in the loading unit
Distribution	Choice of transport mode	Freight assignment on the transport network	Vehicle routing
	Fleet sizing and composition	Transport service network design	Repositioning of vehicles and empty containers
		Vehicle assignment	Consolidation of the shipping orders
		Crew rostering Determination of the vehicles to be rented	

1.6.2.1 Logistics in companies organized according to the functional model

The functional structure is based on principles of work subdivision and specialization. Similar activities, requiring analogous skills and the same kind of resources, are grouped within *functions*. A function is associated to a department, headed by a director.

In a functional structure, the management level deals with strategic decisions, whereas the tactical and operational decisions are delegated to functional areas.

The functional structure is suitable to small- or medium-sized organization. It is directed towards objectives of efficiency which generally offer products or services with a low degree of diversification, and use a stable technology in an economic environment of little uncertainty.

The advantages provided by such a structure can be found in the efficient use of the resources available and in the simplicity of the hierarchical control and communication within the functional areas.

In contrast, the interdependence among work flows is not sufficiently taken into consideration, and it is possible that a lack of coordination occurs among the functions because of divergences of interests and objectives. A functional-type structure (which by nature is not very flexible) is, in fact, often incapable of tackling production diversification or increased turbulence in the outside environment. Moreover, an increase in the company size often comes with a loss of control (slowing of the decision-making process) because each department becomes overloaded with responsibilities.

The functional structure cannot explicitly contain a logistics function (see Figure 1.9). This is possible only if there exists a real climate of support among the various company functions. Coordination among the areas of responsibility for key logistics activities, such as inventory management and transport, can be obtained in an informal way by means of incentives systems, for example.

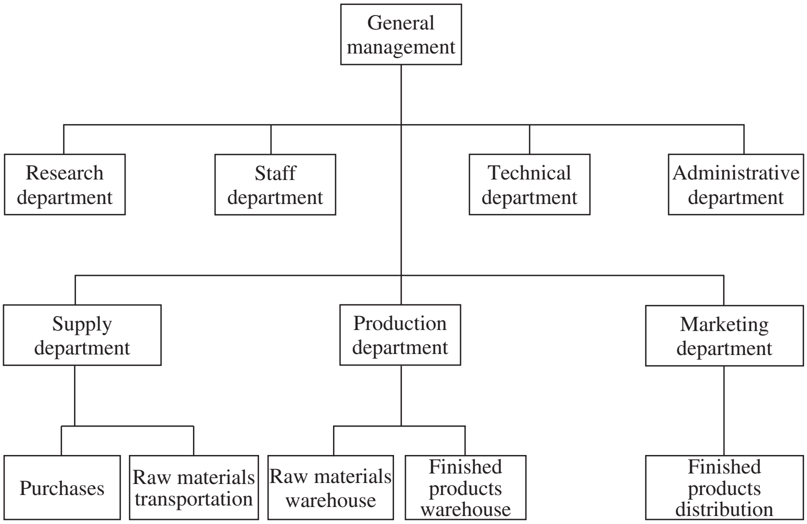

Figure 1.9 Functional-type organizational chart where the logistics activities are separate.

A similar structure is suitable, for example, for organizations achieving a great production output for many customers, widely distributed over a territory. These are generally food, chemical and clothing companies, which do not have a particular supply problem (a limited amount of raw materials) and whose production plants often run on a continuous cycle. One of the most difficult problems is the distribution of finished products since it is necessary to contain the distribution costs and, at the same time, be competitive in a typically mature market.

Alternatively, the logistics function can depend directly on the general management (see Figure 1.10).

The number of underlying activities is the correct compromise among the objectives of efficient coordination (which drives towards their reduction) and technical effectiveness (which drives towards their subdivision). Each of these is under the control of a manager who answers directly to the logistics department to whom the coordination activities are entrusted.

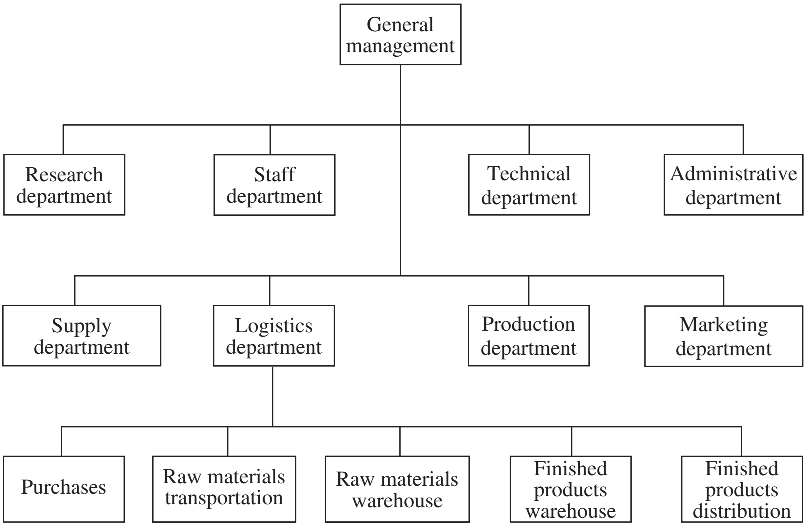

Figure 1.10 Functional-type organizational chart where the logistics management depends directly on the general management.

The Swiss company Akira Foods specializes in the production and wholesale and retail marketing of food products. The organizational chart depicted in Figure 1.11 mirrors a functional structure in which the logistics, owing to its great importance for the organization, has an autonomy equal to that of

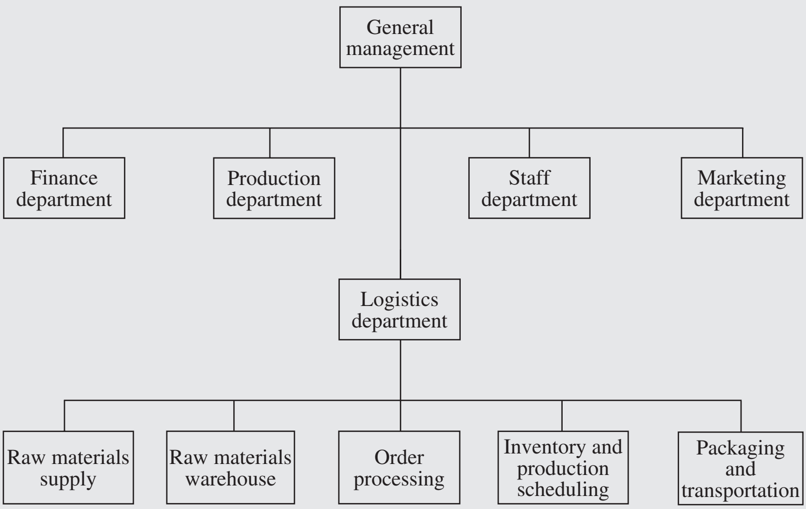

Figure 1.11 Organizational structure of Akira Foods.

the other functions and coordinates numerous activities. Through the use of this organizational structure, the company is able to guarantee high levels of service to its customers represented by numerous retailers and supermarkets operating in the Swiss market.

