Introduction to information systems in logistics and transportation

1

INTRODUCTION TO INFORMATION SYSTEMS IN LOGISTICS AND TRANSPORTATION

Bernhard Tilanus

ABSTRACT

In this paper, the basic concepts will be discussed which this book is concerned with. In this order, we will discuss logistics (first section), transportation (second section), and information systems (third section).

Keywords: Logistics, transportation, information systems, tracking and tracing

LOGISTICS

Let us start with the entrepreneur. Schumpeter said that the entrepreneur makes new combinations of land, capital and labour, and thereby earns a profit. My grandfather said that entrepreneurship is to turn a dime into eleven cents. The entrepreneur invests, and the return on his investments (ROI) is his profit.

The popular idea is that the entrepreneur invests in plants and machines, i.e. capital goods or fixed assets. Investment analysis is concerned with decision making about this kind of investments. This is indeed the major category of investments in the 'heavy' industry, like the metallurgic or bulk chemicals industries.

In 'light' and highly technical industries, like Philips electrotechnical industries, headquartered in Eindhoven, Netherlands, at least five categories of investments need to be distinguished: (1) capital goods, (2) goodsflows (work-in-progress and inventories of raw materials, component parts and finished products), (3) debts from customers (accounts receivable), (4) research and development (R&D) or innovation, (5) marketing and goodwill. It is increasingly difficult to see each of these categories of expenses as investments; indeed, the last two of them are seldom seen on a balance sheet. But it is good to realise that each of these categories may be equally important, or any of these categories may dominate the others. A firm's ROI may equally be influenced by (1) maintenance and replacement management, (2) goodsflows management, (3) credit management, (4) R&D management, (5) marketing management.

The story goes that just after Worldwar II an American came to Philips in Eindhoven to talk about inventory management. The room was full of researchers from Philips physics laboratories, expecting to be told how to invent things, and there was some disappointment when the talk was only about goodsflows.

This book is concerned with goodsflows management or inventory management, or logistics. So what is logistics?

Webster's dictionary mentions that logistics derives from French logistique, art of calculating, but originally from Greek logos, reason. If the etymological meaning of logistics is reasoning, I am in favour of adopting the wide definition of the Council of Logistics Management (1991):

'Logistics is the process of anticipating customer needs and wants; acquiring the capital, materials, people, technologies, and information necessary to meet those needs and wants; optimizing the goods- or service-producing network to fulfill customer requests; and utilizing the network to fulfill customer requests in a timely way.'

It seems plausible that this wordy definition may be condensed to:

'Logistics is customer-oriented operations management'.

This definition at least enables logisticians or operations managers to engage themselves with the full national economy, not only with the manufacturing industries that account for a mere quarter of a modern Western economy, but also with the service and non-profit sectors that account for the other three quarters.

But for our purposes this definition is too wide. This book is concerned with logistics in the sense of management of goodsflows.

To this end, an older, and more limited, definition of logistics from the Council of Logistics Management will serve, which is also the starting point of the textbook by Lambert and Stock (1993, p. 4):

'Logistics management is the process of planning, implementing and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods, and related information from point-of-origin to point-of-consumption for the purpose of conforming to customer requirements.'

In the sixth edition of their textbook, Johnson and Wood (1996, p. 4) use 'five important key terms':

'Logistics describes the entire process of materials and products moving into, through, and out of a firm. Inbound logistics covers the movement of materials received from suppliers. Materials management describes the movements of materials and components within a firm. Physical distribution refers to the movement of goods outward from the end of the assembly line to the customer. Finally, supply-chain management is somewhat larger than logistics, and it links logistics more directly with the user's total communications network and with the firm's engineering staff.'

Cooper (1994, p. 14) tries to 'encapsulate the widened scope and purpose of logistics management in the 1990s' by the following definition:

'Logistics is the strategic management of movement, storage and information relating to materials, parts and finished goods in supply chains, through the stages of procurement, work-in-progress and final distribution. Its overall goal is to contribute to maximum current and future profitability through the cost effective fulfilment of customer orders.'

