The Lean Concept in the Food Industry: A Case Study of Contract a Manufacturer

Ulla Lehtinen and Margit Torkko

The paper discusses how the lean concept could be applied to a food-manufacturing company. The paper first presents the lean concept and value-stream mapping tools. The empirical section discusses how a case company, operating as a contract manufacturer in the food industry, has applied the lean production concept and tools. In the case study, three analysis tools are examined and the structures of demand chains of different customers are presented. The delivery times will decrease and more flexibility will be needed from the contract manufacturer. The case study shows that much movement is possible toward the lean supply chain and partnership-based cooperation. By implementing the lean concept, food companies can increase customer value through cost reduction or through provision of additional value-enhanced services.

This paper focuses on improved understanding of the development of supply-chain management in a food chain with a special reference to the lean production concept. Womack and Jones (1996) defined a vision of the future organizational model of manufacturing, the lean enterprise, as a group of individuals, functions, and legally separate but operationally synchronized companies. This vision of the modern production paradigm was described by Henry Ford in the early 1900s, and his writings were later the basis for the Japanese production philosophy. The new manufacturing paradigm, the lean management concept that places emphasis on outsourcing, cooperation, networking, and agility (e.g. Womack, Jones, and Roos 1990), was developed in the automobile industry and has been widely adopted in engineering-oriented and assembly industries. So far, little has been written about the applicability of the concept to the food industry. This paper presents the lean production concept and value-stream mapping tools that are used to analyze and develop production. The empirical illustration shows how a case company, operating as a contract manufacturer of leading private-label products in the food industry, has applied the lean production concept and tools.

A change occurred in the relationship between manufacturers and distributor organizations in the 1980s and 1990s. Within a number of product markets, both food and non-food, distributors launched their own products that inevitably forced manufacturing companies to compete with the owner of the shelf space, in addition to traditional competition with other manufacturers (Håkansson 2000). Store chains and their brands have increased their market share in Europe and the USA. In Finland, the share for store brands is about 20 percent. In other European countries the shares exceed the share of store brands in Finland—e.g., 41 percent in England and 35 percent in Germany. The manufacturing of store brands—i.e., private-label products—is more commonly assigned to small and medium-sized manufacturers that specialize in particular product lines and concentrate on producing store brands (Private Label Manufacturers Association 2005). These companies are called contract manufacturers or subcontractors.[1]

The reasons for outsourcing include lack of in-house capacity, need for expertise in technology, financing (e.g., cost-cutting), union avoidance, product life-cycle (outsourcing of old designs), and organizational changes in operations (Webster

The authors are researcher and assistant, respectively, Department of Industrial Engineering and Management, University of Oulu, Finland.

An earlier version of this paper was presented at the Fifth International Conference on Chain Management in Agribusiness and the Food Industry, June 6-8, 2002, Noordwijk, The Netherlands. The current paper has been revised and updated.

[1] A subcontractor is an organization which manufactures and develops ordered goods—semi-products, components, or services—whose customized specifications are provided by another company, called the prime contractor. Contract manufacturing is a form of subcontracting which has had different meanings depending on industrial history and evolution (Lehtinen 2001). In general, contract manufacturing involves one company making subcomponents or products for another company.

and Beach 1999). According to Dolan and Meredith (2001), there are three reasons why so many manufacturers have outsourced their products: 1) money is in the brands, not in the machinery—i.e., the intangible assets are more valuable than tangibles; 2) globalization, which implies that production is easy to transfer to countries with low labor costs; and 3) only the biggest companies can fully utilize the capacity of their own factories. In other words, contract manufacturers are able to obtain economies of scale in their factories. The role of the customer company and contract manufacturers varies within the food supply chain. The main responsibilities of a contract manufacturer are product planning, sourcing and allocating materials, preparing and maintaining manufacturing operations, and product manufacturing. The customer company should provide the product label, manage the supply chain, and arrange marketing and after-the-sale service.