An organizational model of this type is also suitable for companies with after-sales logistics problems, such as those arising in the electronic, mechanical and automobile sectors. In these cases, a company should prefer a structure in which the logistics function is highly developed and depends directly on the general management.

To optimize the company's commercial policies and its distribution process, it may be preferable to subordinate the logistics functions to the marketing department (see Figure 1.12).

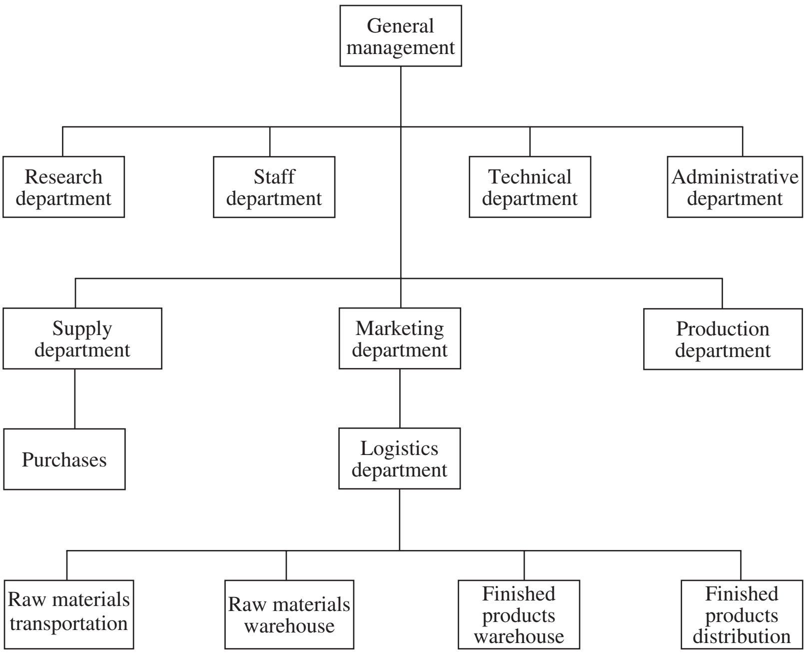

Figure 1.12 Functional-type organizational chart where the logistics department depends on the marketing department.

Another functional-type structure variant is one in which the materials department controls the logistics activities (see Figure 1.13). This choice is adopted by companies that manufacture complex products (in general to order). After the production phase, the problems of distribution and marketing are limited to

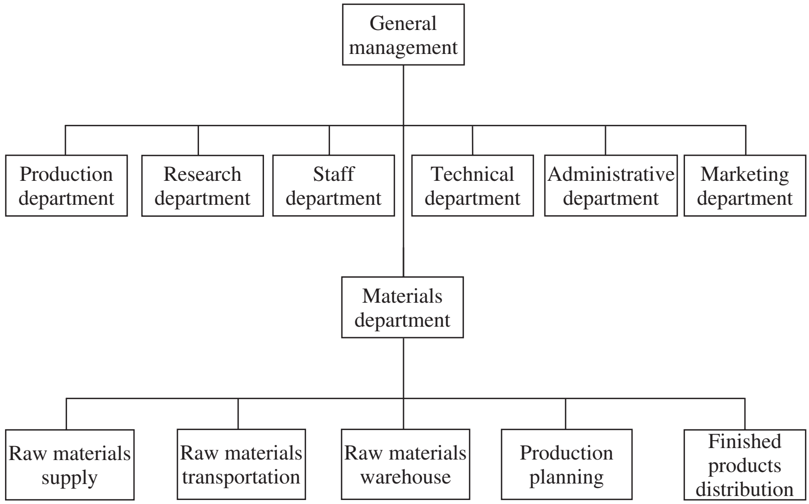

Figure 1.13 Functional-type organizational chart where the logistics activities depend on the materials department.

transport to customers, assembly operations and after-sales problems. There are often numerous materials to manage, with demand distributed over time, and the production is made up of different phases so that precise and continuous control is necessary.

When it is necessary to introduce a new product in the company, it is possible to adopt the variant of functional structure per project (see Figure 1.14). In this case, a specific project is created for the life cycle of the new product. It involves resources pertaining to several company functions, including logistics. Typically, a project embraces activities such as planning, manufacture, materials flow, delivery and customer support during the use of the new product. Moreover, a

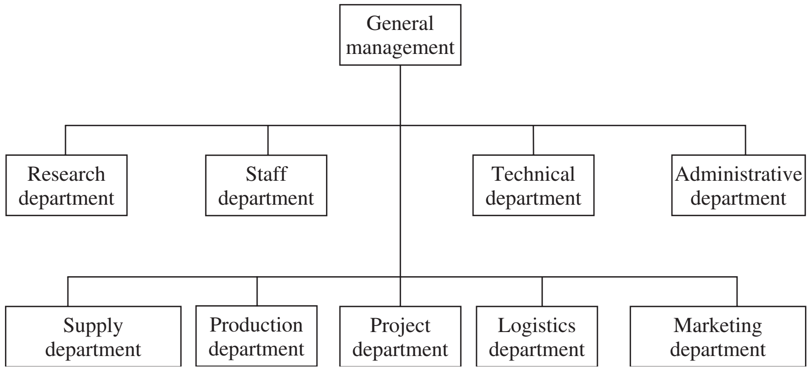

Figure 1.14 Functional-type organizational chart with a project manager.

temporary staff person becomes the project manager, whose task is to coordinate all the resources involved so as to avoid conflicts and to optimize collaboration.

