

Logistics

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Definition

Logistics is the discipline that studies how to organize activities like procurement, production, maintenance, transport, communication,... in a complex system (enterprise, military, public administration,...).

In an industrial context we distinguish:

- procurement logistics
- inventory logistics
- production logistics
- distribution logistics

also called **external** and **internal logistics**. Another important type is **reverse logistics**, dealing with the re-use of products and materials when they are dismissed by their end users.

The incidence of **logistic costs** on the total cost of goods is usually very large: therefore it is necessary to **optimize** logistic systems.

Definition

Decisions in logistics are at different levels:

- **strategic level** (long term): ideally, they are taken once for ever;
- **tactical level** (medium term): they must be repeated periodically;
- **operational level** (short period, real time): ideally, they should not be necessary (exception handling).

Logistics is a typical ground for applying **Operations Research** methods.

The course

Programme:

- Introduction and terminology
- Predictive models and forecasting
- Inventory management
- Queuing theory
- Mathematical programming models

Textbook: G. Ghiani, G. Laporte, R. Musmanno, *Introduction to Logistics Systems Planning and Control*, Wiley, 2003.

Exam:

- Four exercises, one for each part of the course, to be solved at the PC.
- Developing a project is also possible in some cases.

The supply chain

An industrial logistics system can be represented by a graph whose nodes are *facilities*:

- suppliers
- production and assembly plants
- primary warehouses (*Central Distribution Centers*)
- secondary warehouses (*Regional Distribution Centers*)
- Points of sale

In these nodes many *operations* are done: supply, transformation, assembly, packing, storing, sale, collection, disassembly, selection,...

Three main flows traverse the *supply chain*:

- **goods** (forward);
- **money** (backward);
- **information** (in both directions).

Vertical integration

The so-called **vertical integration** occurs when the same entity (company) directly manages several different *operations*, in particular internal and external logistics operations.

Pros:

- Costs are reduced because there is no profit for intermediaries, carriers, contractors,...
- Transportation times are shorter and more reliable.

Cons:

- Small enterprises may not have enough money to invest in warehouses, vehicles, drivers,...
- Concentrating investments on the core business (production) may be more rewarding.
- Lack of economies of scale.

The “engine” of the supply chain

There are two ways in which operations can be triggered:

- *push supply chains* (“make-to-stock”) are typical of economic systems based on large scale industrial production, where operations are triggered by the production of goods on the basis of a sales forecast.
- *pull supply chains* (“make-to-order”) are typical of economic systems based on customer-centric services, where operations are directly triggered by the demand coming from the consumers (on-demand production).

There the two extreme cases: there many intermediate cases.

Today we are in a transition from economic systems mainly based on industrial production to economic systems mainly based on services or product/service bundles. Therefore the term *supply chain* is often replaced by *value chain*, to better emphasize that the aim of logistic operations is not just making or moving objects but rather producing **value**.

Optimization

The most important parameters in optimization at a strategic level are:

- the **invested capital**, to buy or rent buildings, equipment, vehicles, information systems, inventories,...
- the **operational cost** given by salaries, energy consumption, fuel,...
- the **level of service** which depends on several factors, often difficult to measure and to compare (delivery time, number of customers reached, prices, quality guarantees, maintenance conditions,...).

Typically, the overall optimization of a logistic system is a **multi-objective problem**.

Order transmission

This includes different operations that imply only exchange of information:

- order reception by an agent
- transmission of the order to the company
- order input in the information system
- priority assignment
- order satisfiability check
- *back-order* to the production plant, if needed
- customer check (creditworthiness, pending payments,...)
- preparation of the invoice, billing
- generation of information on the order state (e.g. completion percentage, forecast of the completion date)

This is the phase that has most benefited from internet technologies. It has low impact on the costs, but large impact on the level of service.

Inventory management

There are several points along the supply chain where goods are stored in **inventory**:

- prime matter, ready for transformation;
- materials partially transformed/processed waiting for the next transformations/processes or for assembly (“work-in-process”);
- finished products, ready for transportation/distribution;
- transported freight (“in-transit inventory”);
- products on sale.

Inventory management

Inventory has got different **functions**:

- to absorb fluctuations of the demand:
 - satisfying demand peaks so that operations down the supply chain are not blocked;
 - compensating for dips of demand, so that operations up in the supply chain are not blocked;
- to exploit economies of scale to reduce costs;
- to decrease lead times and to improve the level of service;
- to distribute seasonal products;
- for speculation.

Inventories also imply **costs**:

- purchase/rent and maintenance of warehouses;
- classification and movement of goods;
- constrained/blocked capital.