This complies with what Cooper et al. (1994, p. 2) say about it:

Logistics 'refers essentially to the management of supply chains in commerce and industry'. They divide logistics management into 'three constituent elements; namely, procurement logistics, production logistics and distribution logistics'.

Two remarks about these definitions:

(1) It is good to realize that there are not only 'customers' at the end of the supply chain, but there are commercial customers all along the way (at each stage where the goods change ownership) whose 'requirements' must be satisfied.

(2) One might say that the 'procurement logistics' of one link in the supply chain is the 'distribution logistics' of the preceding link. Therefore, in this text, we combine the two and only distinguish between external logistics and internal logistics (i.e., production logistics).

Hence, two kinds of goodsflows may be distinguished:

(1) internal goodsflows within a plant, i.e. inventories of raw materials and parts, work in progress with inventories on the way, and inventories of finished products within the plant; likewise, internal transportation is transportation within the plant, typically by lines, chains and other fixed installations; internal logistics is management of these goodsflows; this is the prime meaning given to logistics in assembly firms like Philips industries and in part of the European continent;

(2) external logistics between plants and to the consumers, i.e. collection, transportation and distribution of goods through public space: by road, rail, inland water, shortsea, deepsea, pipeline or air; this is the prime meaning given to logistics in the Anglo-Saxon world.

This book is concerned with the latter kind of logistics.

TRANSPORTATION

Three things may happen to goods in their flow, i.e., we distinguish three kinds of transformations in goodsflows:

(1) They may be changed in form, processed on their way to end products, transformed in form, or transformed in a strict sense;

(2) They may be stored, withheld to be put back into movement at a later moment, transformed in time, or translatated in a specific sense;

(3) They may be physically moved, brought from one place to another, transformed in space, or transported in the normal sense.

We encounter all three kinds of transformation both in internal logistics and in external logistics. However, their order of importance is reversed. In internal logistics the order is:

(1) transformation;

(2) translatation (inventories of raw materials, parts, and finished products);

(3) transportation (physical movement by fixed installations like lines or chains, or by mobile devices like hand trucks or fork trucks).

Whereas in external logistics the order is:

(1) transportation (through public space, mostly by mobile devices like trucks, trains or ships, but also by fixed installations like pipelines);

(2) translatation (inventories on the way, sometimes viewed in the perspective of the whole distribution channel, so including inventories at wholesalers and retailers);

(3) transformation (postponed production in the distribution channel, value added logistics, customizing end products, packing and unpacking, sticking price labels on, etc.).

The three kinds of transformations are usually represented in schemes as follows:

(1) a transformation in form, by a rectangular box;

(2) a transformation in time, by a triangle;

(3) a transformation in space, by a line, where an arrow indicates the direction of the movement if it is other than top-down or from left to right.

Thus, we may depict the supply chain as in Figure 1.

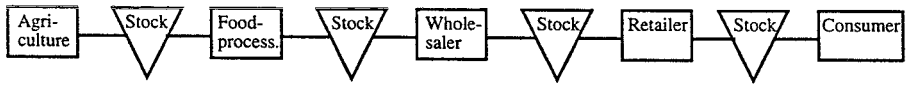

Figure 1. Supply chain from farmer to consumer, from sand to hand, from manure to mouth, etc.

The supply chain refers to the physical flow of goods. Quite rightly, some economists remarked that the supply chain is not supply-pushed, but demand-pulled, hence demand chain is a better name. Economists often use the scheme of the branch column, as in Figure 2.

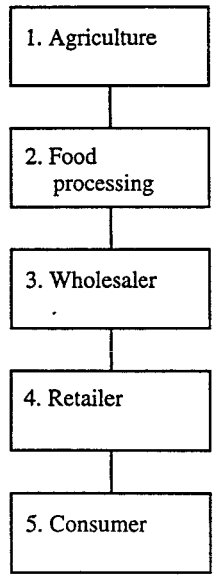

Figure 2. Branch column from farmer to consumer

The branch column refers to the commercial flow of goods. Between the processing firms of different branches are markets. The vertical lines represent trade transactions.