1.6.2.2 Logistics in companies organized according to the divisional model

Divisions are completely autonomous operational structures that behave like independent businesses. They plan, create and market products or services within their own areas of competence. Each division, entrusted to a manager who has total responsibility for it, is organized entirely according to a functional-type logic.

The subdivision of the company organizational chart into divisions can be operated on the basis of products or services, geographical areas or markets. The general management is responsible for strategic decisions. It deals with the allocation of resources to the different divisions, chooses the portfolio products, checks on the divisional managers and coordinates the latter by means of appropriate staff entities.

The single divisions are responsible for product or service strategies and operational decisions. This structure is also adapted to large companies (it allows the creation, at least ideally, of an unlimited number of divisions), even operating in turbulent competitive markets (divisions allow more flexibility in the organization, which is needed to quickly react to outside changes).

By adopting a divisional logic, a company is in a better position to face the proliferation of products or services (possibly within a diversification strategy) and the continuous technological development of the market to which it belongs.

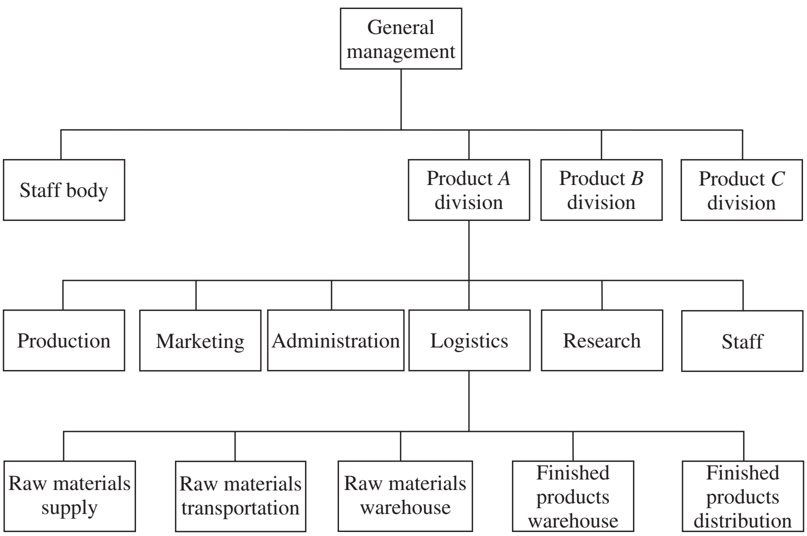

Figure 1.15 Divisional-type organizational chart (subdivision into divisions on the basis of products).

However, if the power of the divisional managers is favoured, the opportunities for exchange of knowledge among specialists are reduced. The duplication of jobs not only generates an increase in structural costs but also can create rivalries between the different divisions. Moreover, there is a risk that short-term objectives, in particular immediate divisional results, will be favoured, and that the general business objective of the company will be lost.

The logistics function (as illustrated in Figure 1.15) is placed like the others within each division for which, as already mentioned, a functional logic is used. This means that each division can adopt its own organization, as discussed in this chapter.

Varsth is a multinational company registered in Denmark. The production plants of the company are distributed in three geographic areas: Europe, North America and South America. The company produces and markets three lines of product: washing machines, television sets and small electrical appliances, respectively P_1, P_2 and P_3. The production of the three lines occurs independently, whereas the commercial channels used for the sales are common to all products. The organizational structure of Varsth (represented in Figure 1.16) is the divisional type (on the basis of the specific geographic

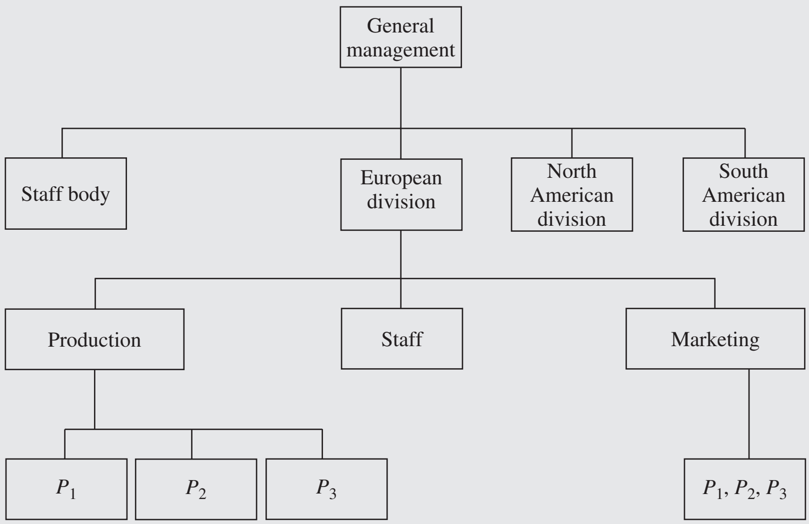

Figure 1.16 Organizational chart of Varsth.

reference area), and there is a functional grouping of the production and marketing units within each division. The former is subdivided among the three product areas, whereas the latter is identical for all three lines.

1.6.2.3 Logistics in companies organized according to the matrix model

The matricial organizational structure is adopted by large-size companies that create complex products with a short, medium or long high-technology life cycle. These companies conduct multiple projects simultaneously, relative to several products or business areas, each of which must satisfy the specific requirements of their customers or users (also by means of high differentiation strategies).

The matrix structure couples the organization's functional elements with its divisional elements. Technicians and specialists belonging to different functions are in fact assigned to one or more project groups, coordinated by a project manager. There are therefore two simultaneous lines of authority (function and project) even if usually, depending on the specific case, one dimension proves dominant.

Such an organizational structure is well suited to turbulent economic markets and favours elements like motivation and staff development. The resources are in fact specialized and coordinated so as to attain specific results effectively and efficiently.

The dual hierarchical dependence can, however, generate confusion and conflict owing to the presence of different commands. Therefore, one needs to establish various coordination mechanisms to favour cooperation among managers, with resulting increased operating costs. Moreover, it is possible that the fragmentation of objectives will generate a lack of overall vision in the business.

The activities of function logistics are assigned to the different projects that involve them.

The functional manager is responsible for the logistics system overall but does not have direct authority over the component activities where he or she shares authority with different project managers.

A simplified example of a matricial organizational chart is provided in Figure 1.17.

