9 Delimitation of industrial markets: Features, significance, and synergies

Introduction

Industrial (B2B) markets constitute an area of main concern as well as being extremely interesting in the marketing industry, especially concerning SCM strategy design and decision-making. This chapter introduces the main differences between consumer and industrial markets and buyers and highlights their significance and areas of interest regarding marketing and SCM, such as materials handling and warehouse management.

Learning goals

After reading this chapter, you will be able to answer the following questions:

- Why is the contribution of industrial marketing crucial to supply chain management?
- What are the main types of industrial products?
- What are the main categories of industrial buyers?
- What are the main roles of the stakeholders involved in distribution networks?
- What are the fundamental features of industrial markets?
- In what ways does the management of materials and warehouses have a decisive effect on the effective implementation of the marketing diversification strategy in the industrial markets?

Structure

9.1 Introduction to industrial marketing in the context of supply chain management

The ultimate goal of marketing and supply chain management is to achieve the best mutually beneficial services for the needs and desires of both the consumers and all the companies involved in the supply chain. As has already mentioned, achieving the goal

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of meeting consumers' needs and expectations involves a number of efficient and effective transactions between supply chain partners (Harrison et al., 2015; Christopher, 2015; Bowersox et al., 2015; Chopra & Meindl, 2014; Min, 2015; Zimmerman & Blythe, 2013; Taylor, 2003; Reid & Sanders, 2013). For example, meeting consumers' needs for fresh pasteurized milk presupposes that each company involved in the relevant supply chain will have to procure all the necessary construction materials and machinery from other companies. Each business link in the supply chain must be supplied with the items it needs, such as raw materials (e.g. feed, milk), auxiliary materials (e.g. packaging materials) and/or goods (e.g. ready-packaged pasteurized milk) so that it can add its own value to a product through (further) processing of materials (e.g. the farmer's bulk milk is pasteurized and packaged as fresh milk in 1-liter bottles by the dairy industry) or additional services (e.g. transportation from the dairy company to the distribution center of a supermarket chain). The outputs of those companies will be the inputs of the next links in the supply chain that are closest to the consumer. For all these transactions between supply chain partners, marketing, as both a philosophy and a business function, plays a decisive role in their effective and efficient implementation.

Industrial marketing focuses on the application of the principles and methodological marketing tools/techniques in transactions governing industrial markets, i.e., between the companies and organizations involved in the respective supply chain (Siomkos & Fotiadis, 2020; Avlonitis, et al., 2015; Pollalis & Patrinos, 1999; Tomaras, 2010; Hutt & Speh, 2010; Biemans, 2010; Saavedra, 2016; Mukerjee, 2009; Kotler, 2006; Brennan et al., 2017; Anderson et al., 2009). Several researchers (Fern & Brown, 1984; Wilson, 2000) have argued that for marketing purposes, the differences between industrial and consumer markets are so significant as to justify a focused study on the application of marketing in industrial markets. However, as presented in more detail below, industrial markets possess special features that differentiate them significantly from consumer goods/services markets. Perhaps the most significant difference between industrial and consumer markets is the emphasis on competitive advantage: there is a great focus on establishing long-term cooperative relationships between sellers and buyers in industrial markets, to the point that, although the two companies continue to operate as independent economic entities, there is an emphasis on the coordination of large numbers of often two-way flows (natural movements of products/services), ownership, promotion, negotiation, financing, risk-taking, ordering, payment), as if it were a vertical integrated enterprise. Therefore, a business's differentiation strategy aims to offer unique value relationships to industrial customers that will contribute most to the satisfaction of customers' needs. A business's differentiation strategy in markets with end customers (consumers) focuses on unique packages of high-value products/services, or with high value for money. The reasons for these differences in the differentiation strategies between industrial and consumer markets include, *inter alia*, the much greater complexity of industrial transactions and, consequently, the purchasing processes followed, and inevitably the higher level of interdependence and the interaction required between customers and buyers in industrial markets compared to that of consumers.

From the above, it becomes clear that marketing, and especially in the case of industrial marketing, is one of the two main pillars on which supply chain management has been built over time, the other pillar concerning logistics. Many of the concepts and methodological tools/techniques developed in the field of industrial marketing

have been harmoniously combined with operations management, logistics, financial analysis, new product development and business research in supply chain management. The purpose of this chapter is to present the particular fundamental features of industrial markets with the ultimate goal of understanding the mechanisms used to create, operate and develop supply chains. The chapter concludes with an analysis of materials and warehouse management, two important functions that have a decisive influence on the effective implementation of the marketing diversification strategy in industrial markets, and by extension the supply chain management of the companies involved.

9.2 Classification of industrial products

Products and services marketed in industrial markets can be classified in a number of ways. Figure 9.1 shows the most common classification of industrial products and services, based on their intended use (whether they are incorporated into the company's final product or not) and how it enters the company's accounting books (in terms of cost structure) (Siomkos & Fotiadis, 2020; Avlonitis et al., 2015; Pollalis &

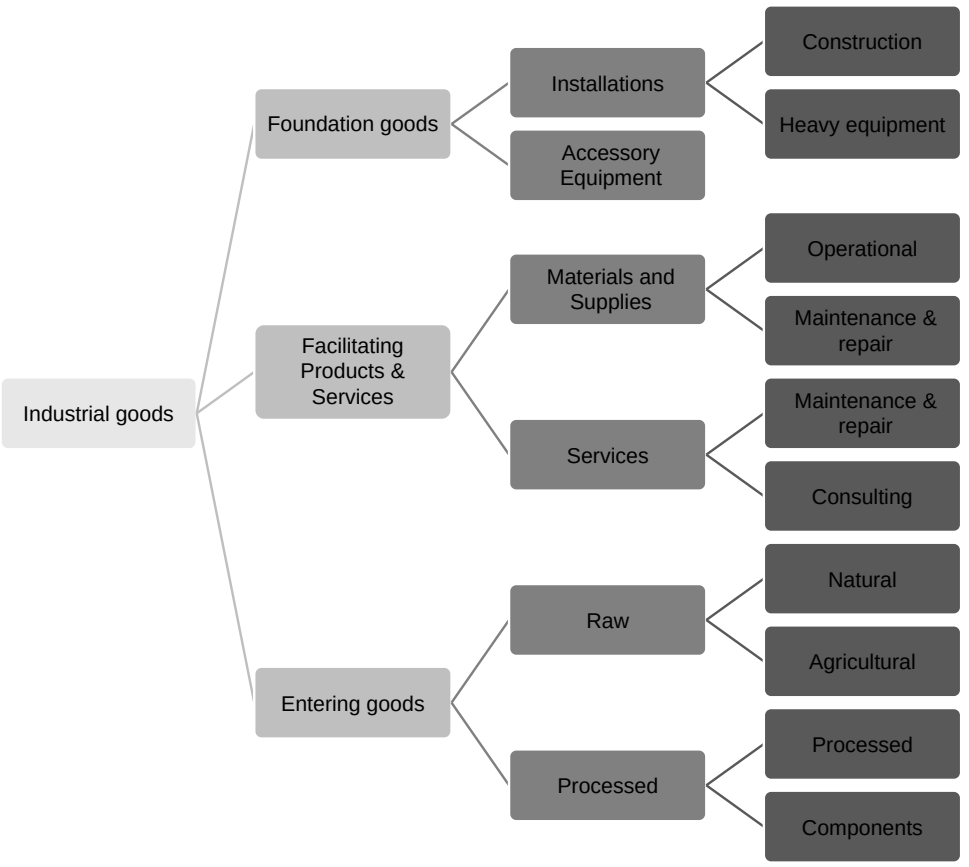


Figure 9.1 Classification of industrial products.

Patrinos, 1999; Hutt & Speh, 2010; Biemans, 2010; Kotler & Keller, 2016; Brennan et al., 2017; Mukerjee, 2009; Avlonitis et al., 2016). According to this classification, industrial goods are divided into three main categories: infrastructure, auxiliary products/services and entering goods.

Entering goods are incorporated into the final product that is produced by their buyer. They are further divided into raw materials and processed materials. Raw materials include natural products such as timber, fisheries, iron and other ores, as well as agricultural products of either vegetable (e.g. wheat, fruit, vegetables, etc.) or animal origin (e.g. meat, milk, wool, honey, etc.). The main common feature of these products is that they have undergone little or no processing, they often have a low value per unit of product, and they are required in large quantities (rate of use and supply) in the production process of industrial enterprises. Therefore, their transport costs form a significant part of their total operating costs. For this reason, industrial companies that use raw products take into account their transport costs and the need for a continuous supply of large quantities of these products when designing their supply chains. As a result, most industrial enterprises are located close to the main suppliers of raw entering goods.

Processed products have gone through various stages of further processing in relation to raw materials, which facilitates their direct integration into the final product. They are then divided into processed products and components. Examples of processed products are steel, cement and fabric, which need some (albeit relatively limited) additional processing to create the final product. For example, a carmaker supplies steel sheets that are molded to produce cars. Components are products that can be incorporated directly into the final product with little or no processing, constituting a distinct and often replaceable component of the final product, such as the tires, battery, mirrors and engine of a car. Transportation costs, inventory management and execution time of supply orders for processed products and components are some of the most important factors that determine the design of business supply chains. In particular, the implementation of the Just-In-Time (JIT) supply strategy requires geographical proximity of (at the very least) the production facilities of industrial enterprises to the warehouses or distribution centers of their strategic suppliers.

Foundation goods refer to a company's fixed equipment which it uses for its various sub-functions; these are classified into installations and additional equipment. Installations refer to large building structures (e.g. production facilities, warehouses and distribution centers) and land use rights (e.g. land, plots, fields), as well as high-value machinery or other technical equipment (e.g. automatic machinery installations, large presses, supercomputers). A key feature of the installations is their long-term investment character since their period of operational depreciation usually approaches a decade (for most machines) and reaches up to 30 years or more for most buildings. As expected, the cost of acquiring them is very high and requires careful planning during the preparation and implementation of the investment plan: any significant failures may lead to very unfavorable future situations that could seriously jeopardize a business's viability. Due to the very high investments required for the installations, especially in a very uncertain and competitive business environment, there has been a clear shift in the last 2–3 decades of companies trying different strategies to convert the fixed costs of the facilities into operating costs. Typical examples of these alternative strategies are leasing and outsourcing of supplies and operations. For example, many companies today prefer to rent cars for their sales staff instead of buying them. In the

automobile industry, components that were previously produced by the company itself or its subsidiaries (vertical integration) are now sourced from independent companies, thus relieving the business of the obligation to implement high-cost long-term investments and the relative risk of doing so.

