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A REVIEW

Role of food packaging in supply chain management

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INTRODUCTION

Logistical networks deliver food via complex distribution channels that encircle the earth. Supply chains range from hand delivery of a neighbor's garden vegetables to the importation of exotic and rare processed foods using specialized trans-global distribution systems. Farm markets, conventional grocery stores, restaurants, fast food take-outs, food service institutions and direct marketing systems are supplied by a myriad of operational variations. They are also supplied by a wide range of package types, sizes and formats.

Logistical activities in a typical processed food supply chain begin at the farm. Commodities are transported to factories in bulk or semi-bulk packages, where the food is processed and packaged to add value. Unit loads are transported to wholesalers or retail distribution centers (RDC) where orders are picked into mixed loads, delivered to retail stores and broken down for retail display. There, consumers buy an assortment of packages and transport them home, where all of the packages are emptied, discarded and either shipped to a recycling facility or collected and transported to a landfill.

Packaging affects the cost of every logistical activity in a supply chain, and has a significant impact on productivity. Transport and storage costs are directly related to the size and density of packages. Handling cost depends on unit loads. Inventory control depends on the accuracy of identification systems. Customer service depends on how well the packages protect products and how easy the package is to open, display and sell. The environmental impact depends on the materials, method of manufacture, reuse and disposal of the packaging.

As Fig. 1 illustrates, logistics is concerned with two types of flow: physical flow and information flow. It is common to consider physical flow as the forward flow throughout the logistics network, the main direction of which is from the point of origin to the point of consumption. Also, the information flow is considered to be backward, so its main direction is from downstream to upstream elements. However, in practical terms, the directions of physical and information flows are not one way. Materials and information flow from both upstream

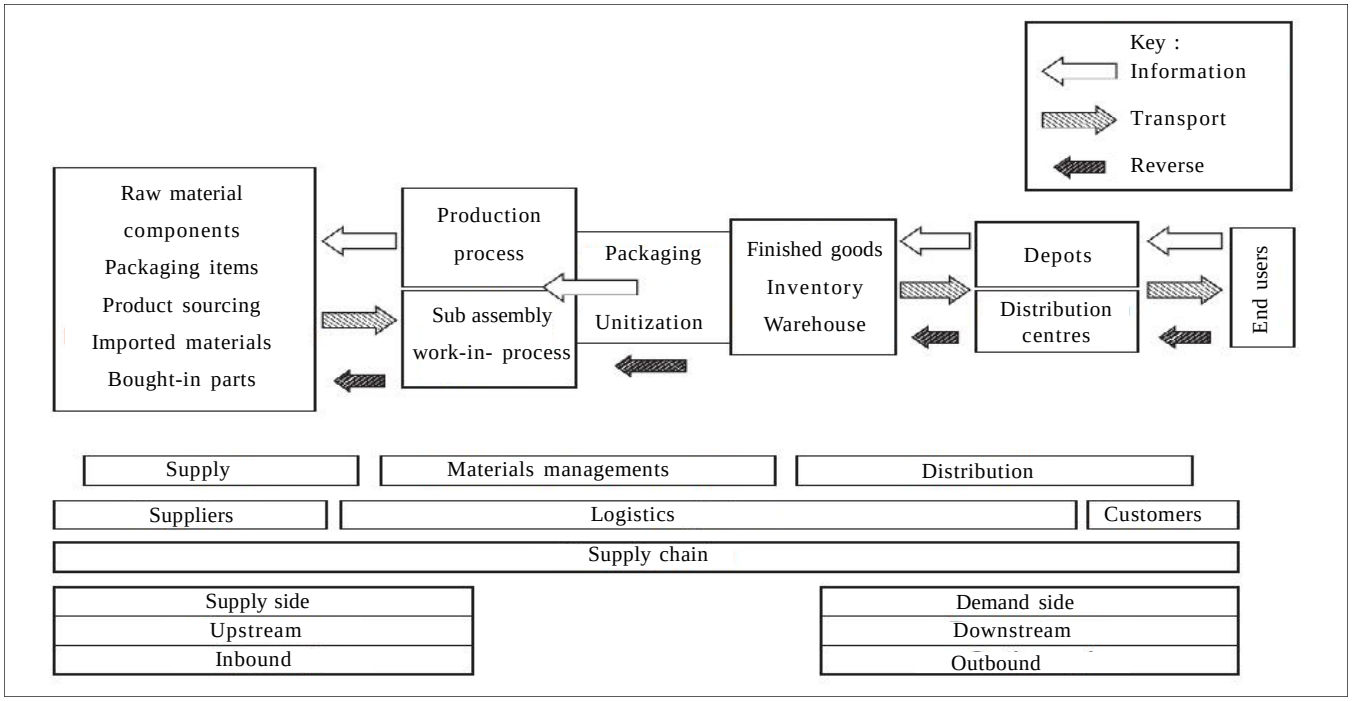


Fig. 1 : Logistics flows and some of the different logistics terminologies

and downstream. In regard to physical flow, the backward flow of product is referred to as reverse logistics. It is the flow of returned goods and used products as well as salvage, scrap disposal and returnable packaging back through the system. In this chapter, the emphasis is on the physical flows (also known as material or inventory flows). Physical flows involve the entire process and activities of logistics systems, however, to explore the concept of physical flows systematically, the major components of logistics systems can be categorized into five functional areas (Ailawadi and Singh, 2005).

– Network design
– Information
– Transportation
– Inventory
– Warehousing, material handling, and packaging

Definition of logistical packaging :

"The process of planning, implementing and controlling the co-ordinated packaging system of repairing goods for safe, secure, efficient and effective handling, transport, distribution, storage, retailing, consumption and recovery, reuse or disposal and related information combined with maximizing consumer value, sales and hence profit." Saghir (2005).

Functions of logistical packaging :

There are three inter-related functions of logistical packaging: protection, utility and communication. There is an increasing trend to view packaging in terms of the functions and value that it provides, rather than just in terms of traditional materials. (Materials are discussed in the third section of this chapter.) Packaging is part of a total system, with responsibility to minimize the cost of delivery as well as to maximize sales (Fig. 2).

Protection :

The first function is to protect the food and the consumers. Protection is an important packaging function because spoilage and distribution damage, wastes production and logistics resources. Replacement orders add further costs, and delays can result in lost customers. A loss of integrity in certain food packages can lead to product quality and safety issues. The type and amount of protection that a package is expected to provide depends on the characteristics of the product and the distribution environment with its associated hazards. A key aim of packaging is to provide the required protection using the lowest cost materials.