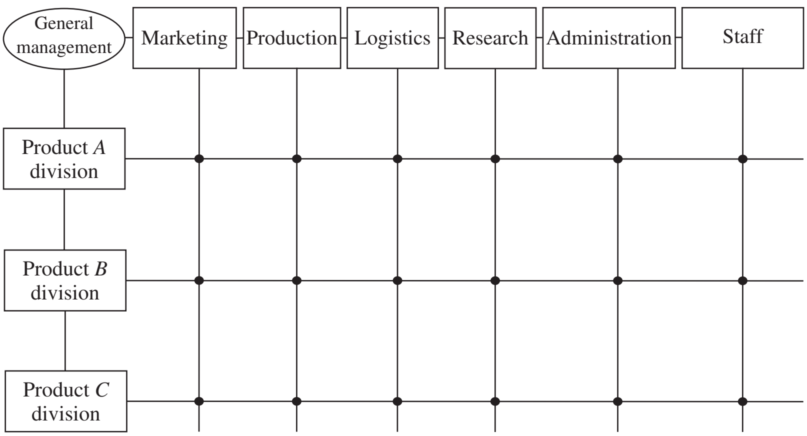

Figure 1.17 Matricial organizational chart.

Fashiondream is a company operating in the Swiss market. It makes and markets three different products: clothes, underwear and shoes. A specific project is coordinated by a manager for each product. In order to use the staff of the different functions adequately, the project groups share resources so that the employees develop the in-depth knowledge that is necessary to serve the three product lines effectively. Figure 1.18 depicts the organizational structure of Fashiondream.

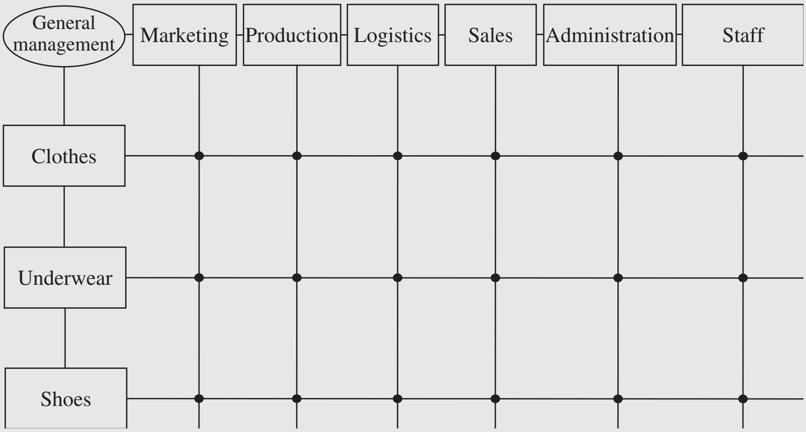

Figure 1.18 Fashiondream matricial organizational chart.

1.6.3 Control phase

The control system of the efficiency of the logistics system requires defining indicators used for monitoring the logistics activities. These are known as *key performance indicators* (KPIs).

It should be noted that there is no generally valid predefined set of KPIs, but their choice is determined by the specific logistics system considered and, in particular, by the classification, based on their importance, of the company logistics activities and by the nature of these activities' objectives. The KPIs are generally classified into several *families*, typically belonging to three distinct categories:

– *volume*, to measure the quantity of work involved in a logistics activity belonging to this category;

– *effectiveness*, to measure the quality of the output provided by a logistics activity belonging to this category;

– *efficiency*, to measure the costs generated by the functioning of a logistics activity belonging to this category.

Each KPI is measured according to a suitable metric that can vary from case to case. To make all the measures homogeneous and reach a synthetic and coherent 'control panel', a normalization operation for each single indicator is needed, transforming it from the initial scale of measure (strictly correlated to the individual KPI) into a single and homogeneous scale.

To summarize, the phases that make up the control system of the logistics system by means of a KPI control panel are the following:

1. classification of the logistics activities and definition of the objectives to pursue;
2. identification of the KPIs subdivided by families;
3. creation of the control panel.

Borg is a Canadian company producing wooden objects. Owing to many management problems resulting from a recent organizational restructuring, the new logistician has been charged with the monthly monitoring of the most critical logistics activities.

When designing a logistics control system by means of a KPI control panel, it was found that the most significant problems were connected to the high number of complaints received about errors in dispatched orders, frequent delivery delays, an incorrect policy of stock management, a disproportionate overstaffing in the warehouse and its effect on costs, the inefficiency of the transport system and its impact on distribution.

The logistician therefore identified 19 KPIs, subdivided into eight families and calculated with a monthly frequency. These KPIs are described in Table 1.9, in which the computing method used for each of them is also indicated.

The KPIs were calculated in March of the present year and were normalized in the interval [1, 10], using the min-max normalization procedure (which will be described in detail in Section 2.4.7) on the historic series composed of the last 12 dates available for each KPI (from April of the previous year to March of the present year). The values obtained are shown in Table 1.10.

The logic of the normalization procedure is that for each KPI, independently from its meaning, the normalized value equal to 1 corresponds to the worse value (e.g. the minimum number of orders or the maximum number of complaints per month), whereas 10 is the best one.

Every KPI within its own family was weighed in a suitable way (with the sum of the weights of the KPIs of every family equal to 1), so as to find a single efficiency value for every family of KPI. Table 1.11 shows these values, together with the weights chosen for each KPI in the month considered.

Table 1.9 KPIs for the Borg logistics system.

Family	KPI	Computing method
Dispatch of orders	Number of orders	Total orders received in the month/days in the month
	Complaints	Number of complaints per month
	Extent of completeness	Order lines dispatched overall in the month/order lines inserted overall in the month
	Errors on order lines	Order lines with errors found by complaints in the month/order lines inserted and not cancelled in the month
	Errors on orders	Number of orders with delivery in the month/total orders received in the month
Punctuality	Deliveries dispatched within delivery time window	Number of lines dispatched in the month within the delivery time window/total number of lines dispatched in the month
	Value of deliveries dispatched within delivery time window	Value of quantity dispatched in the month within the delivery time window/total value of quantity dispatched in the month
Staff	Warehouse employees	Monthly average of number of employees daily employed in the warehouse
	Effective employees	Monthly average of effective daily employees/monthly average of nominal daily employees
	Productivity of warehouse employees	Monthly total average of daily movements/monthly average number of warehouse employees
Warehouse	Warehouse movements	Monthly average of daily movements
	Pick-up operations	Monthly number of movements/monthly number of order lines dispatched
Inventory	Recoveries	Monthly cumulated value of economic-financial savings deriving from recoveries
	Warehouse value	Overall monthly value of inventory

Table 1.9 (*continued*)

Family	KPI	Computing method
Transport	Deliveries per journey	Monthly average number of customers served by a route
	Trip saturation	Monthly average amount of goods dispatched per vehicle/vehicle capacity
	Trip forecast	Trips planned in the month/ effective trips in the month
Costs	Budget	Monthly costs/monthly budget
Reliability	Reliable deliveries	Monthly order lines delivered correctly on time/total monthly order lines

Table 1.10 Normalized KPI values for the Borg logistics system in the considered month.