Auxiliary equipment refers to auxiliary machinery, tools and other light/portable equipment with a lower value and/or business risk, and often a shorter period of operation (often up to 3–5 years), such as portable drills, lifting machines, desks, computers, printers, etc. This equipment is not integrated into the fixed installations and can usually be used in various functions and tasks (e.g. laptops). In general, goods classed as accessories are clearly more standardized than the installations themselves, as there are seldom any modifications – even marginal – based on the individual needs of the industrial customers, nor are they made to order by the buyers, so the number of suppliers is often quite large. Therefore, the market for auxiliary equipment is clearly more competitive than that of the installations, where such investment goods are available from very few and usually highly specialized companies, and are often tailor-made for customers, or customized for them based on their specific needs and expectations.

Facilitating goods and services include materials and supplies, as well as industrial services that contribute to the smooth operation of production processes. Their main feature is that they are not incorporated in any way in the final product, nor do they constitute complementary products. Materials and supplies are classified as: (a) functional, such as stationery, printer inks, fuels, lubricants and electricity for the operation of machinery used in the manufacturing process; and (b) maintenance and repair, such as detergents and other cleaning materials, screws, paints, etc. Most of them are standardized goods with a low unit value; as they are offered by many suppliers, they are therefore sold in highly competitive markets. In addition to their total acquisition cost, crucial factors in the selection of suppliers are also expected delivery time and the variability, quality and variety, as well as the reliability of each supplier.

Industrial services can be classified as (a) maintenance and repair, such as maintenance of information systems, cleaning of business premises, maintenance of mechanical and other equipment; and (b) consulting services, such as accounting, marketing and advertising, drafting and technical support of investment plans, data processing and management. Depending on whether or not industrial services are directly related to the industrial purchaser's final product, they can also be divided into (i) maintenance, repair and operation services, which are not directly related to a specific product or service produced by the client; and (ii) production services, which are used directly in the production process and the distribution of specific products/services; therefore, the cost of their use can be directly integrated into their total cost, such as logistics services. Special features that differentiate services (which are generally intangible) from tangible goods make the purchasing process more complex; the selection of suitable suppliers is based more on quality criteria, such as the reliability of the supplier, their experience in related matters, mutual understanding between the buyer and the service provider on critical issues, etc. In general, the nature of services makes it difficult to set strict standards that can be met each time they are provided, as the end result also depends to a large extent on the buyer's participation in the production process and his interaction with the service provider's frontline staff.

9.3 Industrial buyers and distribution networks

Buyers and their reasons/motivation to acquire goods/services is the main criterion for distinguishing industrial markets from consumer markets; the above analysis on the classification of industrial products shows that the majority of industrial goods are also available to consumers. Industrial buyers can be defined as those who acquire goods/services to use them in their production process, as capital, auxiliary or component parts in their final products/services. Thus, unlike consumer markets where goods are acquired to optimize personal utility, the same goods in industrial markets are often inputs of a supply chain production process whose ultimate goal is to provide consumers with finished products and services with high value for money (Siomkos & Fotiadis, 2020; Avlonitis, et al., 2015; Pollalis & Patrinos, 1999; Hutt & Speh, 2010; Biemans, 2010; Mukerjee, 2009). According to the most common method of categorizing industrial markets, industrial customers are divided into companies that aim to make a profit on behalf of their shareholders (for-profit), governmental agencies and institutions (Figure 9.2).

9.3.1 Commercial enterprises

For-profit companies cover the entire spectrum of the private economy and are further classified into users, original equipment manufacturers (OEMs) and dealers. Users are industrial customers who buy mainly infrastructure goods (installations and additional equipment) and auxiliary products/services that contribute to their production process but are not integrated into the final industrial and/or consumer product/service produced. For example, an automobile industry uses, among other things, building installations, automated machinery, electricity for machinery operation, materials for

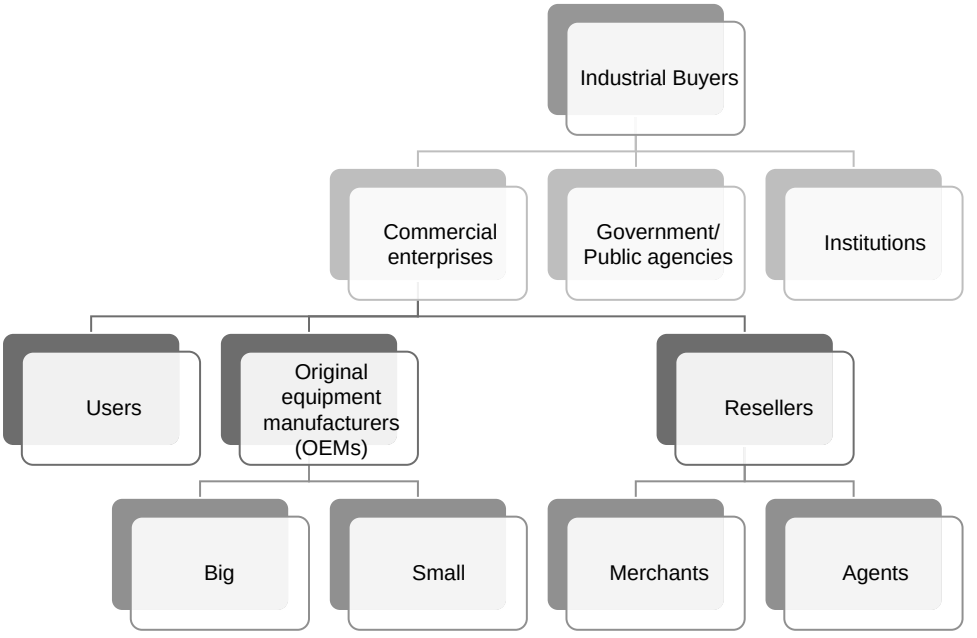


Figure 9.2 Classification of industrial buyers.

maintenance and cleaning of installations and motor fuels for the transportation of inputs (e.g. mirrors) and final products, which are necessary elements in its production process, but none are actually an integral part of its outputs.

Manufacturers of industrial and consumer goods/services are the buyers of the above goods, which are classified as entering industrial goods. These are for-profit companies that buy goods from their suppliers in order to integrate them into their final products/services. For example, a computer manufacturer, such as Dell or Hewlett Packard, procures the various components that make up a complete computer, e.g. processors, internal memories, graphics and sound cards, power cords, boxes, motherboards, etc., which it assembles to produce its final products. Accordingly, an automobile industry procures, among other things, steel sheets, mirrors, disc brakes, seats and tires, which are further processed and/or combined/assembled to create a car. The latter example makes it clear that an industrial customer can be classified as both a user and a final product manufacturer, depending on the use made of the products. Manufacturers of finished products can be classified in a number of ways, but in the context of strategic planning in a supply chain, it is crucial to segment them according to size (small, large), even though it is sometimes relatively difficult to determine the appropriate separation threshold. Large manufacturers are relatively few in number and often geographically concentrated in a small area, but the volume of their total annual purchases is very large. They often require and try to actively participate in product design by interacting decisively with their strategic suppliers; they also have equally high requirements for the immediate execution of frequent orders (even more than one per day) within strictly defined time limits in a JIT implementation framework. As a result, suppliers often maintain warehouses and production facilities near major manufacturers. Smaller manufacturers are clearly more numerous, highly geographically dispersed and with a much smaller annual market cycle than larger ones. Their suppliers have to develop a different strategy for an efficient supply while keeping the total unit cost at an operationally viable level. Therefore, smaller manufacturers procure more standardized products with longer order execution times from suppliers' central warehouses or distribution centers, which are often within walking distance from them.

9.3.2 Distribution channels

Distribution is an external (outside the business) contact organization (companies involved in the trading operations as a product or service moves from the producer to the final consumer) whose management activities and decisions (involvement of the management in solving its distribution network problems at all levels) aim at achieving distribution objectives.

All product and service companies use intermediate business entities to make their products and services available to customers. These entities that facilitate the flow of goods or services from producer to consumer consist of a distribution channel or marketing channel. This organization of companies involved in the functions of contact and physical distribution as a product or service moves from the producer to the final consumer is called distribution. The goal is the success of the whole system is the maximization of profit overall. The goals of each organization in the commercial part of the channel (producer, wholesaler, and retailer) and their successful completion depend on the effectiveness of the other organizations in the system.

Each flow can move either to the customer or vice versa or to both sides. Specifically, physical flow, ownership flow, promotion and marketing flow from the industrial enterprise to the final buyer. The negotiation flow, financing flow and risk-taking flow move in two directions. The order flow and payment flow move from the final buyer to the industrial enterprise.

The main role of a distribution channel is the intermediaries (intermediaries) that help in the operation of the distribution and specifically autonomous wholesale and retail companies, and facilitation companies such as transport companies, warehousing companies, marketing research, warehousing, finance, offices, and finance.

In general, the companies - organizations of the place (with the function of transport), time (with the function of storage) and acquisition (with the functions of sale and information). We can consider an indirect distribution the one that consists of more than two members, while the direct distribution consists of only two members (direct contact with the final buyer).

More specifically, the intermediaries:

- Implement distribution more economically because they drastically reduce the number of transactions resulting in Improve the efficiency of the transaction process. For example, if we assume that there is a market, in which four (4) producers (P) must sell their products to five (5) customers–consumers (K). If each P tried to approach each of the five K directly, a very complex network of contacts would result, as $P * K = 20$. In the same market with an intermediary, instead of a direct sale, a less complex network of contacts would emerge. ($\Pi + K = 9$).
- They adapt the difference to the variety of species through the classification process. Although companies specialize in producing a certain number of products, the variety of products required by consumers is usually greater than that provided by a business alone. Intermediaries try to provide a solution to this problem by bringing together a wide variety of products from different manufacturers and making this expanded variety available to consumers.
- Facilitate the process of searching for products and services. An immediate effect of the best variety offered by intermediaries is to facilitate the search process. As wholesalers, and therefore retailers, offer a wider range of products, the time consumers have to spend looking for the "right" product for them is reduced.
- Provide facilitation services, such as Transportation, Marketing Research, Warehousing, Finance, Advertising Agencies, Insurance Agencies

The types of intermediates arise from the distinction between consumer and industrial products. In consumer products, the members of the channel can be the following (Figure 9.3):

Retailer (R) is the one who sells products to the final buyer. A wholesaler (W) is one who makes the most of his sales to other companies, which either resell the products or use them to produce other (their own) products. Intermediaries can perform all the functions of marketing, from the purchase and sale of products to their transportation, storage, financing, etc. Agents are intermediaries who do not have title deeds of the products whose distribution facilitates.