The relationship can be conceptualized thus:

Product characteristics+Logistical hazards=Package protection

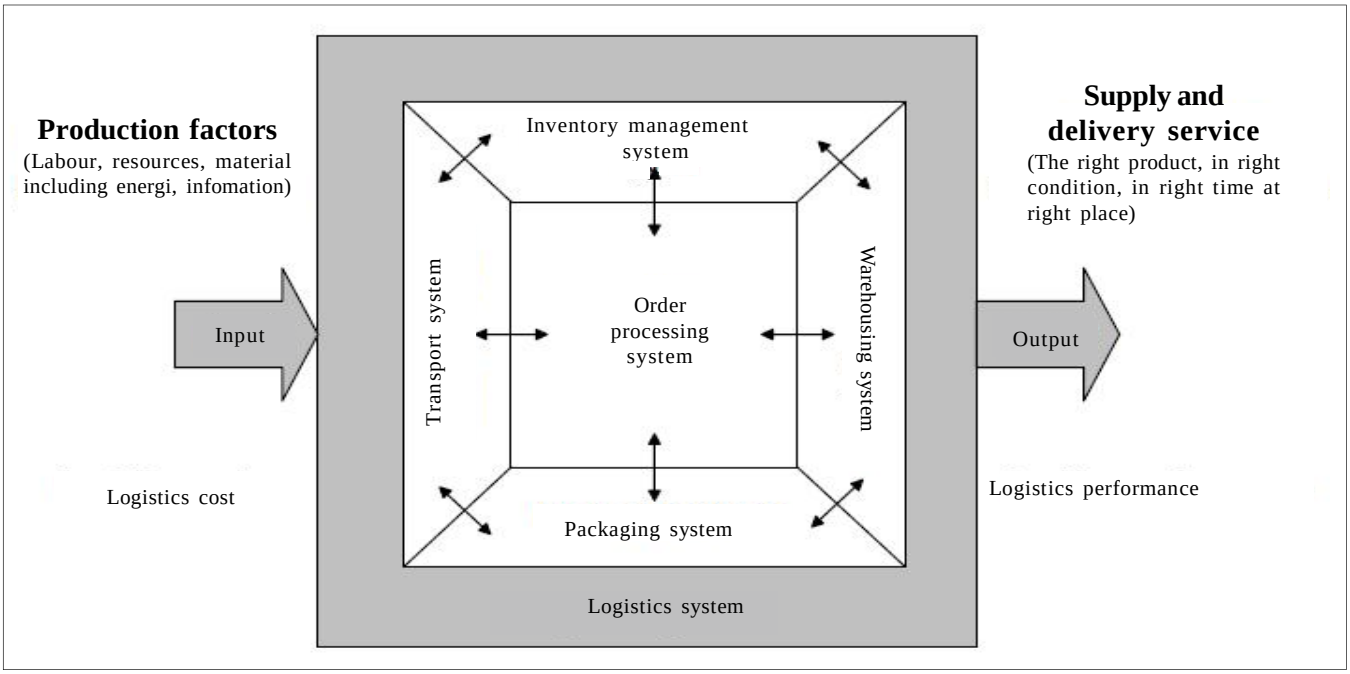


Fig. 2 : Logistical systems and its components

The relevant product characteristics are those that deteriorate or can be damaged over time. Food products are particularly vulnerable to biological and chemical changes that can affect quality and food safety. The hazards of the distribution environment range from exposure to extreme temperatures, dynamic forces and insect infestation to ambient foes such as oxygen, moisture and time. The preservation ability of food packages and their characteristics and properties of packaging importance are discussed elsewhere in this book. It is important to note here that the required length of a food package's shelf-life is directly related to how long it is in storage, transit and on the supermarket shelf. Short temperature-controlled channels for fresh food require less shelf-life from their packages.

Protection from dynamic forces, handling impacts, in-transit vibration and warehouse stacking, is usually provided by the shipping container. Testing can determine how much abuse a product can withstand and can be used to predict how well its package will prevent physical damage such as bruising, breaking, denting and smashing. Some standard dynamic tests are described later in this chapter. The dynamic hazards of a logistical system and hence, the most appropriate tests conducted depend on handling and the types of transportation and storage used. Firms that use a number of different types of distribution channel may need to package for a variety of conditions. Damage is a symptom of an underlying problem that can be solved by changing the packaging or by changing distribution practices. In many cases, it costs less to reduce the hazards than to '*improve*' the packaging.

Utility :

The second packaging function, utility, is defined as value to a user. In the case of logistical packaging, the user is the logistical system and the value is productivity. Productivity in logistics is a very important concern because distribution is labour and capital intensive. Productivity is measured simply as the ratio of real output to real input:

Productivity = Number of packages output/logistics input

Logistical productivity is the ratio of the output of an activity, e.g. the number of packages loaded into a truck, to the input activity, e.g. the labour and forklift time required. Most logistical productivity studies center around better utilization of '*inputs*', particularly labour, work harder. On the other hand, packaging initiatives like unitization and size reduction can easily increase the '*output*' of logistical activities. A good example is palletization, which dramatically improves the productivity of most material handling operations compared to break-bulk handling. Unitization enables a single person and a forklift to handle thousands of kilograms in an hour. Almost all logistical productivity measures are described in terms

of number of packages. Some examples include the number of cartons loaded per hour into a trailer, the number of packages picked per hour at a distribution center, the number of packages that fit into a cubic metre (*cube utilization*) of vehicle or warehouse space, the time to stock retail shelves and the cost of waste disposal.

Packaging configuration directly affects the number that can be handled per hour or the number that fit into a vehicle. Ergonomics is also a utility issue because healthy workers are more productive than employees engaged in personal injury lawsuits. Most injuries in physical distribution activities involve shipping containers. There are two types: accidents, usually involving an unstable package falling on a person and chronic stress injuries due to manual handling of goods. Routine manual handling of packages has always been taken for granted, but it has a reputation for causing chronic back injuries.

Many retail and warehouse workers are hurt by packages that are heavy, bulky, or must be lifted to a top shelf. In order to protect workers, the US Occupational Safety and Health Administration (OSHA) have issued guidelines for maximum weight of manually handled packages and appropriate handholds, and the EU has set ergonomic standards in Directive 90/269/EEC. The recommended package weight is related to how far and how often a package is lifted, how far the worker's hands are extended, how far he/she must twist and the adequacy of the hand grip. For most routine material handling jobs, the recommended weight limit is between 20 and 30 lb (9–14 kg).