Family	KPI	Value
Dispatch of orders	Number of orders	4.72
	Complaints	6.21
	Extent of completeness	5.77
	Errors on order lines	7.83
	Errors on orders	6.34
Punctuality	Deliveries dispatched within delivery time window	6.33
	Value of deliveries dispatched within delivery time window	4.21
	Warehouse employees	5.40
Staff	Effective employees	7.23
	Productivity of warehouse employees	6.42
Warehouse	Warehouse movements	6.27
	Pick-up operations	5.96
Inventory	Recoveries	4.46
	Warehouse value	6.24
	Deliveries per journey	7.28
Transport	Trip saturation	6.34
	Trip forecast	7.22
Costs	Budget	7.25
Reliability	Reliable deliveries	4.88

Table 1.11 Performance of the KPI families for the Borg logistics system in the considered month.

Family	KPI	Value	Weight	Family performance
Dispatch of orders	Number of orders	4.72	0.20	
	Complaints	6.21	0.25	
	Extent of completeness	5.77	0.18	6.13
	Errors on order lines	7.83	0.17	
	Errors on orders	6.34	0.20	
Punctuality	Deliveries dispatched within delivery time window	6.33	0.60	5.48
	Value of deliveries dispatched within delivery time window	4.21	0.40	
Staff	Warehouse employees	5.40	0.35	6.31
	Effective employees	7.23	0.30	
	Productivity of warehouse employees	6.42	0.35	
Warehouse	Warehouse movements	6.27	0.60	6.15
	Pick-up operations	5.96	0.40	
Inventory	Recoveries	4.46	0.30	5.71
	Warehouse value	6.24	0.70	
	Deliveries per journey	7.28	0.30	
Transport	Trip saturation	6.34	0.50	6.80
	Trip forecast	7.22	0.20	
Costs	Budget	7.25	1.00	7.25
Reliability	Reliable deliveries	4.88	1.00	4.88

The logistician has determined that the minimum value to be achieved for each KPI should be 6, and the objective should be 10.

The control panel was constructed using a radar graph (see Figure 1.19), with greater visual and information impact.

The control panel allowed the logistician to identify the areas needing priority action (i.e. those with a KPI value lower than 6), at the organizational and planning levels.

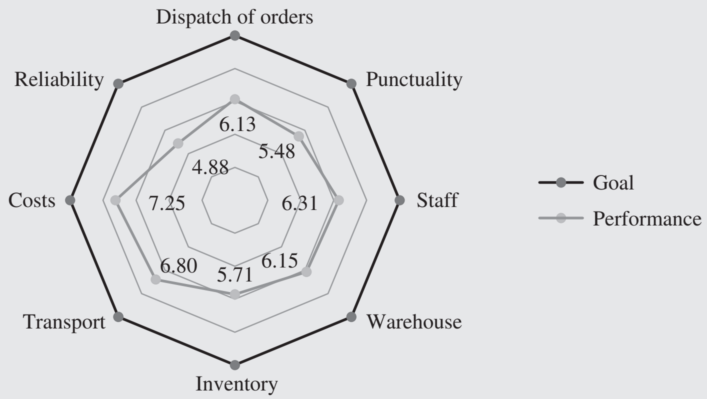

Figure 1.19 Control panel of the Borg logistics control system for the considered month.

1.7 Case study: The Pfizer logistics system

The Pfizer Pharmaceuticals Group is the largest pharmaceutical corporation in the world. Its mission is ‘to discover, develop, manufacture and market innovative, value-added products that improve the quality of life of people around the world and help them enjoy longer, healthier, and more productive lives’. The Pfizer range of products also includes self-care and well-being products and health products for livestock and pets.

Founded in 1849 by Charles Pfizer, the company was first located in a modest red-brick building in the Williamsburg section of Brooklyn, New York, United States, that served as office, laboratory, factory and warehouse. The firm’s first product was Santonin, a palatable antiparasitic which was an immediate success. In 1942 Pfizer responded to an appeal from the US government to expedite the manufacture of penicillin, the first real defense against bacterial infection, to treat Allied soldiers fighting in World War II. Of the companies pursuing mass production of penicillin, Pfizer alone used the innovative fermentation technology. Pfizer manufactures some of the most effective and innovative active ingredients including atorvastatin, whose medicine is the most prescribed cholesterol-lowering one in the United States; amlodipine, which belongs to the calcium channel blocker dihydropyridine class, and is used as an anti-hypertensive; azithromycin, the most-prescribed brand name oral antibiotic in the United States, and sildenafil citrate, a breakthrough treatment for erectile dysfunction.

With a portfolio that includes five of the world’s 20 top-selling medicines, Pfizer sets the standard for the pharmaceutical industry. Ten of its medicines are ranked first in their therapeutic class in the US market, and eight earn a revenue of more than \$ 1 billion annually. Research, development and innovation represent the lifeblood of Pfizer business that supports the world's largest biomedical research laboratory, with 12 000 scientists worldwide and a financial investment of \$ 6 billion annually.

The Pfizer logistics system comprises 58 manufacturing sites around the world (see Table 1.12), producing pharmaceutical, veterinary and cosmetic products for more than 150 countries.

Table 1.12 Geographical distribution of the manufacturing sites of Pfizer.

Continent (s)	Number of sites
Africa	7
Asia	13
Australia	2
Europe	16
Americas	20

Because manufacturing pharmaceutical products requires highly specialized, developed and costly machines, each Pfizer plant produces a large amount of a limited number of pharmaceutical products for the whole international market of the company (see Table 1.13).

Table 1.13 Features of some of Pfizer's European plants.

