TRANSPORT CONSEQUENCES OF NEW LOGISTICS TECHNOLOGIES

Sten Wandel
International Institute for Applied Systems Analysis
Laxenburg, Austria

Roland Hellberg
Norwegian School of Management
Bekkestua, Norway

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FOREWORD

The Technology–Economy–Society Program at IIASA focuses on the evolution, competition, and management of technologies; on identifying economic and social prerequisites; and on assessing the socioeconomic impacts of technological developments.

This reprint summarizes the results of a study performed within the New Logistics Technologies Project in order to explore the interplay between the introduction of some 18 different types of new logistic technologies and the development of freight transport systems.

One in-depth explorative case study from the automotive industry was performed to generate hypotheses and a conceptual framework, which were then tested on some 20 cases from early users of new logistics technologies.

T.H. LEE
Program Leader
Technology–Economy–Society

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Sten Wandel*
International Institute of Applied Systems Analysis
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FOREWORD

This paper is partly based on research which was initiated and supported by the Swedish National Board of Transport (and reported on in Ref. 6), and partly on the current IIASA project New Logistics Technologies – Transport and Socio-Economic Consequences. The authors wish to thank both organizations for their kind support.

OBJECTIVES

The objective of this study is to study transport both as a prerequisite and as a consequence of logistics changes. Logistics is used here in a very general sense to denote all systematic actions aimed at bringing materials from primary sources through all intermediate steps to the end user. In this sense, logistics includes transportation, handling, storage and all related information processes.

Focus is on Scandanavian companies, but comparisons are made with German, US (13) and Japanese (18) case studies.

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* And Linköping Institute of Technology, Linköping, Sweden.

BACKGROUND

Since the Industrial Revolution the trend has been towards large-scale production of standardized products at low costs per unit, which in turn has caused specialization and long material flow chains, thereby increasing transport and storage activities. Material flow has been increasingly separated in space and time, as well as organizationally. Market demands for greater variety, more complicated products and faster, more efficient delivery service have further increased the relative cost of logistics. Studies of logistics costs show percentages of total value added for industrial sectors varying from 63% in the UK (10), 33% in Sweden (1), and 19.5% in France depending on what activities are included and how they are measured.

We are now entering a new phase of the logistics evolution, in which new information and communication technologies offer great potential not only for modifying the individual process stages of production, storage, transportation and transactions, but also, and more importantly, for changing the integration of the process stages in the logistics chain into more efficient, but more complex systems. Statistical data already indicate considerable reductions in inventory levels (4), increased investments in information technology and a general shift to high quality, customized transportation (9). Transport policy has not yet been adapted to this new integrative role of transport.

Customized transportation systems, however, could destroy the possibilities for transport producers to consolidate shipments and achieve economies of scale (7). There is a fear that logistics developments could lead to lowered capacity utilization, more trucks on the roads, severe problems for the railroads, and unemployment problems in regions with small transport flows and therefore infrequent and low quality transport supplies.

It is expected that the transport supply will become more differentiated in regard to quality and that such changes will aggrevate current problems such as overcapacity and subsequent lack of capital for investments in new technologies.

APPROACH AND ISSUES

Since the interplay between logistics changes in the production sector and the development of transport services has been studied very little previously, an in-depth exploratory case study was undertaken in a company that is an early user of advanced logistics technologies. At the same time, a conceptual model was developed based on theories regarding the complex relationships between changes in logistics and the transportation system (2), mainly based on (9). Several structured case studies were then performed to determine the extent of the changes that had been identified in the exploratory case study. The primary studies were complemented with secondary cases that have been described at conferences and in the literature.

The following research questions have been analyzed:

- Which logistics changes can have an impact on which transport systems?
- What are the economic consequences of logistics changes? For whom?
- What penetration rates, hindering or accelerating factors can be expected?
- What new transport standards are required for each type of change?
- What are the changes in the roles of the organizations?

- What are the changes in transport modes, consolidation, load factors, return loads, transport development contracts, terminals, services added, vehicle scheduling, ton km/year, vehicle km/year, manpower levels, costs, prices?

In all twenty-two material flow cases were studied. For and after descriptions were made based both on internal company documentation and on structured interviews with suppliers, users and transport operators.

The following clusters of logistics changes were examined:

1. JIT: Material supply with frequent deliveries where only the exact amount arrives where it is needed "just-in-time".
2. Central Inventory: Fewer inventory points are situated closer to the production center while service levels are maintained or increased.
3. Transport Systems: Changes limited to the transport system permit faster, more precise and frequent transport.
4. Logistics Structure: Total logistics changes are undertaken, which include introducing new machines and locations and affect several steps in material flow.