Distribution

There are three main distribution modes (strategic level decision):

- **intensive distribution**: it consists in using the maximum number of distribution channels. It is used for consumables and low value commodities.
- **exclusive distribution**: it occurs through authorized dealers. It is used for high value products.
- **selective distribution**: it is based on the selection of some wholesalers and retailers.

Distribution channels can be classified on the basis of

- how many and which are the **intermediate steps**: agent, wholesaler, retailer;
- **type of recipient**: company (B2B), end user/consumer (B2C).

Distribution: B2B

The most commonly used modes are:

- direct sale,
- sale via agents,
- sale via wholesalers.

Direct distribution is the most widespread mode, because it allows to avoid profit margins for intermediaries.

ICT helps a lot in establishing a relationship between suppliers and consumers, making [e-commerce](#) possible.

Distribuzione: B2C

The most commonly used modes are:

- direct sale (including door-to-door),
- sale via retailers,
- sale via wholesalers and retailers,
- sale via agents, wholesalers and retailers.

The role of agents is to actively find customers.

The role of wholesalers is to make supply easier for retailers.

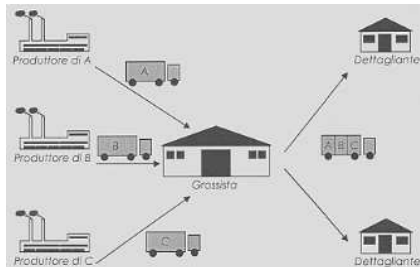


Figure: Role of whosalers: economies of scale.

Transport

Transport is often the weakest ring in the supply chain:

- it represents a large fraction of the total cost,
- it strongly affects the level of service,
- it requires the solution of computationally complex optimization problems.

Transport can be **uni-modal** or **multi-modal**.

The transport **modes** are five:

- truck
- train
- airplane
- ship/barge
- pipeline.

Each mode has different characteristics concerning cost, speed, capacity, reliability, capillarity.

Transport

Consolidation is typical in **multi-modal** transport: it consists in aggregating different shipments to cut costs:

- many pallets in a truck
- many trucks to fill a container
- many containers to load a train car
- many train cars to load a ship

In **uni-modal** transport the main advantage is the capability of visiting origins and destinations almost everywhere. Therefore costs are higher but the level of service is better (“door-to-door”).

Transport by truck

We must distinguish

- **TL** (*truck-load*) transport, i.e. with fully loaded trucks, typically on long distance between fixed O/D pairs (logistic hubs,...);
- **LTL** (*less-than-truck-load*) transport, i.e. with partially loaded trucks, typically on short distances between variable O/D pairs.

Characteristics.

- **Cost**: large. It is 7 times more expensive compared to transport on railway.
- **Capacity**: small. Truck is the smallest means of transport.
- **Time (speed)**: better than train on short distances.
- **Time (reliability)**: this depends on the state of the infrastructures (road network vs. railways).

The most important advantage of transport by truck is capillarity.

Transport by train

It is used mainly for goods with low value for unit of weight or volume.

Characteristics.

- **Cost:** lower than trucks, larger than ships/barges.
- **Capacity:** larger than trucks, smaller than ships/barges.
- **Time:** slow and unreliable, because it requires long and complex operations at stations (composition and decomposition of trains).

It is used both in uni-modal and in multi-modal transport (train + truck = *piggy-back*).

Transport by airplane

It is used only in multi-modal transport, owing to the small number of airports (airplane + truck = *birdy-back*).

Characteristics.

- **Cost:** large. It is the most expensive mode of transport. It is convenient only to send goods of high value per unit of weight or volume on long distances.
- **Capacity:** limited. There are physical constraints on weight and volume that can be loaded on an airplane.
- **Time (speed):** excellent. It is the fastest transport mode.
- **Time (reliability):** high. It does not require complex operations between the origin and the destination.

Transport by ships/barges

It is nearly always part of multi-modal shipments, because harbours are not everywhere (ship + truck = *fishy-back*).

Characteristics.

- **Cost:** low. It is the cheapest transport mode.
- **Capacity:** very large. It is the most capable transport mode. It is used for goods with low value and large weight or volume.
- **Time (speed):** it is the slowest transport mode.
- **Time (reliability):** low. It requires complex loading/unloading operations. It can be affected by weather conditions (rough sea).

It is estimated that about 99% in weight and 50% in value of the whole transport in the world occurs on ships and barges.

Transport by pipeline

It is used only for fluids: typically oil and gas, but also water.

Characteristics.

- **Cost:** low. It has high costs for construction and installation but low operational costs.
- **Capacity:** differently from all other modes, it provides a continuous supply.
- **Time (speed):** low. The flow is limited by physical and safety reasons.
- **Time (reliability):** high. Continuous flow increases reliability.