Country	Number of plants	Number of products	Productivity rate (in millions of items per year)
Belgium	1	29	6.5
France	1	14	2.4
Germany	1	3	11.4
Italy	3	182	87.1
United Kingdom	1	8	5.0

In the following, the attention will be focused on the logistics system of Pfizer with respect to a cardiovascular product, named Alpha10. The product is packaged in blisters, each containing 20 tables of 5 or 10 milligrams. Alpha10 is produced in a unique European plant (EUPF plant) for an international market including 90 countries (see Figure 1.20). Every year the plant produces over 117 million blisters. The product expires 60 months after its production and must be stored at a temperature varying between 8° and 25 °C.

Figure 1.20 Geographical selling areas (in grey) for the product Alpha10 of Pfizer.

The main component of Alpha10 is a particular active pharmaceutical ingredient, based on a Pfizer property patent, manufactured in a North American plant. Its packages are transferred by air to the European Logistics Centre (ELC), located in Belgium, which in turn replenishes the EUPF on a monthly basis (see Figure 1.20). Freight transportation between the ELC and the EUPF is performed by overland transport providers (e.g. Danzas). The EUPF plant manufactures ALFA10 tablets that are subsequently packaged into 120 blister boxes and sent weekly to a third-party CDC.

In Italy, Alpha10 is distributed, together with other products of Pfizer, to both hospitals and pharmacies, using two different channels (see Figure 1.21).

Hospitals (about 2 000) are supplied directly by the company, throughout a CDC and seven RDCs. Hospitals may be supplied by more than one warehouse, depending on stock levels. Transportation is performed by specialized haulers in refrigerated vans.

Pharmacies (about 16 000) are supplied through wholesalers (about 200, managing about 300 distribution centres of medicines at wholesale). Wholesaler orders are collected directly by Pfizer and shipped weekly by the CDC. The CDC is able to deliver the product in any Italian location within at most 60 hours. Wholesalers receive orders from pharmacies very frequently (up to four times a day). Pharmacies expect the wholesalers to deliver medicines within 4 to 12 hours (it is worth noting that, in Italy, pharmacies have a high contractual power over the wholesalers). Therefore, the average revenue of the wholesalers is low, due to the high logistics costs that have to be paid for guaranteeing a high service level to the pharmacies.

The Pfizer logistic network, also extended to the wholesalers, uses a specific information system, named Manugistics.

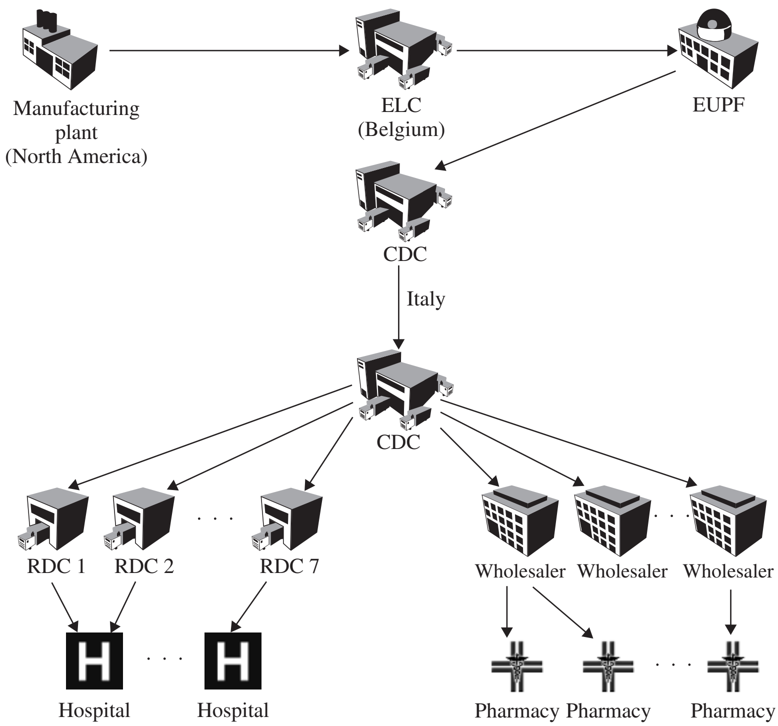

Figure 1.21 Pfizer logistics system representation for the product Alpha10.

1.8 Questions and problems

1.1 Adama is a French manufacturer of photovoltaic panels. The company has a production plant in Rennes, which supplies four warehouses located in Angers, Bourges, Clermont-Ferrand and Montauban. The warehouses directly supply the installers, grouped, for this purpose, into 10 operative districts spread across the country. The installers belonging to the same operative district are served from a single warehouse. Each installer returns defective photovoltaic panels to the corresponding warehouse; these panels are then sent to a repairing centre located in Poitiers. Model the logistics system of Adama through a directed graph and give a graphical representation of it (hint: the installers of the same operative district are assumed to be concentrated in a unique point).

1.2 Explore the websites of companies producing beverages, and represent the logistics system of one of them.

1.3 Discuss the main differences in managing a logistics system of a service company (in particular, a bank) and a production company (in particular, a chemical industry).

1.4 What could represent a direct link between a CDC and the assembly plant of the logistics system depicted in Figure 1.1?

1.5 Florim is an Albanian company specialized in manufacturing ceramic products. The company realizes its revenue by selling six products, as reported in Table 1.14.

Table 1.14 Annual revenue (in €) and amounts sold of the products of Florim.

Product	Sales	Quantity
1	350 000	2 700
2	160 000	2 200
3	920 000	2 500
4	125 000	1 500
5	360 000	4 200
6	160 000	1 900

Let $y = [(1 + \alpha_1)x] / (\alpha_1 + x)$ be the equation of the 80–20 curve C_1 defined such that the first 21% of products sold correspond to 68% of the annual sales; similarly, let $y = [(1 + \alpha_2)x] / (\alpha_2 + x)$ be the 80–20 curve C_2, obtained by assuming that the first 21% of products correspond to 62% of the annual sales. Check which of the curves C_1 and C_2 is a better approximation of the actual trend of the cumulative percentage of the annual sales with respect to the cumulative percentage of the amounts sold.

1.6 Zuick is a German import-export company of household appliances. The company, whose headquarters is located in Hannover, distributes 15 products whose weekly amounts sold and corresponding sales are reported in Table 1.15.
The company is investing additional financial resources in two products, K-505 and K-506, for which the logistician proposes an intensive distribution strategy, involving more CDCs and increasing the stocking levels. By using an *ABC* classification (20–30–50) of the products by the weekly amounts sold, verify whether the distribution strategy proposed by the logistician is correct and, if not, modify it accordingly.