Lean Production

The Lean Production concept, introduced by Womack, Jones, and Roos (1990) based on a comparative study in the automobile industry from Japanese and other parts of the world, could be seen as a quantification of earlier "world class" and just-in-time (JIT) manufacturing studies (Schonberger 1982; Monden 1983; Shingo 1981, 1985). Womack, Jones, and Roos (1990) described the supply co-ordination system from the Japanese point of view. Lamming (1993) developed the concept of the *Lean Supply Model*, describing supply-chain management practices within lean production.

The origins of lean thinking can be found on the shop-floors of Japanese manufacturers. In particular, the early work of Toyota has been highlighted. Lean production was first defined by Womack, Jones, and Roos (1990) as a system that create outputs using less of every input, similar to the traditional mass-production system but offering an increased choice for the end user. This definition of lean production was based on the concept of waste ("*muda*") introduced by the Toyota Production System (Shingo 1981). Waste means non-value-adding activities that, in the eyes of final customer, do not make a product or service more valuable (Hines and Taylor 2000). The main pillars of lean production are management of processes and the integrated logistics flow; management of relationships with employees, teams, and suppliers; and management of the change from traditional mass production (Hines 1994).

After 1990, lean production focused away from the shop floor. The value-stream concept evolved and was able to extend beyond manufacturing to the single company stretching from customer needs right back to raw-material sources. Womack and Jones (1996) crystallized *Value* as the first principle of lean thinking. They define the Lean Enterprise as a "group of individuals, functions and legally separate but operationally synchronized companies. The notion of value stream defines the lean enterprise." As such, lean had moved away from a merely "shop-floor-focus" on waste and cost reduction to an approach that sought to enhance value (or perceived value) to a customer by adding product or service features while removing wasteful activities (Hines et al. 2002).

The mechanism of a lean enterprise is defined as a conference of all firms along the stream, assisted by technical staff from "lean functions" in the participating firms, to periodically conduct rapid analyses and then take improvement actions. Womack and Jones (1996) also note that someone must be the leader of the lean enterprise and argue that the firm bringing all of the designs and components together into the complete product should be the leader. However, the participants must treat each other as equals and the lean system must be transparent (i.e., participating firms should have the right to examine every activity in every firm relevant to the value stream as a part of the joint search for waste.). Womack and Jones (1994, 1996) also highlight the fact that a single company will participate in multiple, competing streams with different upstream and downstream partners in order to learn from companies that think in different ways. This is a key to continuous improvement. The purpose of the firm itself as a part of the lean enterprise is to be the link between streams. The links are the means to make maximum use of technologies and capabilities accumulated by the firm's technical functions. They also provide the means for shifting resources between value streams.

Lean Supply

Lean supply is a strategic model for supplier-customer relationships. Table 1 shows the main features of lean-supply-model characteristics. The main point of lean supply is the concept of partner-

Table 1. An Overview of the Lean Supply Model.

Factor	Lean supply characteristics
Nature of competition	Competition between supply chains. Focus on the total competitiveness of a value stream. No competition between the members of a supply chain: dependent upon partnerships; high level of trust, openness, and profit sharing.
Basis of sourcing decisions	Single or dual sourcing. Long-term, often lifetime, relations. Buying criteria is based on maximum network benefit. Number of suppliers is low and very stable. Early involvement of an established supplier in the R&D process.
Supply structure	Tiered supply structure. OEM* (a firm bringing design and components together) is the leader.
The role of suppliers	Takes a proactive approach to improve the competitiveness of the complete supply chain. High degree of supplier innovation in both new products and processes. Supplier is a leader of technology in the area, which it knows best.
Supplier development	High level of supplier coordination at each level of the supply structure. Suppliers within value streams are seen as a group; group-based development tools are being used. Significant effort made by customers at each level to develop their suppliers. Pursue perfection by continually removing waste along value stream.
Data interchange and interaction	True transparency: costs, capacity etc. Detailed, some strategic, within network. Very frequent interaction at operational level, spreading throughout the network.
Production principles	True just-in-time. Synchronized capacity. Operational flexibility able to operate with fluctuations

Based on Lehtinen and Torkko (2002).