Communication :

The third packaging function, communication, is becoming more important as logistical information systems become more comprehensive. Electronic data interchange (EDI) and control has been key to the development of effective and integrated management of material flow, inventory, transportation and warehousing. For EDI to succeed, accurate timely information on the status of the packaged product is required. For all practical purposes, the package symbolizes the product throughout the distribution. Every time that a product changes status, for example when it is picked for a warehouse order, information about the status change is registered in various logistics records.

The information systems that record a status change include inventory records, shipping records, bills-of-lading, order picking lists, order receiving verification, accounting payables and receivables, manufacturing and logistics system tracking, and retail pricing. Packaging codes are also sometimes used for sorting products to various destinations in a factory, warehouse or transport terminal. International shipments additionally require the language of shipping origin, destination and intermediate stops, as well as international markings for handling instructions.

Correct identification of stock-keeping units (SKU) including SKU number, name, brand, size, colour, lot, code dates, weight and number in the package are critical for good information management. Every logistical activity entails reading the package and recording/changing its status in an information system. Accuracy is essential. SKU information must be clearly legible. Workers must be able to quickly recognize a package from its label. The most popular trend for reducing errors and increasing the efficiency of the information movement is to use automatic identification. Barcodes and radio frequency identification (RFID) enable a systems approach to managing information where every input is standardized, thus, reducing errors. Bar codes require a line of sight to be read by a scanner.

RFID enables packages to *call home* from a distance when prompted via radio frequency. Furthermore, new information can be added to RFID tags as they move through the supply chain. RFID promises to revolutionize package identification, since in theory the packages could be linked directly to a supply chain's information management system. The readability of these automatic identification forms depends on technological and symbolic compatibility of the package's label with every reader in the system. If automatic identification is intended to be used throughout a logistical system, it is necessary to use a common symbology. A number of standards-setting organizations exist for this purpose.

Testing of packaging materials :

The protection afforded by alternative packages can be evaluated and compared in laboratory and field tests. Performance testing is used to assess filled containers in situations that simulate distribution hazards and reproduce damage. It is important to distinguish distribution performance tests, which are used to aid packaging design, from material performance tests generally used for quality control.

Shock and vibration testing :

Dynamic testing of filled packages can be performed on a variety of testing equipment. The purpose of the test generally guides the choice of equipment and test methods. Impact tests can be performed on free-fall drop equipment (e.g. ASTM D775, ISO 2248 and ISTA 1/ 1A, 2/2A), or shock machines. A shock machine, generally used for fragility testing (e.g. ASTM D3332), has a higher velocity change for the same drop height because of its rebound, but can be used to produce repeatable impacts.

The velocity change produced by a shock machine is generally two to three times greater than that of a free fall drop for a given drop height, depending on the machine and the distance of its rebound. Some vibration tests, e.g. those specified by ISTA and ISO 2247, are very basic, performed on synchronous equipment with a fixed low frequency (about 4Hz) and high displacement, generally 25 mm. Synchronous vibration tests are quite severe, and are sometimes called *vibratory impact* or *repeated impact* tests.

Compression testing :

Most compression testing research has been conducted on corrugated fibreboard boxes, since the walls of boxes are often expected to carry the load of a stack. Factors that are known to influence corrugated fibreboard box compression

There are two types of tests. ASTM D642 and ISO 12048 apply an increasing load until failure in a test machine. ASTM D4577 and ISO 2234 use a constant load over a specified time period, and may use a test machine or a simple stationary apparatus.

Since corrugated fibreboard loses a great deal of its strength when it gets wet, compression tests are usually conducted at standard conditions of 23°C (73°F) and 50 per cent relative humidity. But there may also be a need for testing boxes in high humidity conditions or preconditioning boxes before testing.

The role of distribution centers and warehouses in logistics :

The general reasons for installing distribution centers and warehouses are as follows :

Storage of goods :

The basic function of warehouses is to store goods for the time they will be needed. As part of production process: In many cases, a production process needs a period of time (without any operation) to complete a product—e.g., the production of cheese and wine. Thus, warehouses can keep such products as a part of their production process (Ballou, 2004).

Returned goods centre :

In reverse logistics, the handling of returned goods becomes important, so warehouses can act as a place to accumulate and make decisions about returned goods (Stock and Lambert, 2001).

Consolidation :

When customers order a number of products from different places and want them to be delivered together, a warehouse can receive the requested products from their separate origins and deliver them altogether to the customer (Council of Supply Chain Management Professionals, 2000).

Break-bulk :

Break-bulk warehouses divide large receiving shipments in bulk from manufacturers into small less than truckload (LTL) shipments and send them to the customers (Ailawadi and Singh, 2005).

Postponement :

Warehouse can also be used as a place to postpone

the production process. In these cases, a warehouse is capable of doing light manufacturing activities such as labelling, marking, and packaging. In-process goods are kept in these warehouses until a demand with special characteristics such as mark or package occurs; the requested activities will be done in the warehouse and finished goods will be ready to satisfy the demand (Ghiani *et al.*, 2004).

Cross docking :

In some cases, a warehouses act as a cross-docking point. Inventory does not stay in more than 12 hours. However, these warehouses receive inventory, transfer it to vehicles, and deliver to retailers. This system leads to reduction of inventory costs and lead times by decreasing storage time (Hugos, 2003).

Transhipment :

Transhipment is the process of transferring goods from one vehicle to another as necessary (Hugos, 2003).

Product-fulfilment centre :