1.7 El.Ma is an American distributor of electrical equipment. The warehouse in Columbus, Ohio, has 18 products to store and sell. Monthly sales and average monthly stock values are reported in Table 1.16. Make an *ABC* classification (80–10–10) of the products by their monthly sales and by monthly average stock values, respectively. Which inventory policy should El.Ma adopt for the product named ‘locking release 24V’?

Table 1.15 Weekly amounts sold and corresponding sales (in €) of the products of Zuick.

Product	Quantity	Sales
K-501	155	119 806
K-502	64	31 448
K-503	70	25 607
K-504	66	24 406
K-505	61	15 196
K-506	58	13 112
K-507	60	10 106
K-508	197	11 395
K-509	154	9 489
K-510	56	8 664
K-511	74	13 955
K-512	208	16 283
K-513	164	14 085
K-514	71	12 984
K-515	163	123 935

Table 1.16 Monthly sales and average monthly stock values (in €) of the El.Ma products.

ID product	Description	Sales	Stock values
1	Digital starter	22 356	980
2	Differential block 4P	147 800	3 667
3	Land trolley	10 450	1 174
4	HCS cable	65 980	2 030
5	Engine control unit 380V CA	18 654	652
6	Contacter 24–60V CC	27 580	1 721
7	Control builder	19 768	558
8	Universal dimmer	46 225	1 015
9	BRI interface	8 766	775
10	Circuit breaker 10KA	80 350	3 159
11	Motoadaptor	13 746	1 100
12	OPC server	57 558	3 111
13	Spring relay	7 852	733
14	Electronic delayer	9 785	724
15	Sectioner	32 400	894
16	Locking release 24V	12 328	1 020
17	TMA360	15 980	1 058
18	Control unit for release	11 900	1 062

1.8 Barilla is an Italian multinational food company which 'has significantly believed in B2B e-commerce and, in particular, in EDI (*Electronic Data Interchange*), especially in terms of Web-EDI, which supports the order-delivery-invoice cycle and, also, collaborative processes, such as CRP (*Continuous Replenishment Program*) and CPFR (*Collaborative Forecasting and Replenishment Program*)' (Mauro Viacava, CEO of Barilla). From the point of view of integrated logistics, examine the meaning of EDI, CRP and CPFR, and explain how these are presumably used in the logistics system of Barilla.

1.9 Assume that, for a certain company, the estimated annual sales to service level curve $r(l)$ has been determined by means of a simulation method. The resulting equation is $r(l) = 950\,000\,l - 328\,000\,l^2$, where l denotes the percentage of customers served within 24 hours (e.g. if $l = 0.7$, 70% of customers are served within 24 hours); $r(l)$ is expressed in \$. The annual logistics costs (in \$) are estimated as 280 000, 320 000, 380 000, 410 000, 460 000 and 510 000, with respect to the following values of service level offered to customers: 50%, 60%, 70%, 80%, 90% and 100%, respectively. Determine the service level at which the maximum estimated annual profit is achieved.

1.10 There exist five design alternatives for a logistics system, whose costs and service levels are plotted in Figure 1.22. Determine which alternatives should be taken into account as a possible design solution and which ones should be discarded.

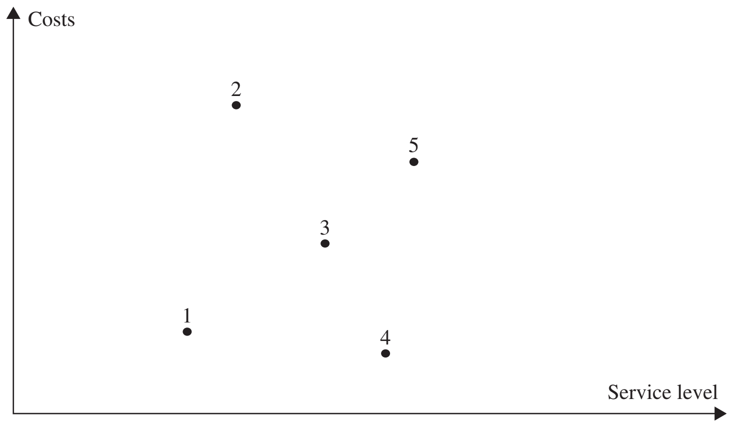

Figure 1.22 Costs and service levels of five alternatives for the design of the logistics system of Problem 1.10.

1.11 Electrolux is a Dutch company that has recently decided to start production and sale of a new energy-efficient light bulb. During the phase of logistics system design, two alternatives are taken into account:

- Use the foreign manufacturing plant located in Tartu (Estonia), where the unit production cost is € 0.97 (the cost of raw materials purchase is included). The transport cost to the CDC of Groningen is € 16 per box, where a box contains 100 units of the product. For simplicity, it is assumed that this cost includes also inventory costs at the CDC. The CDC of Groningen supplies two RDCs, situated in Delft and Eindhoven; their annual demands are 28 000 and 35 000 boxes, and the transport costs per box are € 9 and € 10, respectively;
- use the national manufacturing plant of Dordrecht, where the unit production cost is € 1.38. This facility supplies the RDC of Delft and Eindhoven and the unit transport costs are, in this case, € 2.5 and € 3.0 per box, respectively.

Determine which alternative to prefer, considering the minimization of production and transport costs as the logistics objective to pursue.

1.12 Tranexpress is an international freight forwarder. Its service time consists of two components: the time required for preparing paperwork for customs, coordinating customs inspections, warehousing and consolidation, container loading (time for additional services) and transport time. The recorded data related to some past observations are reported in Table 1.17. Characterize the total service time from a statistical point of view, by computing the sample mean and the standard deviation of the corresponding random variable. Compute a quantitative index for measuring service reliability.

Table 1.17 Observed data related to additional services and transport times (in days) of Tranexpress.