Brokers (B), agents (A), are intermediaries who do not have ownership of the products whose distribution facilitates them. They are paid a percentage of the value of the products sold, while performing a limited number of functions, such as selling

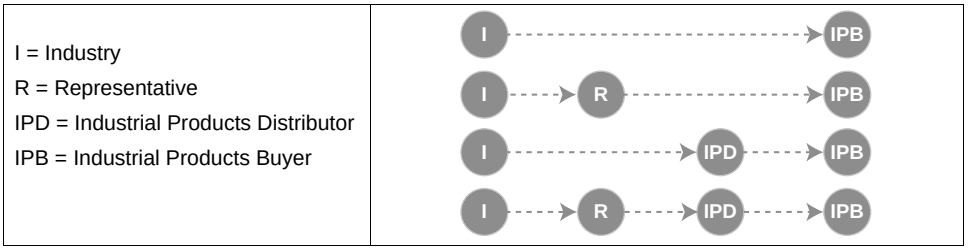


Figure 9.3 Types of intermediaries for consumer products.

and information, with the difference that B brings together buyers and sellers of a usually product and, instead of permanent, their cooperation is seasonal.

For industrial products, members of the channel could be the following people (Figure 9.4).

The main types of distribution channels for industrial products are:

- The first type is the most common due to the small number of Industrial Buyers for most industrial products (many of which are even produced after a very specific order with specialized specifications for the product).
- The second type applies in cases where the Industrial Buyers are numerous in number or are geographically dispersed.

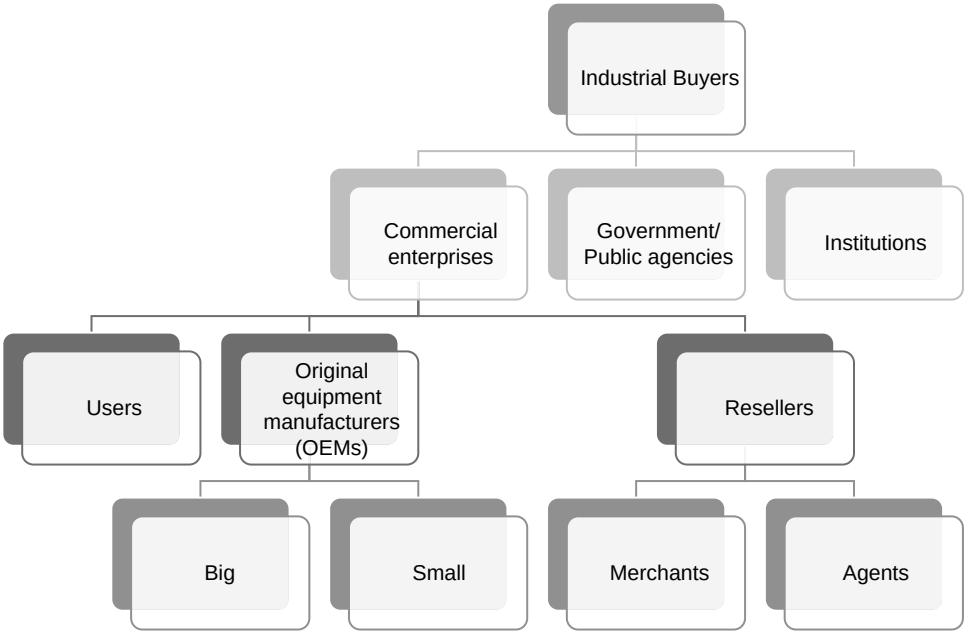


Figure 9.4 Types of intermediaries for industrial products.

- The third type is used by B who cannot or do not want to be involved in the distribution-sale process of their product.
- The fourth type is mainly preferred by B who export the products they produce to other countries.

9.3.3 Government/public buyers

The market of government/public buyers includes, among others, government services, Public Enterprises and Organizations (e.g. power companies, post offices, and railways), Local Government Organizations (Municipalities and Regions), Social Security Organizations, etc. This is a very large market, perhaps larger in terms of monetary transactions than that of for-profit companies in some countries. The large volume of transactions and the secured, albeit late, payment of bills make government/public customers a very attractive market. The relatively limited resources available in relation to citizens' and taxpayers' needs and expectations, and their demand for transparency in the management of public funds have resulted in greater complexity of procurement procedures for public bodies compared to private companies; for this reason, they must follow strictly defined legal frameworks, with a significant amount of diversity between the various public services and organizations. Therefore, the observance of strict procedures makes public procurement a particularly bureaucratic process; stakeholders should therefore be familiar with the different protocols followed by different public services and agencies. For relatively low-value supplies, whose amounts are determined by the relevant legislation, there is the possibility of directly outsourcing the supply of goods, services, studies, as well as public works, through negotiated contracts. For goods and services of greater total value, a public announcement for bids with sealed tenders by interested suppliers is mandatory. In general, the price of the offered goods, services, studies and projects is very important but it is not the only criterion for selecting the right supplier. Other criteria, such as the quality of the goods/services offered, delivery/execution time of the order, compatibility with the equipment used by the public body, and the supplier's solvency, also play a decisive role in the final decision. In any case, all the selection criteria and their weight should be explicitly mentioned in the specifications of the goods/services when announcing the tender.

9.3.4 Institutional buyers

Institutions can take various forms such as public or private, small or large and for- or non-profit, e.g. hospitals, schools, universities, commercial chambers and associations, churches, political parties, penitentiaries, associations (e.g. the Greek children's charity "The Child's Smile"), organizations (e.g. the nature organization "Arcturus"), etc. Institutions that are affiliated, funded and controlled by public/governmental bodies follow similar procedures with a strictly defined legal framework as mentioned above. Private institutions exhibit similar purchasing behavior to private companies. The market for institutional customers is similarly large and some companies, e.g. the food sector, focus on serving specific institutional categories, e.g. hospitals and prisons, which require large continuous supply needs of necessary goods/services for their smooth daily operation.

9.4 Characteristics of industrial markets

Industrial markets have certain characteristics that need to be taken into account when designing marketing strategies, in terms of the cooperation and interaction required of marketing managers with their counterparts from other business departments, as well as with representatives of strategic partners in the supply chain.

9.4.1 Derivative demand

The main noticeable difference between industrial and consumer markets, as previously discussed, refers not to the type of products available in them, but to the kind of buyers and their motives. Consumers acquire goods and services to meet their individual/family needs and desires, while industrial buyers acquire them to produce their own tangible or intangible goods with the ultimate goal of contributing, together with others in their supply chain, to create and maintain competitive value-added product offers to consumers. To be precise, however, we must admit that some goods or services are offered only in industrial markets since it is rather unlikely that an individual consumer will acquire an excavator for their own use or request the services of a company that designs investment plans. The truth, however, is that it is difficult to imagine a product/service that is available in consumer markets, but not in the industrial ones.

From the above discussion, a very important feature of industrial markets become apparent: the purpose of the stakeholders is the optimal satisfaction of the derived (secondary) demand that comes from and depends directly on the primary demand as manifested in the consumer markets (Siomkos & Fotiadis, 2020; Avlonitis et al., 2015; Pollalis & Patrinos, 1999; Hutt & Speh, 2010; Biemans, 2010; Brennan et al., 2017). For example, a grain producer satisfies the needs of the flour industry which supplies various flours to industrial markets such as bakeries, confectioners, pasta industries, etc., as well as to consumer markets such as supermarkets. Any fluctuations in the total demand for finished bread, pastry, pasta or flour products at the retail level will obviously affect the overall demand for cereals. In a similar fashion, potential significant changes in consumer preferences for an alternative dietary pattern, or a manifestation of their concern for the sustainability of agricultural production (e.g. a shift to organic products) may lead to changes in future cultivation plans or the farming techniques of agricultural businesses.

The marketing diversification strategy of companies that serve industrial customers should not focus on the product/service offered, but rather on the collaboration it develops with them to optimize the achievement and maintenance of long-term competitive advantage. Simply put, the ultimate goal of companies operating in industrial markets is to make a decisive contribution to their customers' success, which in turn will ensure their own success. This is due to the fact that the environment in which the supply chain of cooperating companies operates is very changeable and highly competitive, and the collective result can be achieved only through the coordinated responses of the stakeholders, and not through any individual piecemeal solutions that each link in the supply chain wishes to adopt and implement.

In any case, each link in the supply chain, in cooperation with the strategic partners, must closely monitor all the developments in the market which mediate the availability of the final product to the consumer (downstream markets). This is relatively easy for

suppliers who have a small number of very important customers: their outputs are intended for a very limited number of supply chains, such as companies that supply mirrors and seats to the production facilities of the automobile industry. However, this task becomes extremely difficult for companies that produce less processed products (e.g. chemicals, cement, fibers, petroleum), or consumer-oriented components (e.g. integrated circuits, chips, screws) which supply a large number of companies, and in a wide range of heterogeneous supply chains. In such cases, companies have no choice but to focus on the most important markets and the most important customers. Even so, those in charge of monitoring market changes face great difficulties on a daily basis; the more numerous the links in the supply chain between their business and the end-user of the product (consumer), the more invisible their work becomes.

The actions and results of companies' marketing programs at the higher levels of the supply chain are usually less perceptible to the consumers. However, some companies aim to create a branded demand (pull strategy) by developing a comprehensive marketing communication plan that directly targets end customers. Well-known examples are INTEL in the computer microprocessor sector, Tetra Pak in food packaging (e.g. milk, juices) and Gore-Tex in waterproof fabric for coats. Derivative demand has a decisive effect on the appearance of other specific demand features of the industrial markets presented below, such as demand inelasticity, sharp fluctuations in demand and supply inelasticity.