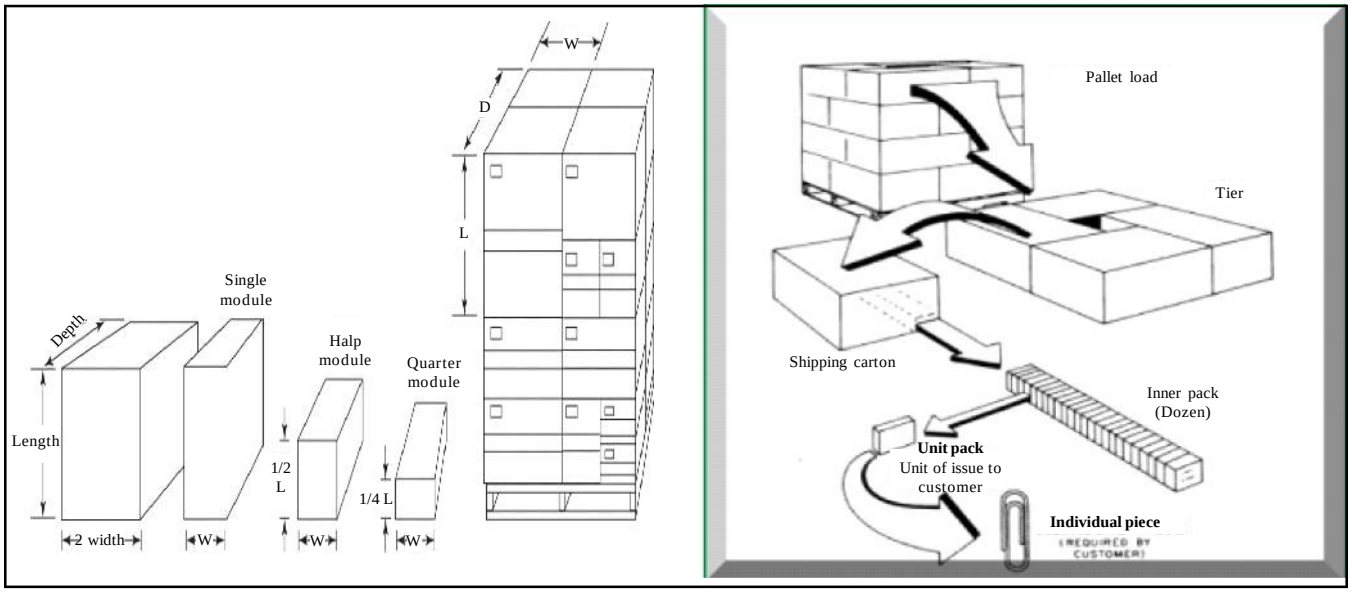
Fulfilment centers are distribution centers or warehouses that connect directly with final consumers. The following are some of the differences between product-fulfilment centers and other warehouses:

– Higher levels of customer service are available because of direct connects with final customers.
– More orders of smaller size are possible; these are almost always received electronically.
– Fulfilment centers typically must receive customer payments, often by major credit card
– Some also create customer invoices and handle banking for their clients.
– Returns from customers are more than that in the other warehouses.

Packaging also needs to make it easy to find the right items when picking orders. Easy to read stock keeping unit (SKU) identification is essential, regardless of whether it is read automatically or in the old-fashioned way. The markings should be concise and legible, on all four sides if necessary. The name of the manufacturer, brand, size and count should not be obscured by advertising messages. Packages have to be *read* when they are received, put away in the correct location, picked, repacked, and shipped. Good packaging communication can prevent shipping mistakes. In many cases co-ordination is lacking among the members of a supply chain to implement a common automatic identification symbology. One packaging solution for warehouses is the use of slave pallets or in-house stickers which have a license plate bar code, magnetic strip, or RFID tag. The license plate can be used to track and record the status of palletloads throughout the single facility.

Unit-load design :

Baily and Framer define a unit load as a standardized combination of a number of items into an integrated one that can be handled as a single item. Reasonable reasons for designing unit loading include making the material handling (MH) easier, reducing costs and increasing transportation security. The elementary principle behind



the unit load is making smaller units more convenient, economical, and easier to handle, transport and store (Johansson *et al.*, 1999). Unit load is an extension of the building-block concept to large quantities. Based on that concept, unit loading involves securing boxes to a pallet; the boxes or containers secured to a pallet are a unit load. The term unitization describes this kind of handling (Rushton *et al.*, 2006).

The high cost of manual labour has made the individual handling of small packages and items prohibitively expensive. If a number of items can be handled as a unit, then MH costs are reduced by moving larger loads, which eliminates unloading and reloading, cuts travel time, uses space more efficiently, reduces inventories, and facilitates shipping, transport and receiving. The size and type of unit load depend on a whole range of factors, the most important being the goods or materials to be handled; the size, weight, strength, and shape of intermediate packs; the type of storage required; the type of transport required; the type of handling equipment that may be available and the quantities of goods and materials to be handled (Johansson *et al.*, 1999). The unit load has several advantages. First, it adds protection to the cargo because the pallets are secured by straps, shrink-wrapping, or some other bonding device. Second, because removing a single package or its contents is difficult, pilferage is discouraged. Third, the unit load enables mechanical devices to be substituted for hand labour. Many machines have been devised that can quickly build up or tear down a pallet load of materials. Robots can be used when more sophisticated integrated movements are needed for loading or unloading.

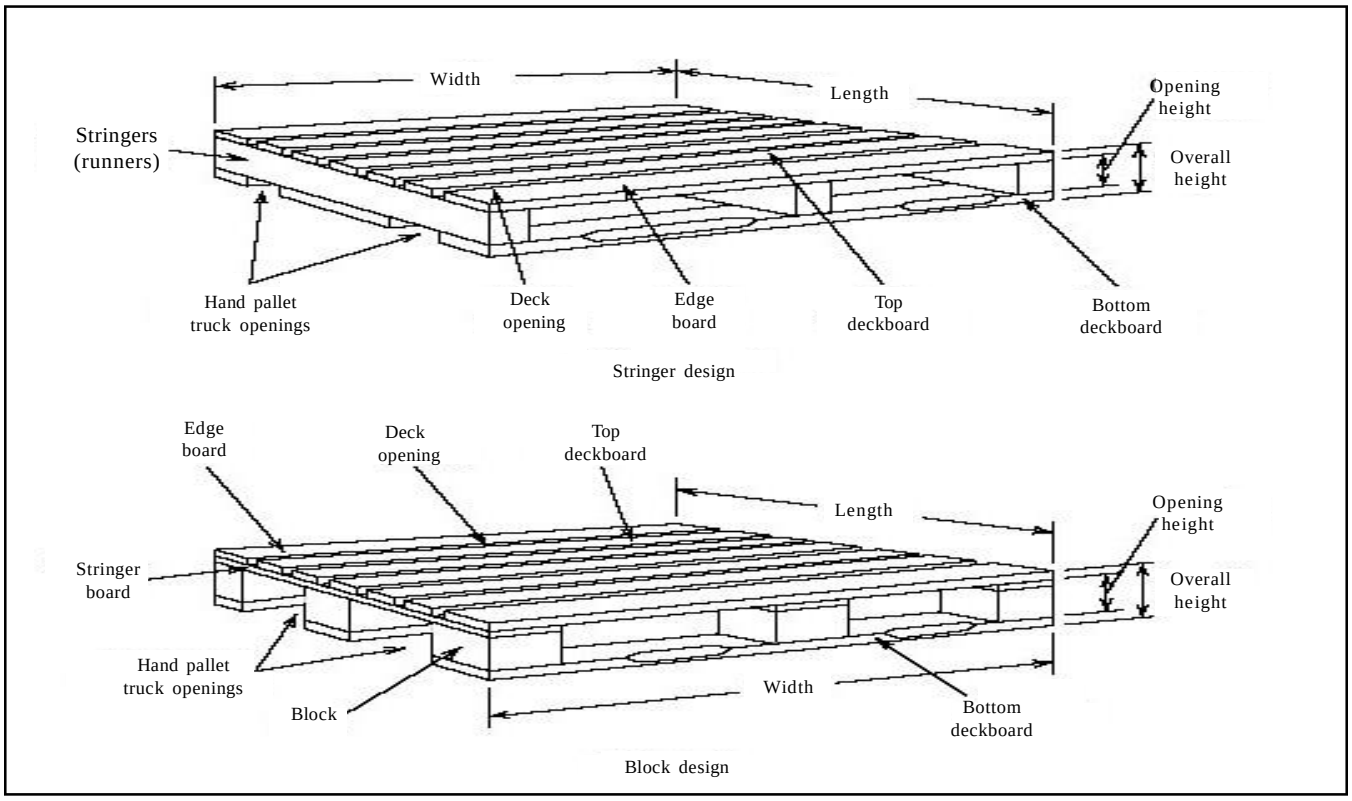
Unit-load criteria :