* Original equipment manufacturer is an organization within a supply chain that is responsible for delivery and development of the end product to customers (Lehtinen 2001).

ship as a form of collaboration. The term is defined by Ellram (1991, 1995) as "an ongoing relationship between two organizations which involves a commitment over an extended time period, and a mutual sharing of the risks and rewards of relationships." The other main features defining partnerships often mentioned in the literature are the exchange of ideas, information, and benefits; joint research and technology development based on trust; and long-term relations (see, e.g., Lamming 1993; Macbeth and Ferguson 1994; Ellram 1995). Lean supply addresses the advantages of supplier development on the network level. At the advanced stage, companies will take a proactive role in developing common working methods for mutual advantage throughout the supply chain. An individual supplier will take a systematically proactive approach to improve the competitiveness of the complete supply chain. This will involve working with both direct and indirect suppliers and customers (Hines et al. 2000).

Value-Stream Mapping Tools

The rationale behind going lean focuses on waste removal both within and between companies. The removal of waste is fundamental to the lean value stream (Hines and Taylor 2000). Improved productivity leads to leaner operations, which in turn helps to expose further waste and quality problems in the system. The seven wastes defined by Shingo (1981, 1988) as part of the Toyota Production System are:

1. Overproduction—Producing too much or too soon, resulting in poor flow of information or goods and surplus inventory.
2. Defects—Frequent errors in paperwork, product quality problems, or poor delivery performance.
3. Unnecessary Inventory—Surplus storage and delay of information or products resulting in excessive costs and poor customer service.
4. Inappropriate processing—Going about work processes using the wrong set of tools, procedures, or systems, often when a simpler approach may be more effective.
5. Excessive transportation—Excessive movement of people information or goods wastes time, effort, and cost.
6. Waiting—Long periods of inactivity for employees, information, or goods resulting in poor flow and long lead times.
7. Unnecessary motions—Poor workplace organization resulting in poor ergonomics, (e.g, excessive bending or stretching) and frequently misplaced items.

Finding waste is a difficult task, and various tools are needed to analyze the physical product and information environment. Six of the most useful tools are presented below.

Process activity mapping. This tool is used for identifying lead time and productivity opportunities for both physical product flows and information flows in the factory as well as in the supply chain. The idea is to map every step throughout the order-fulfillment process that has a number of different steps or stages. There are four types of flows:

1. Operations—value-added activities that are paid for by customers.
2. Transportation—movement around the plant or between sites.
3. Inspections—checks of the quality or quantity of product or information.
4. Delay or storage—where a product or information is waiting for the next step.

This tool reveals wastes, especially inappropriate processing, excessive transportation, waiting, and unnecessary motions.

Supply-Chain Response Matrix. This tool is used to evaluate the inventory and lead times incurred by a supply chain in maintaining a given level of customer service. The objective of this mapping is to improve or maintain the service level of the entire chain at lower costs, by revealing unnecessary inventory and waiting.

Production-Variety Funnel. This visual mapping technique makes a map of the number of product variants at each stage of the manufacturing process. It can be presented graphically, with the x-axis representing the process path and the y-axis showing the number of products. This map reveals the point at which a generic product becomes either increasingly or totally customer-specific. The tool suggests the logical point at which buffer stocks may be held.

Quality-Filter Mapping. This reveals three different types of quality defects (product, scrap, service) in a value stream. Defects can be presented graphically: the x-axis represents various stages of the value stream and the y-axis represents defect rate. This can be used to integrate quality and logistics performance measures.

Demand-Amplification Mapping is a graph of quantity against time that shows the batch sizes of a product at various stages of the production process. It can also be used to show inventory holdings along the supply chain through time. The aim of demand-amplification mapping is to clarify the bullwhip or Forrester effect and to examine scheduling, batch-sizing policies, and inventory decisions.