9.4.2 Demand elasticity

Demand in industrial markets is generally more inelastic than that of consumer markets. Any fluctuations in the price of industrial products are passed quite late onto the price of the end consumer products; this, in combination with consumers' inaction to immediately react to price changes means that in the relatively short to medium term there will be no change observed in the primary demand of the consumer markets. Therefore, fluctuations in the prices of industrial customers' inputs have a particularly limited effect on the formation of the total market demand derivative.

In addition, as detailed below, high transaction costs combined with other factors impose the need for long-term partnerships or even strategic alliances between stakeholders in industrial markets. When price changes are necessary due to external factors (e.g. reduced supply of agricultural products, increases in tax rates, increased supplier input price), industrial buyers are reluctant to change the composition of their supplier base. Even when a new supplier tries to enter a new market or join the suppliers' group of an industrial enterprise by offering attractive prices for their goods, it will still potentially face high entry barriers related to factors such as its reliability, its potential to satisfy and guarantee an uninterrupted supply of the required quantity, quality and variety of goods, compatibility issues of the offered goods with customers' existing production processes, their solvency, etc.

However, this does not mean that the various promotional techniques and the general activities of the integrated marketing communication mix are irrelevant in industrial markets. Companies operating in industrial markets are constantly facing challenges to protect their market share and their growth is based, among other things, on their expansion into existing markets and/or their penetration into new markets. Therefore, industrial marketing as a function, but also as a philosophy, plays a catalytic role in building long-term partnerships or even the company's strategic alliances

with the downstream links in the supply chain, with the ultimate goal of ensuring that the chain, and therefore, the company maintains competitive advantage.

Joint demand also contributes to the inelasticity of industrial input demand. If, for example, a large supplier of car mirrors can offer its customers goods at steadily reduced prices, the total primary demand for cars will not be highly affected, as the reduction in the cost of a car component will only marginally lead to reduced prices for the final products. Therefore, the overall derivative market demand for mirrors is unlikely to show any upward trend.

9.4.3 Demand fluctuations

Supply chain stakeholders are required to handle demand fluctuations both efficiently and effectively with the lowest possible cost; this increases the further away they are located from consumer markets (Figure 9.5). The demand volatility faced by the various links in a supply chain stems from a number of factors, the most important being derivative demand, increasing supply inefficiency at the higher levels of the supply chain, and the commitment of some – often all – stakeholders to maximize their corporate goals, to the detriment of the overall efficiency of the supply chain. The difficulty of responding immediately to changes at the primary and subsequent secondary demand level is due, *inter alia*, to the nature of the upstream production processes of the supply chain, which usually take much longer to complete in relation to those at the lower (downstream) stages, as it is analyzed next.

At this point, it is worth emphasizing that any form of variability in a business's operations, and consequently supply chains, geometrically increases the cost of effective management. Variability is evident not only at the levels of primary and secondary demand but also in other critical parameters of supply chains, such as the execution time suppliers need to complete an order, production yields (especially of agricultural and natural products that can be affected by weather conditions), percentage of defective products, maintenance and repair times of mechanical equipment,

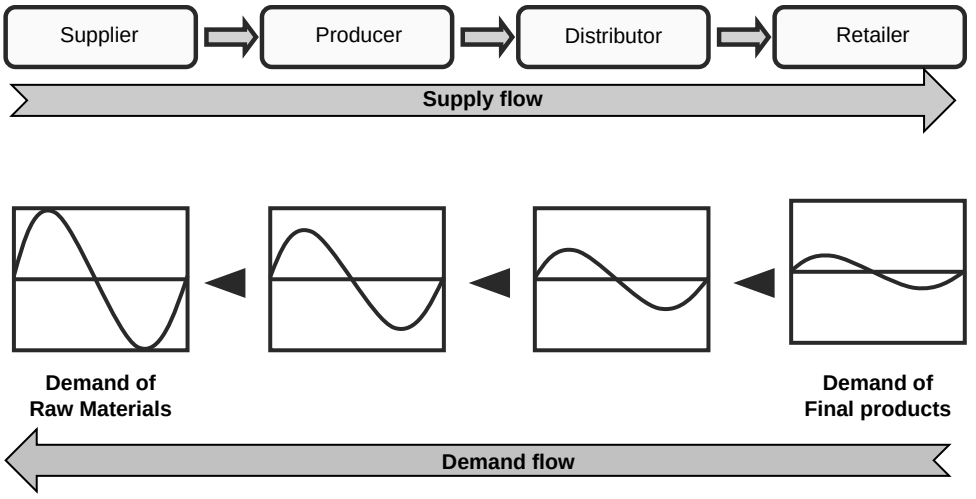


Figure 9.5 Demand volatility in a supply chain.

etc. Therefore, it is crucial for each supply chain to limit variability of any kind as much as possible, including demand variability (Harrison et al., 2015; Christopher, 2015; Bowersox et al., 2015; Chopra & Meindl, 2014; Min, 2015; Taylor, 2003; Reid & Sanders, 2013).

The high demand fluctuation observed in industrial markets is due in large part to the bullwhip effect, i.e. inaccurate or distorted information concerning primary and secondary demand within a supply chain. According to Figure 9.4, the retailer is the only link in the supply chain that has direct access to information on primary/consumer demand, which allows it to make highly reliable and accurate demand forecasts for its goods in the short and medium-term. If this information is not circulated to the rest of the supply chain, the wholesaler will try to forecast short- and medium-term primary demand through the retailer's demand data, the producer from the wholesaler's demand and so on. But fluctuation in the retailer's demand to the wholesaler does not depend exclusively on the observed changes in the primary demand; it also depends on other factors for which the wholesaler has limited or no information at all. As a result, the wholesaler has inaccurate/distorted information about the primary demand, with increased amounts of misinformation as we climb up the supply chain.

The causes of the bullwhip effect include the demand forecast updates from the various members of the supply chain, order grouping, changes in the price of industrial market inputs and the inflated needs of industrial customers. The accuracy and reliability of demand forecasts tend to decrease as the forecast horizon widens. But demand forecasting is a dominant factor used to base both medium- and short-term planning of all business and supply chain operations. Companies inform their suppliers about their short- and medium-term planned orders by basing them on demand forecasts. But the ordering schedule is updated according to the latest demand data, resulting in a chain of changes in the projected demand at all stages of the supply chain. The consequences of updating demand forecasts take on even greater proportions due to the grouping/categorization of demand. While retailers face a constant demand for their products from consumers, optimizing their inventory management requires them to group their orders based on an optimal order quantity model. Wholesalers in turn have to calculate their own optimal order quantity, which, in theory, is an integer based on the retailer's order; the producer must determine the optimal quantity of the production batch and so on. Therefore, while demand for consumer products is constant, demand for industrial products manifests itself at intervals in large order quantities.

One of the parameters for determining optimal order quantity is the price (acquisition cost) of the goods. Any changes in the price of industrial goods, especially in the form of temporary quantitative discounts (where the price decreases gradually as the quantity of the order increases, e.g. 5€/unit for the first 100 units, 4.80€/unit for 101–150 units, etc.), will further distort the demand signal. For example, a wholesaler orders 550 units of product X on average every eight days. Due to a supplier's promotional action, the wholesaler will increase the regular order quantity to 1,000 units; therefore, the next order will probably be placed in two weeks. In industrial markets, it is also more likely for demand to be reversed: any decrease (increase) in the price of a good is interpreted by customers as a trigger for further reductions (increases), resulting temporarily in a decrease (increase) in the requested quantity. Finally, virtual needs arise when supply and demand lag behind, with almost all industrial customers dramatically increasing supply volumes at the same time in the hope of extracting as much of each supplier's available quantity as possible.

Marketing, in conjunction with other business functions, can make a decisive contribution to managing the bullwhip effect. Creating and further strengthening partnerships, or even better, strategic alliances with the main supply chain partners will ensure that all stakeholders are kept informed about primary demand trends, thus making it possible to make plans based on common demand forecasts. Consolidation of the supply chain also leads to a significant reduction in the fixed cost of placing an order, hence the optimal order quantity is significantly reduced and so are the consequences of order grouping. Appropriate pricing policies and planning promotional activities can drastically deter *ex ante* markets by further normalizing the demand signal. The division of demand based on historical and not real-time recent data will also lead to the elimination of virtual markets.

9.4.4 Supply elasticity

Another characteristic of industrial markets that interacts decisively with derivative demand is the difficulty of reacting directly to changes in consumer demand, i.e. the inelasticity of supply. Response times to changes in consumer markets increase gradually the farther away a supply chain link is located from the consumer markets, due to the delayed transmission of the primary demand signal with – most likely – the inaccuracies and distortions mentioned earlier. The total time required between the moment an order is submitted and the time it is delivered to the industrial customer is clearly longer in relation to consumer markets; in fact, it tends to increase more and more as we move up the logistics stages of the supply chain towards the producers of raw (natural and agricultural) products. For example, the cultivation of wheat in Greece is an annual event with preparations starting in the fall, so that the grain can be harvested by early to mid-summer. Therefore, agricultural companies must anticipate the demand for their product at least nine months before the delivery of future orders. Critical decisions about the crop plan, such as the area under cultivation and the specific varieties of cereals to be sown, are based on long-term forecasts and demand expectations and are unlikely to change until the following cultivation period. This time period can be even longer in the case of tree crops, for example, where it takes several years (4–6) for the plantations to reach their full productive age.

The situation of large industrial units is similar to a significant degree, such as that of chemicals, oil refineries, electricity generation, etc., where the cost of changing the projected rate of production is very high and huge investments are required in specialized capital goods that cannot be used to produce alternative products/services. This is because, among other things, the percentage contribution of the average fixed cost to the total unit cost of products is very high, so any fluctuations in the rate of production lead to direct inverse changes in the average total production costs. Significant fluctuations in the production schedule are likely to cause a rift in the relationship of these industries with the strategic suppliers of their main inputs.

The effects of supply inelasticity become particularly painful in the event of abrupt changes in consumer demand. The coronavirus pandemic resulted not only in the imposition of restrictive measures on the movement of citizens/consumers but also in the operation of retail stores. Consumer demand for delivery of their purchases in their private spaces (homes) has reached unprecedented levels. Most large retail chains did not anticipate the type, size and intensity of the crisis, and hence failed (especially in the first months) to meet the unprecedented demands of their customers, mainly due

to the inability to receive the appropriate support from their partners in logistics chain. There have also been cases of particularly successful adaptation to these new conditions, due to the systematic commitment that some companies have shown towards creating and strengthening strategic alliances with their supply chain partners, which has resulted in an effectively coordinated supply chain response.