Naturally, the supply chain and the branch column are simplifications. Goodsflows may be split and proceed to different industries (diverge), or they may be combined to form a joint product (converge). Thus we may get complicated pictures of production and distribution networks, which may even have cycles in them (input-output analysis is based on the idea of mutual deliveries between branches, including both 'forward' deliveries in their 'natural' order, and 'backward' deliveries).

Let us take just one link from such a production and distribution network, where the nodes are consecutive processing firms, and zoom in to the relation between the two nodes, which we will call supplier and consignee, or demander. We may distinguish at least four flows in the relation between supplier and consignee, see Figure 3.

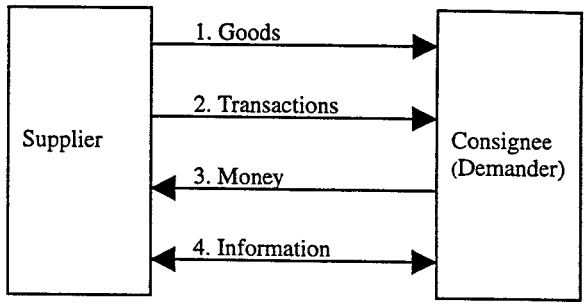

Figure 3. One link in a production and distribution network dissolved into four kinds of flows

(1) Goods flows; are the external logistics goods flows, where transportation is predominant, but where translatation (storage) or transformation (value added logistics) may occur on the way. Depending on the question of who manages which part of the supply chain, the goods flows may be part of physical distribution by the supplier, or part of physical collection by the demander.

(2) Transaction flows; this is a generalisation of the markets in the branch column. From the perspective of the supplier, this is commercial distribution, as opposed to physical distribution; from the perspective of the demander, this is commercial supply, as opposed to physical supply. Often a transaction flow can be broken down into a complicated chain of outsourcings and responsibilities, e.g. see Figure 4; this leads into the field of transportation law and outside the scope of this book.

(3) Money flows (please refer to Figure 3 again); this is mainly payment for the goods received. Between all the flows distinguished between supplier and demander, there are time relationships. If the goods delivery precedes their payment, the supplier invests in the debt of the consignee. However, goods may also be paid in advance. And money flows may be reversed, e.g. if the supplier pays for any damages claimed by the consignee.

(4) Information flows; these go both ways and usually there are a number of them related to each goods flow. Information flows are also closely related to money flows - in a sense one may say that money flows are often transformed into information flows.

This book is concerned with information systems in logistics and transportation. The information flows as depicted in Figure 3 will be our starting point for a discussion of information systems in the next section.

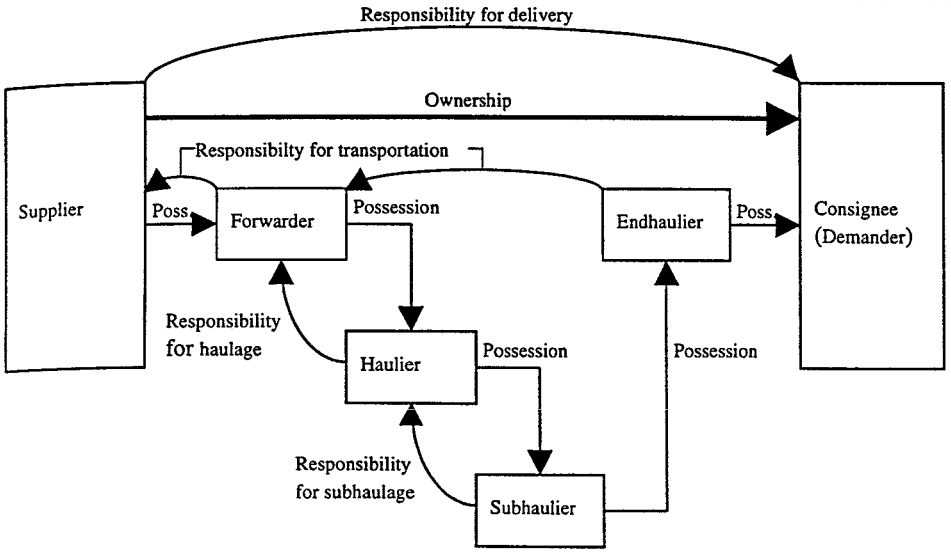

Figure 4. Breakdown of transaction flow; thick straight line: ownership; thin straight lines: possession; curved thin lines: responsibility and liability; insurance companies may enter the picture at each stage