Two important limits that help determine the unit-load design are those for size and weight. The unit-load size must be standardized so it can be handled easily and economically with modern equipment. Some unit loads may be bigger or smaller to meet other criteria and/or product characteristics. The weight of the unit load must be kept within the capacities of the MH equipment and the storage facilities.

Unit loads of some high-density materials such as steel, flour and stone are smaller than optimal size in order to keep the unit-load weight within limits (Rushton *et al.*, 2006). The unit load calls for a standard base or container. Among the possibilities are:

– Pallets

– Stillages



– Skids
– Slip sheets
– Containers
– Self-contained cartons.
– Intermediate bulk containers

The transportation system :

Transportation accounts for between one-third and two-thirds of total logistics costs; for most firms, it is the most important single element of logistics costs (Ballou, 2004). Firms and their products' markets are often separated geographically. Transportation increases the time and place utility of products by delivering them at the right time and to the right place where they are needed. By doing so, the customers' level of satisfaction increases, which is a key factor for successful marketing. A comprehensive discussion of transportation is beyond the scope of this text, so we focus here on essential issues of transportation systems, which are more related to the physical flows of materials.

Transport modes and their characteristics :

Various options for moving products from one place to another are called transportation modes. Road, rail, air, water and pipelines are considered the five basic modes of transportation by most sources. Any one or more of these distinct modes could be selected to deliver products to customers (Fig. 7). However, all transport modes may not be applicable or feasible options for all markets and products.

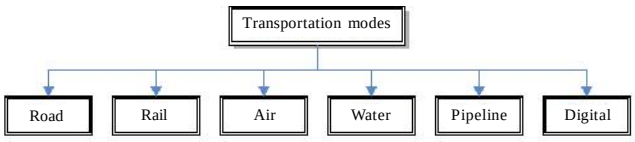


Fig. 7 : Basic modes of transportation

Truck transport / Road transport :

The key advantages of road transport over other transportation modes are its flexibility and versatility. Trucks are flexible because they offer door-to-door services without any loading or unloading between origin and destination. Trucks' versatility is made possible by having the widest range of vehicle types, enabling them to transport products of almost any size and weight over any distance (Lambert and Stock, 1993). Road transport also offers reliable and fast service to the customers.

The technical principle of truck transport, pneumatic wheels on pavement, is the major contributor to in-transit vibration, generally below 25Hz. This is the force which vertical vibration testing aims to simulate. In addition, potholes and other surface discontinuities cause transient impacts that can disorganize a load. This is the reason why packages should be loaded to a level height in the trailer. Stopping, starting and turning forces are generally moderate, but do necessitate minimal restraints or void fillers when there are voids in the TL.

The loss and damage ratios for road transport are slightly higher than for the air shipment, but are too far lower than for the rail carriage. Road transport generally offers faster service than railroads, especially for small shipments (less than truckload, or LTL).

For large shipments (truckload, or TL), they compete directly with each other on journeys longer than 500 miles. Also, as motor carriers are more efficient in terminal, pickup, and delivery operations, they compete with air carriers, for both TL and LTL shipments that are transported 500 miles or less (Stock and Lambert, 2001). In regard to economic aspects, road transport has relatively small fixed cost, because it operates on publicly maintained networks of high-speed and often tollfree roads. However, the variable cost per kilometer is high because of fuel, tires, maintenance, and, especially, labour costs (a separate driver and cleaner are required for each vehicle) (Ailawadi and Singh, 2005). Road transport is best suited for small shipments and highvalue products, moving short distances.

Truck transport is expensive, compared to rail and ocean transport. There is a decided advantage to optimizing the cubic and/or weight capacity of the trailer, and there is a trend towards making packages as small and lightweight as possible. Improving cube utilization is packaging's greatest opportunity to provide logistics value. If package size can be reduced by 50 per cent, transportation efficiency doubles. There are many ways to reduce package size, such as concentrating products like orange juice, or by eliminating space inside packages by shipping items nested, with minimal head space and dunnage.

Rail transport :

Rail carriage places the second dominant mode of transportation. Although rail service is available in almost every major city around the world, the railroad network is not as extensive as the road networks in most countries. Thus, rail system lacks the flexibility and versatility of

the road transport. Indeed, rail carriers offer terminal-to-terminal service rather than the door-to-door service provided by motor carriers. Therefore, railroads, like water, pipelines and air transport, need to be integrated with trucks to provide door-to-door services.

The technical principle of rail transport – steel wheels on steel rails – restricts rail movement to fixed routes. The inflexibility of the wheels and rails restrict the vertical vibration, but staggered rail joints can exacerbate a tendency for low frequency (below 5Hz) sidesway. As trains are assembled and disassembled in their relay across country, railcars are often slammed together to engage couplers. To avoid damage cargo must be securely blocked and braced, or voids must be filled within the railcar. Various national railroad organisations have researched rail damage and have developed tests and restraint recommendations. The fixed routes, route switching process and train schedules make rail transportation slower than by truck. Packaging may need to provide a longer shelf-life, more protection from climate changes, or products may need to be shipped in insulated or refrigerated cars.