9.4.5 Seller–buyer relationships in industrial markets

The relationships of those involved in industrial markets constitute the main point of interest in supply chain management, and the marketing department in turn. Relationships formed in the supply chain are the result of dynamic decision-making over many years, and actions taken to implement common strategies and tactics through which stakeholders expect to achieve their strategic goals. Figures 9.6 summarizes the range of relationships found in industrial markets based on two very important criteria: the degree of relationship integration and the independence of ownership level (Harrison et al., 2015; Christopher, 2015; Bowersox et al., 2015; Chopra & Meindl, 2014; Min, 2015; Taylor, 2003; Reid & Sanders, 2013).

The simplest relationships to manage are those involving individual transactions, which are characterized by minimum requirements in their management, great flexibility and a strongly short-term character. Although diametrically opposite to strategic alliances, which are perhaps the holy grail in supply chain management, individual transactions can withstand the relative pressures of an ever-increasing competitive environment. They are used in markets that show little or no differentiated products, of little or no complexity,

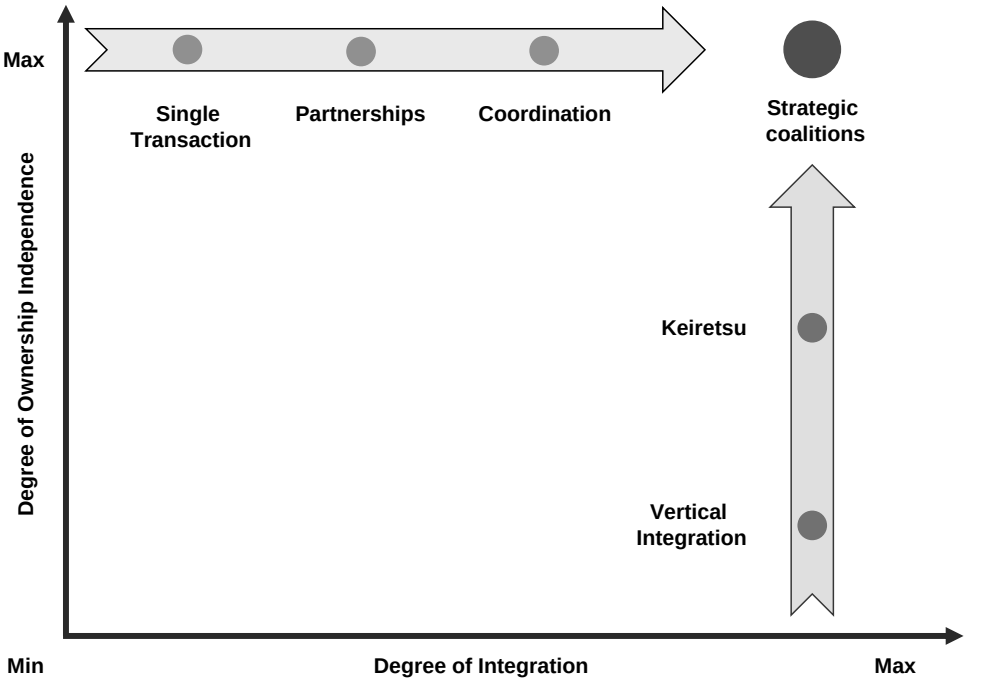


Figure 9.6 Supply chain relationships.

and are characterized by perfect competition. The main criterion for selecting the supplier for each transaction is the minimum purchase price of the product/service. The occasional and contingent nature of the relationship, with minimal requirements and obligations between the parties involved before and after the transaction, creates enormous difficulties in the efficient and effective planning of the overall business operation, including the ability to respond to market volatility and the production process. Therefore, such relationships are very rarely used by companies that aim for optimum satisfaction of their customers' needs and desires in a modern competitive environment that requires flexibility and prompt responses to ever-changing conditions.

A partnership is a long-term partnership that develops between two (or a limited number of) privately-owned companies which are, however, limited to long-term contracts without further functional connections between them. Coordination expands the intensity and scope of the cooperation between two (or a relatively limited number of) players and links in the supply chain, with the installation of an integrated critical information exchange system aimed at coordinating the action plans of the collaborating companies. These kinds of relationships are very important in terms of achieving strategic alliances, but they have a major drawback: they limit their scope of application and strategic planning to a restricted number of supply chain actors. The benefits of such partnerships are not always transformed into a competitive advantage for the supply chain's overall performance, which constitutes the ultimate measure when consumers evaluate alternative product offers. Simply put, no matter how strong the connection between two or more links in a chain, if the connections between even a few links remain weak or vulnerable to any changes in the environment, this chain is in danger of breaking and failing to achieve its purpose. In fact, it is not uncommon for whatever benefits the collaborators of the partnership or consortium obtain to stem from a collectively negative environment for the whole supply chain, as they often lead the other links in the chain to a more difficult position.

Partnerships and coordination are not new forms of relationships that have emerged from modern supply chain management, even though their frequency is constantly increasing, as the potential for groundbreaking innovative solutions offered by information and communication technologies continues to improve. They constituted the first steps and pillars on which highly integrated corporate relationships were based, which had little or no ownership independence, such as vertical integration and the Japanese keiretsu, respectively. However, despite the obvious benefits of both vertical integration and, to a lesser extent, keiretsu, they are not the most appropriate form of business relations for companies seeking a very high degree of integration with the rest of the supply chain. This is related to the legal constraints they face, especially in terms of vertical integration, to ensure healthy competition in the market. Most modern global/multinational supply chains usually consist of a huge number of companies, often tens of thousands, which are scattered and operating around the world in diverse social, cultural, economic and legal environments. Therefore, it becomes very difficult, if not impossible, to effectively control and manage the various bureaucracies of complex transactions, especially in a highly volatile business environment, even with keiretsu, let alone with vertical integration.

Strategic alliances combine the benefits of relationships with a very high degree of integration, together with a high degree of ownership independence, in order to facilitate their management and ensure their immediate and effective adaptability to rapid environmental changes. They are the kind of partnerships whose ultimate goal is

the implementation of collaborative planning, forecasting and replenishment (CPFR) at all stages of the supply chain, from the miners of natural resources to the retail distribution of goods in the market. The benefits of the appropriate application of the principles of integrated supply chain management are manifold, the most fundamental being the acquisition and maintenance of competitive advantage for the entire supply chain, which is recognized and rewarded by the loyalty of the ultimate critic of the supply chain, the customer. Competitive advantage is guaranteed in many ways: keeping all stakeholders directly informed about developments/trends in primary demand, the joint management of a large part of the inventory, sharing relevant information, reducing the total unit cost of transactions, shortening the period from the moment a decision is made for a new production batch until stocks are placed on the retailers' shelves, an immediate response to changes in primary demand, etc.

The main difficulties in the adoption, implementation and longevity of strategic alliances, and perhaps the most insurmountable, stem from human nature, particularly opportunism. The development of long-term highly interdependent relationships between the partners of a supply chain makes the members with the least bargaining power vulnerable to the moods of the powerful members since they are the most exposed to opportunities; therefore, they exhibit greater motivation for opportunistic behavior. This risk increases dramatically among members of the supply chain that have made specialized investments, and there are huge barriers against making changes in the direction of the production to meet the needs of other industrial customers. Similar risks are faced by companies that rely on a very limited supplier base (1-2), with specialized inputs for their production process, or the existence of external partners (e.g. outsourcing of transportation). Although modeling supply chain operations favors strategic alliances to achieve the optimal level of added value for all stakeholders in the chain, pursuing the same interest is clearly a higher priority than trying to achieve a common interest.

9.5 Materials handling

The term 'materials handling' refers to the handling and movement that products and materials undergo within the business premises, specifically the movement, storage and control of liquids, large solids, items by the piece, pallets, containers, vehicles, etc. inside the business premises. The term "product transport" is used to denote the movement of products over long distances outside the business. In particular, "transportation" is the movement from point A to point B while 'distribution' is the movement from point A to many different points B, C, D, etc.

The following questions must be answered for the proper planning of materials handling: "Why?", "What?", "Where?", "When?", "How?" and "From whom?". Generally speaking, in materials handling, an appropriate method should be adopted for each kind of material; the right amount of the right product should be provided, at the right place, at the right time, at the right frequency, in the right position and condition, and at the right price. Materials handling planning is influenced by the following factors: product characteristics, product type, traffic volume, layout of storage spaces and code locations.

Materials handling also refers to the range of equipment and/or devices that have been designed to work in synchrony, in order to organize the movement, storage and monitoring of materials in materials handling procedure or activity of a business's

logistics circuit. These comprise the materials handling systems inside the warehouse, including transportation equipment using a fixed route (e.g. elevators, piping), handling equipment for limited distances (e.g. bridges, cranes), mobile equipment for transporting materials (e.g. forklifts, trucks, trailers, wagons), tools that are used in materials handling and warehouse equipment (e.g. platforms, pallets, scales). The corresponding equipment for transportation and distribution is referred to as "transport systems" and is analyzed in the last section.

9.5.1 Concept of unit load in materials handling

The unit load is the minimum storage and handling unit for the purposes of the mass handling of cargo and minimization of handling, loading and unloading times. It can also be defined as a collection of materials placed and stored in such a way that they are treated, stored, and managed as a single entity. The advantages of unit loads are their standardized use of packaging and storage equipment, limited product information, controlled weight and more efficient macroscopic use of warehouse space. Their disadvantages are the cost involved in the assembly and reassembly of stored units, boxes and packaging materials, the cost of managing empty boxes and their disposal, and in some cases their inefficiency in the use they make of space.