INFORMATION SYSTEMS

We will not here go into the distinction between bits and bytes, data (meaningful bits and bytes), and information (semantic or pragmatic meaning derived from data by a human being). We will use the terms data and information interchangeably.

The same three kinds of transformation that may happen to goods flows, may also happen to information flows. Information may be transformed in form, in time, or in space. In information flows in external logistics and transportation, the order of importance of the various kinds of transformation is from last to first, so we have:

(1) Transformation in space; transportation of information is often called telecommunication. If the telecommunication is two-way between computers belonging to different information systems, we call it electronic data interchange (EDI). EDI plays a major part in this book.

(2) Transformation in time; translatation of information is often called information storage and retrieval. Retrieving information from a computer is far more difficult than storing it. Note that storage of goods implies three things: (a) actually storing the goods or putting them into storage or handling them in, (b) actually keeping the goods in storage, where the three R's are incurred: Room costs for maintaining the storage space, Rent costs for the money invested in the goods, and Risk costs for the goods to go out of fashion or otherwise lose their economic value, (c) retrieving the goods or picking orders or handling them out. Very similar costs may be distinguished for information storage and retrieval.

(3) Transformation in form; transformation of information in this strict sense is what is usually understood by data processing, computerized decision making, simulation or optimization. The topic of this book, information systems in logistics and transportation, offers the scope, therefore, to also discuss decision modeling in external logistics.

Let us go back to our ingredients for depicting production and distribution networks or, as the case may be, information networks:

(1) boxes, to depict transformation processes, executed by successive suppliers and consignees in the network; these are nodes in the network;

(2) triangles, to depict translatation processes, storage and retrieval of goods or information; these are also nodes in the network;

(3) lines, to depict transportation processes of goods or information, goods or information flows; these are the arcs in the network.

If we use these symbols to make pictures, and indeed use the very words like 'network' and 'flows', we commit a dangerously misleading graphical and verbal modeling error. In external logistics, goods and information are not flows. In external logistics, goods are transported in shipments, information is transported in messages. Shipments and messages are discrete entities. As a rule, there are no actual, but at most virtual, links between the nodes in the network. (This is in contrast to internal logistics, where fixed installation or permanent information connections more often provide physical links between the sender and the receiver.)

A more realistic picture of goods and information 'flows' between a supplier and a consignee may be seen in Figure 5.

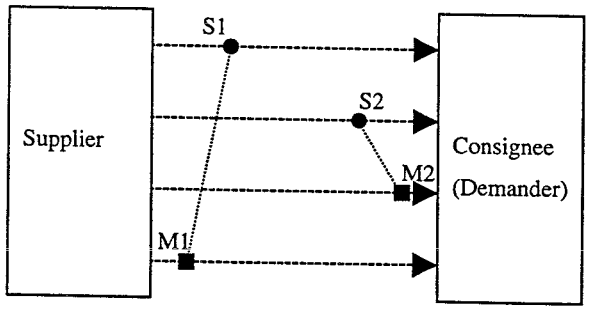

Figure 5. Shipments (S1 and S2), and messages (M1 and M2) in the space between a supplier and a consignee. Broken lines: ideal, virtual routes of shipment or message from sender to receiver; dotted lines: semantic, not physical, relation between a shipment and a corresponding information message. Note: time precedence relations are not represented in the picture

Perhaps we should eradicate the notion of goods 'flows' and information 'flows' from our mind and think of the following definitions:

A shipment is a transmission of a set of one or more discrete handling units, from a shipper to a receiver, that may be handled by human beings or machines; the shipment is forwarded

through public space, by various modalities, which may be surface (road, rail or inland water), sea, air or underground, by the own transport means of the shipper or the receiver and/or by professional hauliers in their various modality branches. On their way, shipments may change. They may be combined (consolidated) to larger shipments, or they may be broken down (deconsolidated) into smaller shipments. For that matter, even handling units may change on their way (repackaged into larger or smaller handling units).