EXPLORATORY JIT CASE

At the Saab car assembly plant at Trollhättan, Sweden, the JIT system functions according to the following example. At 12 a.m. the car company ascertains how many "JIT items" have been used during the previous two work shifts. Corresponding quantities of the JIT items that need replacing are then ordered by telex from the supplier. Between 12:00 a.m., when the supplier gets the message and 4:00 p.m., when the truck arrives for loading, the supplier has time to get the JIT order ready. Between 4:00 p.m. and 7:00 a.m. the JIT items are transported to the car company. When the products arrive, the quantity is checked. If the right quantity has not been delivered, the company adds the missing items to the next order. Of course, the schedule of the JIT system is adapted to each individual supplier of JIT products.

From the transport operator's viewpoint, however, the following problems with the JIT system have been identified:

- Everyday transport can be a problem if an individual supplier's volume is low or fluctuates, if the suppliers are not located near by, or if there is not enough flow of other goods from the area to fill a truck.
- The tight time schedule can often mean better utilization of the vehicles. Unforeseen events, however, such as traffic jams, snow chaos, or ferry delays can have devastating effects, including bringing an entire assembly plant to a standstill.
- Direct transports of small, frequent shipments on tight schedules demand very efficient loading and unloading if the vehicles and load space are to be fully utilized by consolidating shipments from and perhaps also to many locations. Goods that require special packaging or handling equipment aggrevate the problem.

High levels of variation in day-to-day volumes are due to schedule variations and the division of assembly operation into small groups, whose products are packaged in standardized units. However, despite these problems, transport costs have not increased after the change to JIT supplies for some pilot flows.

OTHER JIT CASES

At the Volvo factory in Ghent seat covers are produced at a rate that is synchronized with the assembly schedule for particular car models and shipped in special containers to the assembly line in the correct sequence. The shipments are made every two hours using single trailors equipped with special racks. In the German car industry there are examples of warehouses located between the supplier and the assembly and operated by transport companies which make JIT deliveries directly from the warehouses. Such indirect links are used only when volumes are low or fluctuating, distances are long, a supplier has many different customers, or a commodity is produced in batches (5).

At the General Motors plant in Lansing, Michigan the assembly sequence is frozen for eight days at a time, which makes it possible to have as much as 85% of the daily dollar volume in JIT deliveries at the point of use. Having 90% of the chassis suppliers and 73% of the body suppliers located within 250 miles of the assembly plant makes the JIT system feasible. GM has established standards for transit time, arrival times, unloading delays and other parameters. After JIT was introduced, rail volume was reduced from forty cars to a single car per day for Pontiac imports from Mexico. GM does use more specialized vehicles, however, and a rail service has been set up that travels the three and a half miles between stamping facility and body assembly plant at two-hour intervals.

CENTRALIZED STORAGE CASES

The consequences of changing from some 130 storage and order processing points to one central, highly-computerized operation for telephone distribution in Sweden is shown in the table below. Inventory and labor were reduced by a factor of four, while the cost of transport went up by the same factor due to fast shipment of small parcels instead of full truck loads.

CENTRALIZED STORAGE OF TELEPHONES
(Sweden, Million SKr.)

	Before	After
Capital	116	24
Capital cost	28.7	6.0
Labor cost	27.3	7.2
Transport cost	1.2	4.8
Total	57.2	18.0

The distribution of Electrolux household appliances in Sweden is organized from three central storage depots adjacent to the factories. Each individual product is stored at only one location. From the central depots the appliances are transported to sixteen distribunals, operated by an independent forwarding agency, where they are sorted for final distribution to retailers and users. A new plan calls for only two storage depots to be in operation. If a customer orders appliances from both depots, the appliances from one depot are first transferred to the other where the entire order is then loaded into a container in the order in which individual items will be unloaded.

Three 7.5 meter long containers can be loaded onto one 24 meter truck, which is the maximum size in Sweden. When the truck reaches its distribution area, the containers are transferred to three distribution vans. This system has reduced delivery time from four days to two and almost completely eliminated handling damages and thefts.

TRANSPORTATION SYSTEMS CASES

The Volvo Car Division at Gothenburg has divided Sweden into fifteen areas each large enough to require a full truckload every day. Each supplier has a fixed delivery day, one to three times a week. This system permits direct transports, that is, transports that need not pass other terminals. If there are enough goods for a full truckload from a particular supplier every day, special transports are arranged. A flat rate, i.e., a fixed price per kg independent of the shipment size was achieved, which lowered transport costs for Volvo. At the same time, the scheduled arrival times have nearly eliminated waiting times at Volvo's unloading docks.

The average size of the shipments has gone down from 4 to 1.6 tons. Ten percent of the essential parts, i.e., some 75 to 100 critical items, are under tight control. Ten percent of the low volume value articles with low transport demands can be used as buffer goods to fill leftover transport capacity.

It took about five years from idea to implementation of this system. The transport service was bought from a forwarding company which initially experienced problems due to the loss of base freight in line haulage between terminals. The freight flow that remained was too small to fill a truckload every day, but by reducing the number of terminals and thereby the amount of direct line haulage, the company was able to increase capacity utilization, even though large flows are now handled by separate and customized transport systems such as Volvo's. Experiments using more advanced transport information systems, double trailors and containers are being performed to find ways to combine line haulage with customized services for materials supply to large customers.