Listed below are some common forms of unitization:

- Bottles: Made of glass or plastic and used for products in liquid or viscous form. Product examples include beverages, milk, soft drinks, water, pharmaceuticals and chemical products.
- Boxes: Made of (corrugated) paper, wood, synthetic plastics, metals (high strength) or a combination thereof and used for all kinds of products: solid, liquid and viscous, for all kinds of sizes and weights. They come in different shapes for every requirement: rectangles, polygons, with lids, etc.
- Small metal containers: Made of tinplate, aluminum and their alloys, and used for storing food, usually in solid or liquid form (canned food).
- Pallets: The pallet is the main form of tertiary packaging, together with the container. Their unitization process is called palletization, which aims to facilitate the loading and unloading of packaged products among the different means of transport. There are two main kinds of pallets, the Europallet and the American/British pallet. Their standardized dimensions are described below:
    - Europallet: 1200 × 800 × 144 mm (length × width × height). These are identified by the EUR certification initials inside an oval frame, printed in a visible place on the pallet (only for pallets made from a specific quality of wood, thickness of boards and blocks, number and length of nails). The Europallet is also used outside Eurozone countries. Its construction method is standardized; the dimensions of the train carriages, containers, forklifts and storage systems are also standardized, being based on the Europallet's dimensions, and this also applies to their respective storage spaces on trucks, ships and planes.
    - American/Anglo–Saxon palette: 1200 × 1000 × 144 mm (length × width × height). Different transport conditions are involved compared to that of the Europallet, and they have a different cost structure for alternative modes of transport.

Table 9.1 Types of pallets

Material	*Durability*	*Repair/recycling*	*Application*
Wood	Medium	Yes/No	Heavy products, accessories, food
Wood pulp	Medium	Yes/Yes	Medium weight and low-value materials (e.g. building materials)
Special compressed fibers	Low	Yes/Yes	Light products
Plastic	High	No/Yes	Closed transportation systems (in-house transportation)
Metal	High	No/Yes	Closed transportation systems for very heavy loads (e.g. military materials)

The American pallet can be said to be superior in that it reduces the lifting paths by 25%, because more packages fit on it without protruding (larger area). On the other hand, the Europallet is more appropriate for use in train carriages, for which it was in fact designed. Based on a decision by the European Commission, trucks are also designed to make full use of them. Three Europallets fit on a standard truck with only two industrial ones (prevalence of Europallets in international transportation trucks), while Europallets make better use of the principle of flexibility: Production Unit = Inland Transport Unit = Transport Unit = Storage Unit = Sales Unit.

Table 9.1 presents the materials used to make the pallets, their durability, the ability to be repaired or recycled, as well as examples of their applications.

- Pallet tanks: Tanks mounted on pallets for the transport of liquid and gaseous products.
- Pallet boxes: Boxes with a base in the shape of a pallet, so that they can be moved by forklifts. They are made of wood, and mainly plastic and metal, and may have a folding or detachable construction so that when they are empty, the space they occupy is minimized (horizontal storage). A variation is isothermal storage and transport pallet boxes for the transportation of sensitive products that need to be stored/transported at low temperatures above 0°C, e.g. medicines, biotechnological foods, industrial products, etc.
- Roll pallets: Pallets with wheels on their base for easy movement without the use of any special machinery/equipment.
- Crates: These are many kinds of crates for transporting solid products of a relatively large size, such as fresh fruit and bottles containing sensitive liquids (e.g. beer, milk). They can be made of plastic, wood, paper or expanded polystyrene.
- Bags: These are made of paper, burlap, fabric, synthetic plastics, a combination of paper and fabric or plastic, and they are involved in the management and flow of bulk materials (bulk loads).
- Barrels: These are made of hard paper, wood, plastic or metal and are used in the transportation of mainly liquid and viscous loads, or materials in granular form.
- Paper: Paper is used for bulk solids (sugar, flour, etc.) and in the packaging of liquids (juices, milks, etc.). Paper packaging can be reinforced with aluminum and plastic sheets.
- Auxiliary packaging materials, particularly stretch film which is a transparent synthetic film, about 0.5 meters wide, for pallet wrapping, manually or automatically using a special machine, together with the hoop which is a film made of synthetic material or metal for stabilizing boxes or other objects between each

other and on the pallets; it is applied with special machines, which may be portable or desktop. Tie chains, ropes, straps, cable reels, among others, are also included in this category.

For bulk handling and to minimize handling, loading and unloading times, the following factors must be considered when unitizing a load:

- Product shape, size and weight.
- Size of the transport unit base.
- Self-supporting loads (supporting one packing unit on top of another).
- Ease of (re)loading from the means of transport.
- Width of corridors from the facilities it will pass through.
- Floor strength of installations it will pass through.

Generally speaking, materials handling systems are classified according to the method applied as manual, mechanized and automated. There are several differences between the three methods. The manual one is limited to low weight, intensity and work speed, while it provides flexibility in movement, has low acquisition costs but also very high operating costs. Mechanized handling can tolerate heavy loads of high intensity with moderate management needs in relation to speed, flexibility, frequency and capacity, while its acquisition costs are not as high as its operating costs. The fully automated method provides high levels of handling in terms of weight, intensity, speed, frequency and workload. While it has a high acquisition cost, it also has a low maintenance cost but provides low flexibility of movement. Their differentiation lies mainly in flexibility, in terms of the way they manage space. Manual materials handling is flexible but limited in the volume of materials it can manage and the size capacity of the total work; mechanized handling is less flexible but manages a larger volume of materials; the fully automated method provides greater capacity in terms of project management, but it comes up against difficulties in terms of flexibility in the way the materials are handled.

The systems can be classified on the basis of the equipment used in them, namely:

- Conveyors: This labor-saving system permits large volumes of materials to move as fast as possible, allowing businesses to send or receive large quantities in the shortest amount of time with the least labor cost. They provide continuous traffic on specific routes but with limited space coverage. There are two types of conveyors: synchronous and asynchronous.
- Pipelines: They provide a small range of services, and are used mainly for the transportation of liquids, gases, crude oil and refinery products. Their main feature is the slow movement of products inside the pipeline which is compensated by the fact that there is a flow of products on a 24/7 basis. Wider pipes have a very high capacity and there is a very low risk of product losses and damages during transportation. While its installation is very expensive, maintenance costs are very low and the availability of the pipeline is restricted only by the possibility of other carriers using the facility.
- Cranes and winches: These are overhanging vertical transportation systems with intermittent movement and limited accessibility, either in a circle around their axis or forming a rectangle, taking advantage of the length and width of the installation where they are housed, with relatively low installation costs, and characterized by work of moderate intensity.

- Industrial vehicles: These are wheeled vehicles for intermittent work, with the ability to move along different routes, with a high level of accessibility in the workspace and low acquisition costs; they are mainly industrial means of handling low labor-intensive materials.
- Electric and manual pallet trucks.
- Warehouse equipment: This is used to preserve/maintain and store materials.
- Auxiliary equipment: This is used for the most efficient, optimal and easiest management of materials.
- Storage and retrieval systems: They transport the product to the person (part-to person) or they transport the person to the location of the product (person-to-part), in order to complete the collection process.
- Robots: They can be anthropomorphic (Gripper) or general-purpose (multi-functional) and they can be programmed to do tasks in environments that are difficult for humans to operate in, or in 70%-automated industries.

9.6 Storage

The core of a company's logistics system is the warehouse. A simple definition of a warehouse could be "*the space used to collect and store products*". From personal experience, we know that this space should be well organized (so that we can easily find the product we are looking for), adequate (so that we can store the quantities we need), clean (so that the products are maintained in good condition) and technologically well equipped (so that we can perform the required tasks more efficiently with less effort). In the simplest case, a warehouse can serve only one business, for example, a retail company. In this case, the warehouse space is usually located inside the business premises. It can also serve a network of companies, operating as a distribution center, i.e. those companies' suppliers, e.g. a distribution center that may supply some branches of a retail chain. In this case, the warehouse is an independent building.

A distribution center can also combine products, and consolidate shipments from different factories which are directed to customers; it can even receive large loads from one factory that deals with many customers' orders and break them down into smaller loads to be shipped to each customer. In this case, the warehouse can also function as a coordination point and a temporary storage space for inventory. It is also very common for a warehouse to belong to a company that provides logistics services to third parties (such as warehousing, transportation and distribution services, etc.).

The role of the warehouse has obviously changed significantly in recent decades. Initially, it was considered the storage space for the products used or marketed by a company; at the same time, it did not add value to a company's marketed products of a company. Today, warehouses act as centers for the receipt of products (e.g. raw materials and/or finished products) from suppliers, temporary storage spaces for these products to support production, and/or resale/transportation of the final products within a supply chain. In other words, the roles of warehouses and distribution centers in today's world add value to a supply chain in two ways: through storage, so that products are available when needed; and through transport/distribution, so that products can then be collected, grouped and transported to the points of sale.

An issue concerning the exact definition of a warehouse is the distinction between a warehouse and a distribution center. Both terms are often regarded as similar in concept, but in truth, they have different characteristics. A warehouse is a facility

where goods are stored for a long time, whereas a distribution center is where goods are stored for a shorter period. The warehouse does not have high levels of daily activity, unlike a distribution center where receipts, arrangements, storage and shipments are part of employees' daily work. Therefore, a distribution center is oriented towards the execution of orders, i.e. the satisfaction of demand. Value-added processes in particular are performed in a distribution center, as opposed to a warehouse that simply offers storage services. This creates different requirements in each case, concerning different systems and equipment. In a warehouse, investments are aimed at maintaining the good condition and safety of the goods; in a distribution center, the main goal of the systems is the optimization of procedures.

9.6.1 Importance of the warehouse

It is all the more clear that the warehouse occupies a key position in the business. Some consider it – and not unjustly – the "heart" of a business; just as the heart regulates blood flow, the warehouse which contains and sends out products regulates their flow from their acquisition (supply) and production, to their transportation, distribution and consumption.

The warehouse is the storage space for product stocks. These products are stored from the moment they are produced or supplied, until their sale, consumption or use. In other words, the warehouse is related to the stocks, the coverage of space (distance) and the corresponding time needed to cover this distance (the place-time gap), between the products' points of production and the points of sale/consumption. Even in today's highly interconnected world, a low percentage of small businesses do not monitor their stock levels on a daily basis, while an even larger percentage does not even perform stock-taking activities. This often leads to late shipments, late processing, late order execution and of course a negative image of the company from the customers' point of view. The warehouse is the central point for stock control and monitoring. Keeping stocks in warehouses close to points of sale helps towards the timely and efficient supply of the market.