Also, railroads offer less-frequent services compared to motor carriers. Rail transportation is relatively slow and quite unreliable, as the loss and damage ratios of rail transport for many shipments are higher than other modes Railroads have high fixed costs and relatively low variable costs. Expensive equipment, multishipment trains, multiproduct switching yards and terminals, and right-of-way maintenance result in high fixed costs. However, the variable costs are low, especially for long hauls, so rail carriage generally costs less than motor and air transport on a weight basis.

Air transport :

Although airfreight offers the shortest time in transit (especially over long distances) of any transport mode, most shippers consider air transport as a premium emergency service because of its higher costs. However, the high cost of air transport may be traded off with inventory and warehousing reductions or justified in some situations: (1) for high-value products, (2) for perishables, (3) in limited marketing periods, and (4) in an emergency (Ailawadi and Singh, 2005). The portion of total product costs dedicated to transportation is an important issue for most shippers.

Packages shipped by air are always picked up and delivered by truck and so they have to withstand truck dynamics also. They are handled repeatedly, sometimes outdoors in the rain or other extreme weather conditions, and, therefore, packaging needs to protect from impacts, moisture, temperature extremes and being stacked with other cargo. Many small parcel carriers ship by air and the packaging requirements are similar to those for LTL shipments. When quantities shipped are sufficient, unitization can reduce damage and handling costs. Packages shipped by air need to be marked with addresses, but in order to deter theft, should not be marked to identify the contents.

The high price of airfright consumes a greater portion of low-valued products' total costs, so it is not economically justifiable for these items. This could be why air carriers usually handle high-value items. Total transit time (from pickup at the vendor to delivery to the customer) is important to shippers and the customers. From this point of view, well-managed surface carriers can compete favorably with air carriers, especially on short and medium hauls. Even though air carriers provide rapid time in transit from terminal to terminal, they may spend too much time on the ground (e.g., for pickup, delivery, delays and congestions, and waiting for scheduled aircraft departures) (Lambert and Stock, 1993).

Loss and damage ratios resulting from transportation by air are considered lower than the other modes. The classic study by Lewis *et al*. (1956) shows that the ratio of claim costs to freight revenue was only about 60 per cent of those for road and rail. Airline companies generally own neither airways nor airports. Air spaces and air terminals are usually developed and maintained with public funds, so fixed airfreight costs (including aircraft purchases, specialized handling systems and cargo containers) are lower than rail, water and pipeline. Air-transport variable expenses are extremely high because of fuel, maintenance, and the labour intensity of both inflight and ground crew (Ailawadi and Singh, 2005). Variable costs are reduced by the length of journey because takeoffs and landings are the most inefficient phases of aircraft operation. Moreover, increasing shipment sizes reduces the variable operating cost per tonmile. Hence, variable costs are influenced by both distance and shipment size (Ballou, 2005).

Water transport :

Water carriage by nature is particularly suited for movements of heavy, bulky, low-value-per-unit

commodities that can be loaded and unloaded efficiently by mechanical means in situations where speed is not of primary importance, where the commodities shipped are not particularly susceptible to shipping damage or theft, and where accompanying land movements are unnecessary. As already mentioned, the majority of commodities transported by water are semiprocessed and raw materials; thus, water transportation competes primarily with rail and pipeline. Water carriage can be broken into the following distinct categories (Lambert and Stock, 1993).

– Inland waterways (such as rivers and canals)
– Lakes
– Coastal and intercoastal oceans
– International deep sea

The technical principle of ocean or river carrier transport – gliding through the water – determines the dynamic forces that ships encounter. Waves, swells and storms cause a ship to move in every direction. Cargo must be well-secured inside its packages and within the vessel or intermodal container. Since waterborne transport usually interfaces with a land-based transport mode, packages also need to be suitable for rail or truck transport. The air aboard ship is high in humidity. Ordinary day/night cycles and climate changes in temperature can cause condensation, rust and rot. Packaging solutions to resist moisture damage include using desiccant sachets or treated films, ensuring efficiently sealed packs which prevent moisture ingress, and controlling the moisture content during packing.

Water transportation service is limited in scope, mainly for two reasons: its limited range of operation and speed. Water service is confined to waterway systems; thus, unless the origin and the destination of movement are located on waterways, it needs to be supplemented by another transportation mode (rail or motor carrier). In addition, the average speed of water carriage is less than rail transport, and the availability and dependability of its service are greatly influenced by weather (Ailawadi and Singh, 2005 and Ballou, 2004). Containers are used for many domestic and most international water shipments. Moving freight in containers on containerized ships affects the intermodal transfer by reducing handling time and shortening total transit time. It also reduces staffing needs and allows shippers to take advantage of volume shipping rates. Finally, containers reduce loss and damage (Ballou, 2005 and Stock and Lambert, 2001). For all these reasons, high-value commodities (especially those in foreign shipments) are shipped in containers and containerized ships.

Loss and damage costs for water carriage are lower in comparison with other transportation modes because damage is not much of a concern with low-valued bulk commodities. Also, because large inventories are often maintained by buyers, losses from delays are not serious. For high-valued products, claims are much higher: approximately 4 per cent of ocean-ship revenues. Most damages are caused by rough handling during loading and unloading operations, so substantial packaging is needed to protect goods (Ballou, 2005).

Regardless of the limitations inherent in water transportation, water is the least expensive mode for transporting high-bulk, low-value freights. The fixed cost of water carriage is mainly found in terminal facilities and transport equipment. Although water carriers have to develop and operate their own terminals, rights-of-way and harbors are developed and maintained publicly. This moderates water-transport fixed costs, putting the mode between rail and motor carriages. Water-transport variable costs, including waterway charges and transport equipment operation costs, are very low. Because of the high fixed cost and low line-haul costs of water carriage, its costs per ton-mile decrease significantly as the distance and shipment size increase (Ailawadi and Singh, 2005 and Ballou, 2004).

Packaging materials:

Currogated fibreboard :

The most widely used flute configurations are known simply as A, B, C, and E. The first corrugated materials were either coarsely fluted A-flute or fine B-flute. The

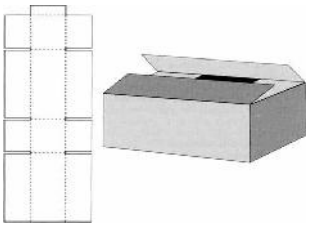
Table 1 : Common forms of currogated fibreboard

Flute	Flutes/ metre	Flutes/ft	Flute height
A	105-125	36 ± 3	4.8 mm or 3/16''
B	150-185	50 ± 3	2.4 mm or 3/32''
C	120-145	42 ± 3	3.6 mm or9/64''
E	290-320	94 ± 4	1.2mm or 3/64''

Source: BS 1133, section 7 and fibre box association handbook

intermediate grade, C-flute has now become the most commonly used type, being a compromise of the best qualitites of the other two. E-flute has very small flutes, and there are even finer grades called microflute, which are used as alternatives to solid fiberboard (Table 1).