With Volvo's new TIR system, each article is followed on the computer on line during the entire material flow. Delivery plans are automatically sent to the transport companies, which often use them to adjust their hauling capacity for the most efficient loading possible. In the old system, suppliers often ordered the transport needed only shortly before the goods were ready for shipping, a method which rarely gave transport agencies enough time to adjust their hauling capacities to fit actual needs.

LOGISTICS STRUCTURE CASES

There is a long-term policy in most companies covered in the study to reduce the overall number of suppliers and to eliminate those suppliers situated in areas with no possibilities for high quality transport. Such suppliers will be replaced by others unless the parts are somehow unique, have a low volume value, or combine high labor content with a particularly low price, such as some currently imported from Portugal, Spain or Korea.

Production units of the Swedish roll bearing manufacturer SKF are located in Sweden, Germany, Italy, France and the UK. Previously, most SKF products were produced at all five locations. Now each item is produced at only one location. Diversified production has been replaced by daily transports between the five locations of some 300 tons in 15-20 trucks. Transport frequency is 2 to 5 times per week, and for emergency shipments, air transport and express trucks are used. This is an example of how transport has been increased to achieve economies of scale in production. With new production technology this trend may be reversed as hypothesized in Figure 1.

HYPOTHESES ON CHANGES IN TRANSPORT DUE TO LOGISTICS DEVELOPMENT

Logistics Changes	Transport Impacts						
	Speed	Times handled	Ton km	Ship-ment size	Fre-quency	Preci-sion	Vehi-cle km
Production to order	+			-	+	+	+
Variant production				+	-		-
JIT supply	+			var.	+	++	+
Zero inventory	+			-	+	+	-
Integrated Infor-mation systems	+				+	+	
Flexible manu-facturing				var.	+		
Parallel lead times 1)					+	+	-
Automatic handling		+		-	+		-
Higher quality 2)	+						
Pooling product capacity		+		+	-		+
Pre-assembly 3)	+	+		-	+	+	+
Fewer produc-tion stages	-	-	-				-
Fewer storage points	+	-	-	-	+	+	+
Fewer suppliers		-		+			-
Geographic con-centration	-		-				-
Small scale production		+	-	-			-
Distribunals	-	+	+	+	-	-	-

Figure 1

+) = increase; -) = decrease; var.) = increasing variance

1) Earlier transport orders. 2) Goods protection. 3) Special containers.

CONCLUSIONS

It can be expected that the speed of introduction will vary in different sectors of the economy. Sectors with great international competition, mature products, relatively large production units and locations along main transport arteries will be the first to adopt and develop new logistics technologies. In Sweden, OEM companies and their industrial networks, as well as the forest and steel sectors, are leading the development. The automobile industry may have a majority of its Scandanavian supply on a JIT scheme within 3-5 years. Smaller, newer high technology or service intensive companies in weak transport regions can be expected to introduce new logistics at a slower rate. The major hindering factor is the slow adoption of transport supply and governmental policy in regard to this new role of transport.

JIT deliveries can be made from a distribunal that is operated by a third party, that is, neither by the supplier nor the user. Similar intermediate organizations have already been introduced in the information sector. For example, mailboxes and switchboard services for computer networks allow delivery orders and shipping documents to be transferred from one computer to another. It is expected that the role of existing organizations will change and that new organizations with new types of logistics services will enter the market. Wholesalers, for example, may find profitable roles as information brokers, while the physical material flows may be handled by transport companies at distribunals. Such organizational innovations are expected to accelerate the speed of development.

The current trend toward higher specialization and lower value added to sales relations may be reversed for mature products in sectors where flexible production with economies of scope can be introduced. However, the length of the logistics chains, both in the number of stages and in the physical distances involved will probably increase for new, complex products and for complex production systems in which economies of scale are still important.

Figure 1 shows some hypotheses about how transport will change in response to logistics changes. These are based both on theory and the case studies described above. The analysis has been made "ceterus paribus", i.e., no other factors have been changed. Total production volumes, the relative sizes of various sectors, the geographical locations of raw materials and final demands have remained unaltered. In the long run, however, new logistics, transport and production technologies could change these factors as well. For example, labor intensive production could be relocated from Less Developed Countries with cheap labor to industrial nations where the work could be achieved at low cost by using robots. A good overview of the socio-spatial implications of JIT is given in (17).

Normally, many logistics changes are combined in individual cases. We hypothesize that administrative changes will be made before new hardware is acquired and that relocation of production will take an even longer time.

Note that the development of consolidation systems has a direct effect on vehicle kilometers and modal split. If containers, automatic handling and integrated information systems are introduced, traffic work as measured in vehicle kilometers and the number of vehicles and drivers involved can be reduced relatively quickly. Due to larger loads and more rail and sea transport, shipment frequency, precision and handling speed could be simultaneously improved.

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