Some of the key tasks in the warehouse area are also performed for the purposes of effective planning, execution, monitoring and control of orders, such as receipt of products in the warehouse, arrangement and rearrangement of products, labeling, collection and monitoring of orders, loading and shipping, handling returns, stock-taking, etc. And here lies the second important difference between the traditional and the modern warehouse. The nature of warehouse operations was traditionally labor-intensive (i.e. it required a lot of heavy manual labor on the part of the storekeepers themselves, to load/unload products and collect them to complete orders), whereas today, it requires people with special knowledge and skills who manage complex composite tasks. It also requires people who operate machinery, tools and expensive equipment to perform precision work. Furthermore, the special role of a warehouse manager is a prerequisite; this person will coordinate the above-mentioned tasks that are performed in the warehouse area, as well as the human resources and equipment needed. Today, the nature of warehouse operations is considered information-intensive because information transfer – stock levels, product storage locations, products' import and expiration dates, transactions that are being performed or will be performed, incoming and outgoing shipments, data concerning customers and suppliers, as well as staff – is very important for the smooth operation of the business.

Industrial production units that want to take advantage of economies of scale can produce and store large product quantities, thereby reducing production costs. Similarly, commercial companies can supply large product quantities by gaining access to reduced market prices. Wholesale market pricing generally offers cost savings per unit, which, when purchased in large quantities, exceeds the cost of storing and maintaining materials. Similarly to production and supply savings, the better a company can use the full abilities and capacities of transportation equipment, the more efficiently and economically the products can be transported. Transportation costs per unit decrease as more units are transported. The cost associated with managing and maintaining large amounts of inventory in stockpiles should be compared to the cost of transporting large quantities to achieve transport savings associated with reduced unit pricing. In many supply chains, transport savings per unit exceed the cost of storing additional products. Warehouses add value by supporting large transportation needs.

There are products whose demand (of a seasonal nature) or production (e.g. harvest time, seasonality of production) concerns a specific period of time within a year. There is therefore a need to store and sell these products at the appropriate time. For example, when winter is over, a company that manufactures and distributes sports equipment for winter sports can store its production instead of putting goods on the market at a lower price. In this way, it will maintain stable stock levels when needed, and therefore, maximize its profits.

Warehousing not only protects businesses from large price fluctuations but also provides safe storage of their products. Generally speaking, when goods storage may imply exposure to many dangers such as theft, damage, fire, etc. A warehouse provides protection to the products from the above dangers, as well as from destruction or damage due to heat, dust, humidity, etc. Special systems and technologies are applied to different products depending on their nature, thereby reducing losses due to deterioration during storage. Plants, works of art, candles, food, medicine and cosmetics are just a few examples of products that require special storage, e.g. refrigeration, preservation, etc. A warehouse that offers this service keeps products at the right temperature, preventing deterioration and changes in their color and texture. This helps to extend the life of these products. Products stored in warehouses are usually insured and the warehouse manager often shoulders the responsibility of maintaining these products in good condition for the owner of the goods.

Finally, warehouses provide appropriate facilities and equipment for packaging products and delivering them to customers. Packaging can be primary (by the piece), secondary (in a box) and/or tertiary (as a pallet). Moreover, goods can be packed in the warehouse in various dimensions and with a variety of packaging materials, and they can also carry a range of information, labels, codes, etc. according to the customers' instructions/wishes.

9.6.2 Roles of warehouses

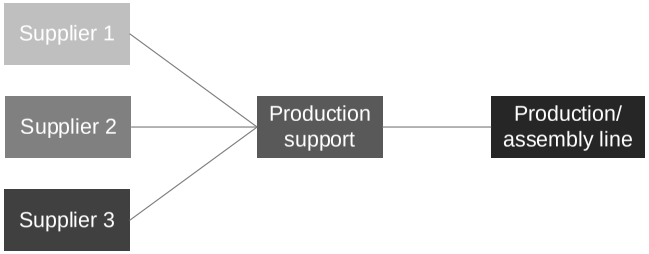
Warehouses comprise a critical factor in successful SCM. In today's business environment, they can take on the following roles, as described in Table 9.2 (Ballou, 1999).

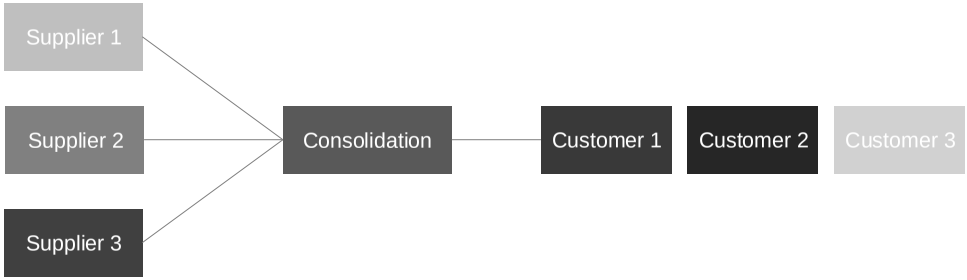
9.6.3 Types of warehouses

Warehouses can be classified into different categories (types), according to specific criteria:

Table 9.2 Warehouse roles

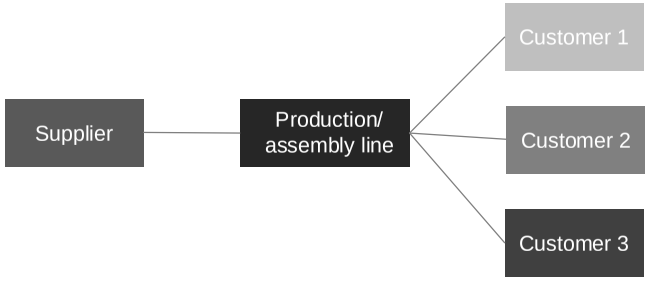
Role	*Description*
Production support	The warehouse functions as a consolidation center for the receipt of products (e.g. raw materials and/or semi-finished products) from the suppliers, followed by their internal distribution in the production and/or assembly lines.
Consolidation of Loads	The warehouse combines products and consolidates shipments from the various factories to the customers. The freight collection area is where individual cargoes are grouped into larger ones in order to reduce the total transportation costs. In this case, suppliers take advantage of the economies of scale of the warehouse owner, but the customer does not buy large enough quantities to justify separate shipments from each supplier.





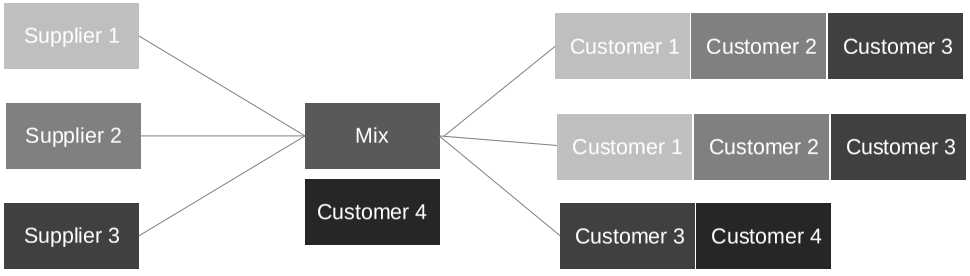
Load breakdown

The warehouse receives large loads from a factory containing many orders from many customers and breaks them down into smaller loads to be shipped to each customer. This is the exact opposite to load consolidation. Cargo quantities with low transportation costs arrive at the warehouse and are then re-shipped in smaller quantities to customers.



Order mix

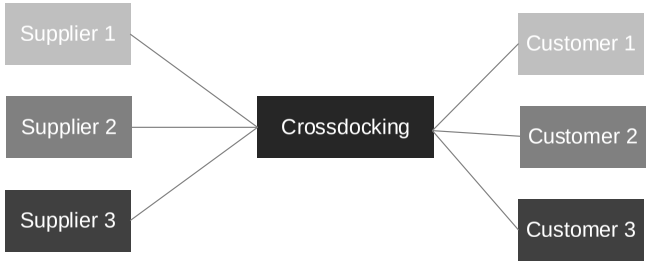
An example of a warehouse that performs some or even all of the above-mentioned roles is usually called a "distribution center". Since each factory produces only a fraction of a company's total production output, multiple factories ship different products to a central warehouse. The warehouse may support the production and/or assembly of a new product. Products are then re-shipped in smaller quantities to customers.



(*Continued*)

Table 9.2 (Continued)

Role	*Description*
Cross-docking	The warehouse functions as a coordination point and a temporary stock location rather than as a storage point. The goods are distributed directly and continuously to the customers.



- Based on whether or not the company has privately-owned facilities, a distinction is made between private and public warehouses:
    - Private warehouses are owned and operated by large construction/commercial companies to meet their own storage needs. Privately-owned premises offer businesses better control, lower costs and greater flexibility, especially when demand is stable or special storage conditions are required.
    - Public warehouses are a tertiary business entity that provide facilities and storage services to business customers for a fee. Public warehouses are very useful for the business community. Most companies are not able to maintain their own warehouses due to the large investment capital required. Public warehouses provide convenient facilities for easy pick-up, shipment, loading and unloading of goods, making use of equipment that can handle heavy/bulky products. They are usually located near terminals, railways, ports, motorways and airports.
- Warehouses store all types of products, including those that need special management (preservation, refrigeration, flammable/chemical/other hazardous materials). Thus, warehouses can be categorized by product type:
    - General warehouses (warehouses for general goods)
    - Warehouses for bulk cargo for the storage of liquid chemicals, petroleum, etc.
    - Temperature-controlled warehouses (for refrigeration/preservation): These use temperature and humidity control mechanisms. Sensitive products, such as fruits, vegetables and frozen goods, are stored in them.
    - Warehouses for household goods, for the storage of household equipment and furniture.
    - Warehouses for special products.
- Warehouses can undertake storage for any kind of goods. There are:
    - Warehouses for storing raw materials, which receive products from an external source, store and collect them, and then send them on for internal use (on production lines)
    - Warehouses for semi-finished products, similar to warehouses for raw materials, but they are used for shipments to assembly lines.
    - Warehouses for finished (final) products, which receive products from an internal source, store and collect them, and then send them on for external use.
    - Warehouse for packaging materials.