Single wall board (with 2 facings) is the most common form used for cases and trays. Double and triple wall boards are used for palletload-sized intermediate bulk containers, used for some dry ingredients in the food industry. At one extreme, single face board is soft and used for wrapping items like light bulbs and glass bottles. The other extreme is multi-wall laminated structures



made into lightweight pallets.

Corrugated board has an important drawback: it can lose much of its strength (indeed, all of its compression strength) when it is wet. Further, the commonly used starch-based adhesives are also moisture sensitive. It makes good design sense, where possible, to design the box with minimal head space, allowing the inside products to help support the load. This will prevent the uneven collapsing of containers which can topple a palletload. Wax dipping or coating has been used for particularly wet contents, like broccoli which is shipped with ice, but this practice is diminishing because the wax causes problems during recycling.

Wood :

As a packaging material, wood has many advantages. It provides high strength compared to its weight, high stiffness, good durability and acceptable versatility for design in medium and large sizes. In comparison to other rigid materials like glass and steel, it is relatively light. Packaging made of wood has excellent rigidity, stacking strength and physical protection (Twede and Selke, 2005).

Wood is a low-cost commodity, easily available everywhere in Scandinavia, South America and North America. Trees are a natural resource, making wood universal, abundant and inexhaustible given proper forest management. Wood is an environmentally benign packaging material because it requires little energy to process, does not pollute and bio degrades (Twede and Selke, 2005).

Wood excels when it is made into packages that require great strength or are expected to convey a natural or furniture-like effect. Wooden packages are suited for small-scale production and can be manufactured with simple equipment in a variety of forms, including boxes, crates, pallets and barrels. For packages in which mass is an asset (like reusable pallets) wood can be lower cost than plastic or steel. Wood can be combined with metal to obtain benefits from both materials. Wood is used in pallets and crates for its strength and relatively low cost compared to other high-strength packaging materials (Twede and Selke, 2005).

Since it is a natural material from a living tree, wood continues to undergo a natural lifecycle after harvesting. It is especially affected by water and is not a good moisture barrier. It is subject to sorption of water vapor and liquid and the presence of water can change its dimensions (Twede and Selke, 2005).

Wood is predominately used for coarse transport packages and is still widely used around the world (Johansson *et al.*, 1997). The most common wooden package is the wooden pallet, which is extremely popular within Western Europe. Wooden pallets have become quite popular with the increasing demand for transportation (Johansson *et al.*, 1997).

Plastic :

Plastic or polymer consists of a very wide range of materials with different properties. These materials also have a wide price range. The cheapest of these materials, polyethylene (PE) and polypropylene (PP), were used for packaging. These packages range from simple plastic bags and warping to plastic boxes and containers (Johansson *et al*., 1997).

PE was classified by density into PE-LD and PE-HD. PE-LD is a low-density polyethylene which has a density of approximately 0.92 - 0.94 g/ cm^3. It was

produced by a high-pressure process while PE-HD is a high-density polyethylene with a density of approximately 0.94 - 0.96 g/cm^3. It is produced by a low pressure process (Transport Information Service).

Both PE-LD and PE-HD are insensitive to water and exhibit a milky haze when uncolored (nearly crystal clear only when converted into thin films). The usual temperature range for PE usage was approximately -50 to +60°C for PE-LD, while the upper limit for PE-HD was approximately 90°C (Transport Information Service).

PE films were in particular, characterized by their good water vapor barrier properties. However, their permeability to gases and aroma substances is disadvantageous. Thanks to its higher density, PE-HD has better barrier properties towards oxygen, carbon dioxide, water vapor and aroma substances compared to PE-LD (Transport Information Service).

PE is not only converted into films (PE films, composite films, shrink films), but it was also used to produce bottles, bottle crates, drums, boxes, bowls etc (Transport Information Service).

Metal :

First steel and then later aluminum, became the most common metals used in packaging. The advantage of aluminum to steel is its lighter weight and its higher resistance to corrosion (Johansson *et al.*, 1997). Aluminum is one the most common.

To produce new aluminum, significant energy is required while recycling the old aluminum (by melting) only requires around 5 per cent of that energy. Pure aluminum tends to be soft and plastic, both in warm and cold conditions. Therefore, for packaging, alloys of aluminum, which were strengthened, were mostly used.

Steel is an alloy of iron, which had less than 2 per cent carbon content. Due to its high strength, steel could be used as a support for parts in large packages. Steel was also considered stronger than aluminum but it was also heavier.

Retail issues in logistic network :

The distribution process finishes with retailing, where each transaction sells a product or service that has personal, family, or domestic use whether in the form of food, clothes etc. As a science, logistics also has affected retailing, and today's mix of retailing and logistics provides great benefits. Logistics is concerning with producing, executing, transporting, sorting, providing services, and managing inventories in ways that interact with each other. The big cycle of logistics starts with planning the physical movements of products from wholesaler to retailer to customer and then implementing and controlling them. The plan must be effective in time and costs. There are three common and simultaneous advantages for companies if their logistics system is working and useful: (1) reducing stock outs, (2) decreasing inventories, and (3) improving customer services.

An optimum retail logistics is the one which leads us to a 100 per cent satisfaction in accessibility to on shelves goods for customer when they are needed. Retail logistics is concerned with product availability. It means we must know what the customer wants, how to produce it and where and when to deliver it (Council of Supply Chain Management Professionals, 2000). Today is a high point in retail sales history.

Many companies are now leaders in terms of sales, including WalMart and other manufacturing giants. Because of more opportunities, it is easy to start a new retail business or become a franchisee. However, some consumers are bored with shopping or do not have time for it, and many retailers sell goods at low profit and try to satisfy customers' expectations, so there are many challenges that retailers face. A retail decision maker must be able to answer such questions as, how can we serve customers while earning a fair profit? How can we remain competitive in an environment in which consumers have so many choices? How can we improve

our business with loyal customers? These questions must be addressed in any well-structured retail strategy.

Retail strategy :

A retail strategy is a plan that guides the retail firm. It affects the firm's business activities and its reactions to competitors and markets. Every retailer must follow six steps in strategic planning.