A message is a transmission of a set of discrete data, from a sender to a receiver, that may be handled by human beings or computers at either side; the message is forwarded through public space by various modalities, which may be a shipment (the message may be physically connected to a shipment), mail, telephone, telefax, telecommunication (e.g., Internet) or EDI. In external logistics, a message may be semantically or pragmatically related to a shipment.

In external logistics and transportation, a great amount of effort must be spent on maintaining the relation between the information system and the physical goods. Goods identification, tracking and tracing are the key issues. Although there is a lot of overlap between the terms 'tracking' and 'tracing' according to the dictionary, we want to distinguish these terms. Thus, tracking is to find back a shipment when the connection to the information system was broken, to inform any party concerned about the whereabouts of a shipment at his request. Tracing is to follow a shipment as it proceeds through space and to have available information about its whereabouts continuously; this does not necessarily mean that the shipment is 'observed' continuously (for instance, by satellite localisation). At the present time, tracking usually boils down to having a few checkpoints where the shipment should pass, 'observing' the shipment as it passes, and giving a warning message if the shipment does not pass the checkpoint at a predetermined time.

Thus a tracking and tracing system links up an information system with a physical distribution system. The identification is at the level of shipments, or at the level of individual handling units. At one or more (or infinitely many) checkpoints, the tracking and tracing system will:

(1) register the presence, at which time, and possibly the quality status, of the shipment or individual handling units (the Ist-situation);

(2) plan and/or forecast the arrival and departure of the shipment or individual handling unit (the Soll-situation);

(3) compare the Ist- and Soll-situation and take informative action if the two do not match.

Note that (2) and (3) imply that the whole gamut of planning and forecasting transportation operations is included in the tracking and tracing system, but in doing so, its functionality is greatly enhanced.

IN CONCLUSION

This book is concerned with information systems in logistics and transportation. Logistics is external logistics, the management of shipments between shipper and consignee or, depending on the manager's scope of power, the management of the whole or part of a supply chain or a production and distribution network. Transportation is transformation of place: moving shipments through public space by various modalities, over the earth surface, through the air,

or underground. Information systems include modeling and management decision making, but key issues are EDI, tracking and tracing.

Readers may be surprised that some articles in this book seem to be rather far off this topic. That is because sometimes a wide perspective is taken as part of a top-down approach. In analogy with Nijkamp et al. (1994, p. 29, 176ff) we view the topic as a prism with five facets, enumerated top-down in the same sequence as the chapters in Part I of this book:

(1) eco ware (the environmental aspects);

(2) fin ware (the financial/economic aspects);

(3) org ware (the organizational aspects);

(4) soft ware (the electronical aspects);

(5) hard ware (the physical, palpable aspects).

REFERENCES

Council of Logistics Management (1991), *Logistics in Service Industries*.

J. Cooper (Ed.) (1994), *Logistics and distribution planning: Strategies for Management*, Second edition, Kogan Page, London.

J. Cooper, M. Browne and M. Peters (1994), *European Logistics: Markets, Management and Strategy*, Second Edition, Blackwell, Oxford.

J.C. Johnson and D.F. Wood (1996), *Contemporary Logistics*, Sixth edition, Prentice-Hall, London.

D.M. Lambert and J.R. Stock (1993), *Strategic Logistics Management*, Third Edition, Irwin, Homewood.

P. Nijkamp, J.M. Vleugel, R. Maggi and I. Masser (1994), *Missing Transport Networks in Europe*, Avebury, Aldershot.