9.6.4 Principal storage tasks

Warehousing is a key Logistics function, and includes the following five work tasks:

1 Goods entry: initial receipt, form checking, unloading and placement of goods in goods receipt area, inspection (qualitative and quantitative control), delivery, unpacking/repacking, placement in the storage or returns area.
2 Main storage: placement at the storage point, stock level update (inventory), issuance or update of materials files.
3 Execution of orders: issuance and receipt of collection forms, collection of ordered

products, product grouping per order, packaging and labeling, form checking, updating of materials files.

4 Goods exit: loading, shipping/transportation of products.

5 Other tasks also performed in the warehouse area: cleaning/tidying up of the premises, maintenance of equipment and machinery, and other administrative tasks, the most important being stock-taking and management of available resources.

9.6.5 Distribution center design: Key parameters for supply chain networks

Business executives responsible for Logistics and Supply Chain Management must respond to the following issues that are directly related with the warehouse and the storage operations:

- Selection of the warehouse location.
- Architectural design and basic layout of the warehouse.
- Spatial planning of the warehouse layout and detailed siting.
- Philosophy behind the chosen storage system.
- Final selection of storage systems.
- Selection of inter-handling systems.
- Design of roles and responsibilities.

Each of the above issues could, on their own, form the topic of a separate book; the main parameters involved in the design of warehouses/distribution centers will be described briefly in the following sections (problem definition and troubleshooting steps or options). The management (design, monitoring, execution and control) of storage procedures constitutes the final issue. It should also be emphasized that these decisions are either strategic or tactical. This virtually means that after they are taken, they can only be overturned at great cost in terms of time and money for the business.

Selection of the warehouse location. The problem of selecting the location of a warehouse lies in identifying its most advantageous geographical location, to maximize cost reductions and provide better services in the market. This will lead to increased business revenue and greater consumer satisfaction. The factors considered for the selection are many and varied: cost of land acquisition, its government valuation, proximity to existing or future markets, access to roads and chosen modes of transport, the infrastructure available (industrial zones/parks), potential facilities (telecommunications, energy, etc.), tax/development laws and existing legislation, incentives, labor availability and labor costs. A large number of studies in the literature propose the application of quantitative methods or mathematical models such as the center of gravity, the scoring model, the loading method, distance, break-even point analysis, etc.

Architectural design and basic layout of the warehouse. The warehouse building's boundaries must be defined. Issues that need to be resolved include how much land can be built on for the construction of the warehouse, the design of lorry and freight routes (transit pathways), and determination of the number and location of industrial doorways. There is also the issue of dividing the building into separate sections/spaces based on the operational design of the warehouse. Towards this respect, the main operating areas are as follows:

- Storage, freight, processing procedures and support services

- Administrative areas, and whether or not they are discrete from other storage areas
- Production operations, packaging, repackaging and product standardization areas;
- Electromechanical support facilities for the warehouse, fire extinguishing-water pumping station, air-conditioning and heating systems, etc.

Selection of the main warehouse areas within the boundaries of the plot is made on the basis of construction costs as well as the application of functionality criteria and expandability, with optimal and safe support for freight vehicles. It also depends on market demand; increasing demand usually causes demand for greater capacity, which a company can overcome by expanding the business in an existing facility.

Spatial planning of the warehouse layout and detailed siting. This issue concerns the location choice for each product code in the storage areas and the final layout of those zones. In the first case, many methodologies have been proposed, the main ones being based as follows:

- The unit load that the company uses (pallets, cartons, etc.),
- The title of the product or its code (supplier or company),
- Product movement: Fast-moving products are selected and placed near the order picking area. Another way to do this is to allocate products based on an index for a "number requested by a code" to the "required storage space", and placement of products starting from the largest quotient near the collection site, thereby achieving placement of a larger number of fast-moving product codes near the collection area;
- Product (code) family (group): Products are grouped and positioned according to the same dimensions, weight and individual parts, requiring the same cooling/safety conditions (eg toxic, flammable);
- Traffic flow: When applying the FIFO (First-In-First-Out) philosophy, access to all locations is required, especially to secure products with an expiry date for export; in the case of LIFO (Last-In-First-Out), smaller spaces and more depth levels are required;
- Inter-handling systems (pallet truck, counterweight forklift, reach truck, VNA truck, etc); and
- Order picking (manual, semi-automated or fully automated).

Final determination of all storage locations based on the required storage conditions must also be made.

Philosophy behind the chosen storage system. The business must decide, for each product or each product group, on the management philosophy it will employ (especially when and how to export them from the warehouse). The main philosophies are as follows:

- First-In-First-Out (FIFO): This philosophy concerns products with a short life cycle. In its application, the first to be imported into the warehouse is the first to be exported. FIFO consumes its reserves starting from the oldest imports in the warehouse. This philosophy applies especially to vulnerable products; the main criterion for their management and export is the batch number. It is also proposed as a useful method for series depletion.
- Last-In-First-Out (LIFO): This is used in cases where the last import that came into the warehouse is selected as the first to be exported. It is often used as an inverse/

reverse depletion series. Unlike FIFO, LIFO follows the reverse sequence. It exhausts stocks by receiving quantities for consumption from recent stock imports. It is used for products such as shoes and clothing, electrical appliances, etc. and is common in cases where production is made by the same company. It is also used when the cost of manufacturing a product increases. Maintaining it increases inventory costs, so the company tries to consume these products more quickly in order to keep storage and maintenance costs low. This philosophy makes better use of space and reduces movement within a warehouse. The criterion for product management in this method is the date of their entry into the warehouse.

- First-In-Still-Here (FISH): This system describes an undesirable situation resulting from LIFO's inability to function in a particular situation: products that were imported first and which could not be recycled remain in the warehouse without leaving it. Inventory costs accumulate as codes remain stagnant, and they occupy storage locations that would otherwise be available.
- First-Expired-First-Out (FEFO): This philosophy is based on FIFO, with a stricter application: the product that expires first is the one that is exported first. The criterion for exporting products, in this case, is based on their expiration date.

Final selection of storage systems. Choosing permanent storage systems is one of the most basic decisions that a Logistics officer has to make. Today, the market offers a wide range of solutions, which can be categorized into three groups: stacking, shelving and special storage systems.

Stacking is the manual placement of products in the warehouse (next to each other and on top of each other). A special case of stacking is overlap, where unit loads (handling units), i.e. pallets, boxes, crates, etc., are positioned side by side or on top of each other, forming a single block.

Shelving is the most common choice for stacking. It is classified as lightweight shelving up to 2 and is an easy and inexpensive solution for businesses whose products have low mobility (demand). Shelves 100 kg per level or meter, long-span shelving up to 500 kg, and heavy-weight shelving (pallet racking) from 500 kg to 4–5 tons per level or pallet.

The first two options use perforated metal shelves that allow for easy placement and dismantling, variable height for different loads and utilization of better space. With the dominance of the pallet as the most basic unit load, many pallet racking options have been manufactured and are available on the market, e.g. regular back-to-back shelves, very narrow runways, very high shelves for pallet stacking cranes, mobile shelves, drive-in or drive-through shelves with free entry, slide-in shelves and inclined shelves.

Finally, there are special storage systems, such as cantilever shelves for long products, and carousels that allow for part-to-person collection: the product moves towards the employee. Storage systems are selected based on criteria such as product accessibility (i.e. free or limited access), product placement in the warehouse, warehouse layout, corridors, etc. The choice generally depends on these decisions. For this reason too, storage systems are considered to be "complementary" to the inter-handling systems that constitute the next decision.

Selection of inter-handling systems. Inter-handling refers to the activities and movements of the product or material – the unit load, as discussed in the previous section – within the business premises (and not exclusively within the warehouse). On the other hand, product transportation is used to move products on long routes outside the business. The choice of inter-handling system includes the selection of a series of related equipment

or device components designed to work in synchrony, in order to organize the management (movement, storage and control) of materials in the storage procedure. Almost all the procedures that will be presented in the following sections use one or more intra-handling systems in practice, the main two groups being pallet trucks and Clark forklifts.

The various kinds of intra-handling options are discussed below:

- Pedestrian pallet truck (electrically powered) or onboard operator, for the placement and collection of pallets in warehouses with small height levels.
- Counterbalance forklift, which is also used to place and collect pallets in warehouses with small height levels, offering the ability to move them around in the surrounding area; this entails the requirement of corridors inside the warehouse, from 3.5 m to 4.5 m width.
- Reach truck, where the driver can see in front and behind. It is suitable for warehouses up to 12 m, it is faster than the counterbalance forklift, but it is more expensive and requires narrower corridors (up to 2.8 m).
- Very Narrow Aisle (VNA) truck, which is suitable for high-level warehouses (it is the only option for heights above 12 m). The pallets are mounted and collected on both sides of the pallet rails, while the operator can be elevated in a dedicated cabin. The VNA truck can be rotated 180 degrees, it requires runways (from 1.5 m to 1.8 m), it is fast, but it also has a high purchase cost.

Design of roles and responsibilities. The warehouse is a 'living' part of a business, where many employees work, with distinct, well-defined roles and responsibilities. There are two main roles in a warehouse: the warehouse manager and the warehouse keeper. The warehouse keeper seeks to secure the relevant human and capital resources for the execution of the day-to-day operations of the warehouse, to satisfy the requirements of the various offices, departments or divisions of the business by receiving and dispatching the products required, and finally, to design, supervise and exploit the available resources so as to continuously produce an efficient service with low operating costs. Among warehouse keepers' general responsibilities, they must ensure the prompt receipt of all materials supplied by the competent committees, and that they are brought into the warehouse or, where appropriate, delivered directly to the services where they are needed.

Warehouse staff must compile documentation of the goods (or materials) received, arrange for the goods to be signed by the competent authorities, manage all the warehouse materials, update the materials' transaction records (debit-credit), keep the relevant files of the materials updated for transactions made between warehouses and various other services, and update the corresponding files for the billing of the supplied materials.

To conclude this section on decisions that Logistics officers are required to make, it should be emphasized that each decision is directly related to the others: it affects and is affected by them. The warehouse can be considered a dynamic and open system that is affected by the environment, at the same time that it too affects it. Moreover, a systematic approach exists in the warehouse, where each part of it is itself a subsystem of the warehouse as a whole. We are not concerned with the high performance and efficiency of each separate department or operational unit; we are concerned with the coordination of the subsystems and functional parts of the warehouse, to achieve the goals of the Logistics system, and by extension, the objectives of the business.