– Define the category of goods or services and the firm's specific mission (such as full service or no frills).

– Define long- and short-term targets for sales and profit, market share and so on.

– Determine customer types and characteristics (such as gender and salary level) and needs (such as brand preferences).

– Plan a long-term target to define direction for the company and its employees.

– Develop a complete strategy that includes factors such as store locations, classified products, costs and advertising in order to achieve targets.

– Assess and execute the plan and solve ongoing problem.

As mentioned already, retailing is the final part of the distribution chain and includes businesses and people transporting products and services from producers to consumers. A typical distribution channel is shown in Fig. 3. What consumers expect from a retailer is to have large variety of products from which to choose and buy a limited quantity, because a retailer collects goods in large quantities from various producers but sells in small amounts. Some producers choose a basic system of distribution and sell their products to a few retailers. Consequently, retailers play an important role between manufacturers, wholesalers, and customers. The main role of retailers is a sorting process.

Fig. 3 : Typical channel of distribution

Retailers play a critical role between customers and wholesalers, so they can provide considerable valuable information to wholesalers in anticipating sales, such as consumers' needs. Manufacturers can improve goods and services according to retailers' feedback. Small suppliers and their retailers can maintain close relationships that may help each other in transporting, storing, advertising, and prepaying for products, and the relationship also can affect costs and profits when retailers accomplish their goals. Retailers also keep close relations with customers via accessible locations, prompt responses to customer's demand and accurately and being able in credit purchases processing. Some retailers also offer customers special activities such as wrapping, delivery and installation. In addition, most large retailers use multichannel retailing in selling goods and services to customer, and both face-to-face selling and selling by websites to make shopping easier for customers.

As mentioned, there are many ways for manufacturers to sell their products such as through retailers, mail-order catalogs, websites, and toll-free phone numbers. This means manufacturers can have more customers, reduce costs, increase sales.

Goods and service retailing :

One of the most important retailing items to be considered is the difference between retailers. Two types of firms offer goods and services: store-based and non store-based. There are also differences between retailers that sell services and those that sell goods. Customers want to know the differences in the services that retailers offer (Johansson *et al.*, 1999). Goods retailing includes selling tangible (physical) products. Service retailing involves intangible issues; customers do not buy or gain physical products. Some retailers just focus on goods, some just provide service retailing and others work on both.

Factors that affect international retailing :

Now-a-days retailers do not limit themselves to national borders, and international retailers have focused on new markets. The following elements affect the level of productivity of a retailing strategy (Johansson *et al.*, 1999).

Timing :

Being first in a market is less important than being in the market before there is serious competition.

A balanced international programme :

Selecting the suitable market is critical.

A growing middle class :

According to current trends, middle class markets

are growing which will lead to more sales and more income.

Matching concept to market :

Improving quality and mixing fashion in a market will make a business more successful. If a market has developed, then retailers that offer discounts are more successful because consumers are more interested in price, variety and convenience (Johansson *et al.*, 1999).

Information flow in a retail distribution channel :

Technologies now are changing the roles of business players more than ever. Information technology is one of the largest influences. In an effective retail distribution channel, efficient information passes through three main players: providers (manufactures or wholesalers), retailers and consumers. The outcome is close relationship among these parties with the purpose of forecasting the needs of each party.

A supplier needs the following kinds of information:

– From the retailer, needs sales prediction for each group, rates of inventory turnover, information on rivals, the amount of customer returns and so on.

– From the consumer, needs to know attitudes about styles and models, how loyal customers are to brands, how willing customers are to pay more for better quality, and so on.

The information a retailer needs consists of the following:

– From a wholesaler, he/she needs advance notice of new styles and model changes, instructions for complex products, sales forecasts, price changes, and so on.

– From consumers, he/she needs to know why people shop at a particular retailer, what satisfies and dissatisfies them about retailers; where else they shop, and so on also.

Consumers want the following :

From wholesalers, they want instructions on how to assemble and operate a product. From retailers, they want to know in which stores they can find specific products and how they can pay for them.

The main role in gathering data for wholesalers, suppliers and customers belongs to retailers. They can assist other channel members by performing the following functions:

– Permit data gathering according to their principles. Many research firms like to conduct

– Surveys at shopping centers because of the large and broad base of shoppers.

– Collect needed information for suppliers such as how shoppers react to displays.

– Pass along information on the attributes of consumers buying particular brands and models.

Because credit transactions account for a major portion of sales, many retailers link purchases with consumer age, income, occupation and other factors. For the best information flows, collaboration and co-operation are necessary; especially between suppliers and retailers. This is not always easy. According to one senior retail executive, the traditional supply chain has one important problem: retailers and suppliers do not like to share information. This is the main reason for disorganized supply chains.

Recycling of packaging materials :

The cost for discarding shipping containers is generally paid by logistical customers like retailers. Besides the environmental impact, disposal is costly and can severely reduce a customer's productivity. There is a clear incentive for firms to reduce, reuse and recycle logistical packaging waste in order to avoid or reduce disposal costs.

This economic incentive has caused logistical packaging to be less of a target for legislation than has been consumer packaging waste, where disposal is an *external* cost. In Europe, where there is packaging waste legislation, the provisions for logistical packaging are different from those for consumer packaging. They usually result in the packer-filler paying a tax that funds a recycling infrastructure and reduces the retailer's

disposal costs. Each strategy – reducing, reusing and recycling – has an economic impact beyond disposal costs. Reduction of packaging materials also reduces package purchase costs. Packaging reuse generally adds some costs for sorting and returns transportation but may reduce package purchase costs in the long run. The growth of recycling is reducing collection and processing costs and improving the market for recycled materials. The trend towards recycling and reusable packaging also has environmental benefits.

Recycling is an efficient disposal method for most logistical - packaging waste, since it naturally collects in large homogeneous piles at the facilities of manufacturers, warehouses and retailers. There are a limited number of materials: wooden pallets, corrugated fibreboard, polyethylene film, plastic foam and strapping. Recyclers welcome such concentrated and relatively clean sources (compared to sorting and cleaning curb side and food service wastes). As a result, logistical packaging has a very high recycling rate. Likewise, purchasing packages made from recycled material encourages the growth of a recycled products market and infrastructure.

Recycling is sometimes erroneously called *reverse logistics*. Actually, the packaging materials are not taken back to the company that filled the packages, but rather the logistical system moves forward, through waste management companies, to reprocessors. In many cases, associations of packaging material manufacturers have set up their own networks for collecting and reprocessing.

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