Additional services		Transport	
Number of recorded data	Time	Number of recorded data	Time
1	21	20	120
3	26	29	132
4	33	56	148
9	41	66	162
18	52	52	178
35	60	26	197
42	98	16	209
22	107		
13	114		
2	122		
1	129		

1.13 Norsk is a Danish company that specializes in food product for daily consumption. It has five associated subsidiaries in the European Union and a network of distributors in North America. Recently, the company has decided to redesign its distribution network in Scandinavia where 140 distribution centres have been transformed into simple stores without administrative functions. The administrative functions have been concentrated in 14 logistics centres with regional character, and forecasting activities based on data analysis have been centralized in the company headquarters. List and classify the decisions taken at the business management level during the reorganization phase of the logistics system.

1.14 Explain why stocks of products are usually increased in one or more facilities in the absence of logistics coordination.

1.15 An ineffective management of a logistics system can produce instability. One of the effects due to mismanagement is known as the *bullwhip effect*: a small fluctuation in customer demand can cause amplified fluctuations in material flows orders over time via the upstream supply chain itself. This particular phenomenon was first recognized by the managers of Procter & Gamble who noticed significant variability of sellers' orders despite the fact that consumer demand remained constant; this is because the orders were issued on the basis of limited information regarding the final demand of the product (in this case, Pampers disposal diapers). In general, distorted information along the logistics system gives rise to a growing imbalance between demand and supply; a distorting effect creates the same problems throughout the supply chain. For example, decisions about the management of the CDC in a company are, in general, based on the level of stocks and on the orders issued in a logistics node immediately downstream of the CDC, such as an RDC, without knowing the end-user demand. The orders issued by the RDC are used to estimate the mean and standard deviation of demand. These estimates are the basis of decisions on reorganization issues. For example, in the (s, S) method (see Section 5.3.2.2), an order is issued whenever an inventory level falls below a given reorder point s and the inventory level is then increased to an order-up-to-level S. As the perceived demand varies, the parameters S and s are updated and order quantities are also changed. In light of this, show that a typical bullwhip effect in a logistics system, made up of a production plant, a CDC, a RDC and a retailer, is like the one reported in Figure 1.23 (where it is assumed that a sudden 10% increase in end-user demand occurs). Can this effect be reduced through more and better information sharing?

1.16 Define the functional organizational structure of a petrochemical company showing the position of the logistics activities. Compare advantages and disadvantages when a divisional organization is adopted.

1.17 Ajt Solar is an Indian company of photovoltaic products. To control the logistics system, some critical logistics activities are monthly monitored. Three families of KPI are considered: order processing, inventory management and transport. The KPIs, their families and the computing method used for each of them are shown in Table 1.18.

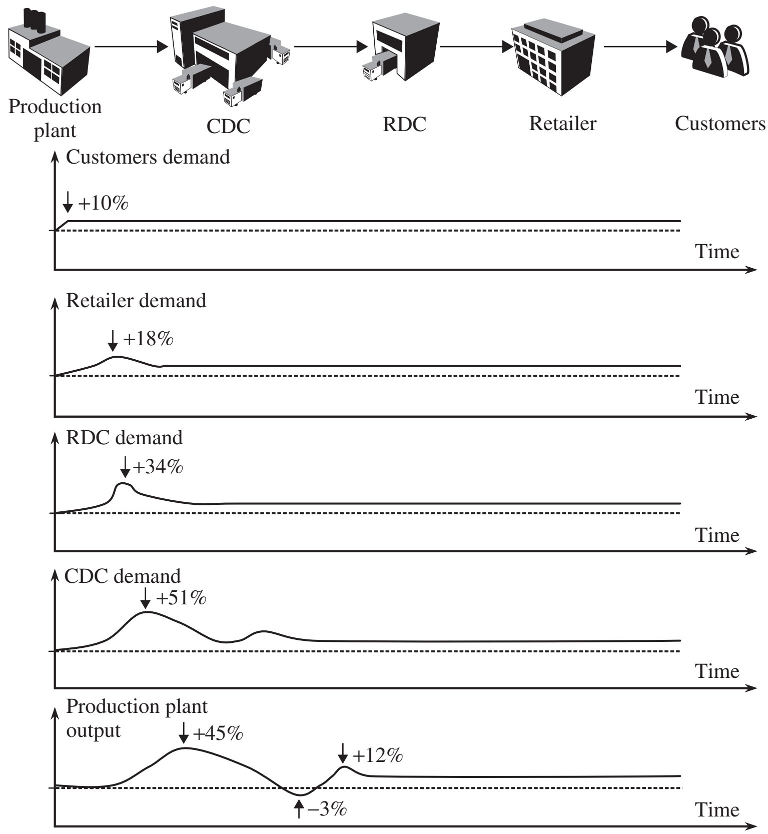

Figure 1.23 The bullwhip effect for the logistics system of Problem 1.15.

Table 1.18 KPIs and computing method used of the Ajt Solar company.

Family	KPI	Computing method
Order processing	Orders	Number of orders in a month/ number of weekdays in a month
	Complaints	Number of complaints a month
Inventory	Stocks values	Monthly inventory value
Transports	Deliveries per journey	Average number of customers monthly served with a journey
	Planned journeys	Monthly number of planned journeys/ monthly number of journeys carried out

Table 1.19 KPI values for the last 15 months for the Ajt Solar problem.

Period	Orders	Complaints	Stocks values ($)	Deliveries per journey	Planned journeys
1	154.26	21	470 800	15.48	1.07
2	151.04	12	500 800	36.76	0.97
3	161.23	16	533 000	18.94	1.13
4	145.33	24	565 900	33.07	1.14
5	158.66	14	567 700	31.15	1.13
6	171.25	16	471 900	40.37	1.10
7	98.66	31	522 200	23.35	0.83
8	102.45	8	531 000	14.33	1.00
9	134.74	12	509 800	39.80	0.93
10	147.24	16	579 700	18.37	1.20
11	133.54	21	548 300	26.04	1.15
12	154.81	18	458 700	30.10	1.00
13	148.82	20	542 100	36.60	0.95
14	124.31	13	524 500	26.52	1.11
15	164.03	11	567 400	33.46	1.00

The values of each computed KPI in the past 15 months are reported in Table 1.19. In the current month (with 23 working days), the company has recorded the following data: 3 568 orders, 15 complaints, $ 560 400 in stock value, 24.25 customers on average served on a journey, 4 950 planned journeys and 4 902 journeys made. Build a control panel for monitoring the three identified KPI families, according to the methodology illustrated in Section 1.6.3. Show how the actions on the logistics system can change depending on the weights assigned to each KPI belonging to the first and third families.