The stages of the production process at which data will be collected are identified; the first stage is usually the actual demands made by customers. Subsequent stages are at major production stages or cells. Inventory and batch-size data is collected at and after each inventory location. The time period for analysis should decide and represent the normal operations situation.

Value-Analysis Time Profile is a time-based value-analysis tool which allows for the plot of both total cost and value of the product as it moves along the supply chain under consideration. The difference between the total-cost line and value-adding line represents the cost of the wastes. The area under the total-cost line represents the amount of money tied up in a unit of inventory. It is a very useful tool to follow time compression or mapping where money is being wasted.

The Case Example

The case company is a contract manufacturer that has no products of its own. The company specialized in manufacturing ketchups, mustards, sauces, and jams for leading brands. The products are designed and manufactured according to the wishes of customers, who are marketing companies, wholesalers, and industrial companies. The company consists of 60 employees serving over 50 different customers; about 280 products of different recipes are manufactured. The aim of the case study was to analyze material and information flows within the company and its demand chains in order to find best practices and targets for further development. The study was carried out in 2001, including analysis within the company and interviews with customers. The analysis of materials and information flow in five different kinds of demand chains was based on interviews among wholesalers and agents.

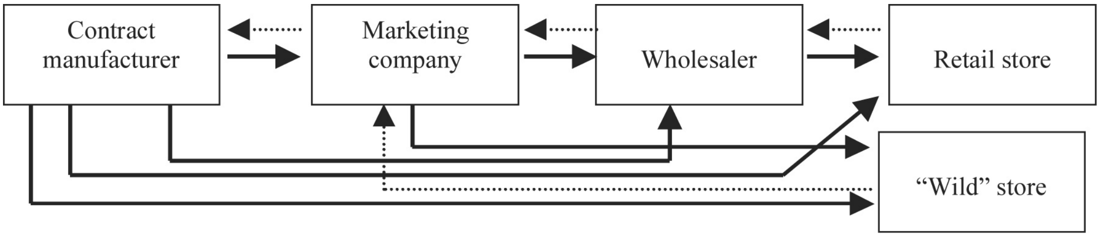
The effectiveness of internal material and information flows was studied by using three value-stream mapping tools: process-activity mapping, supply-chain response matrix, and demand-amplification mapping.

The Structure of the Demand Chains

The case company had limited knowledge of the structure of its demand chains before the study. There were five types of customers, each with different logistical-chain structures and products. In this paper, the demand-chain structures of three customers are presented.

Big Marketing Company. Figure 1 shows the demand chain of a big marketing company. The case company manufactures a number of different products for the marketing company. Electronic data interchange (EDI) is used in communication between the marketing company and the wholesaler to provide data on consumer needs. Based on this demand information, forecasts are made for six-month periods. Open orders are given to the contract manufacturer every four months. The fixed order period is one month.

The final products could be stocked in four stages: in the factory, in the inventory held by the marketing company, in the distribution centers of the wholesaler, and in the stores. The contract manufacturer is able to deliver unplanned orders within one week. The products are shipped either



Source: Lehtinen and Torkko (2002).
Note: “Wild” store is an independent store which does not belong to a retail store chain.

Figure 1. The Demand Chain of a Big Marketing Company.

to the marketing company, to the wholesaler, or directly to the stores. In the future, direct deliveries to the stores will be more common and the use of electronic data interchange will increase.

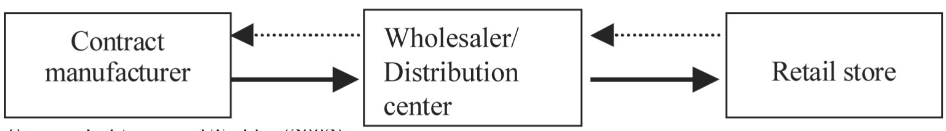
Wholesaler (Figure 2). Retail stores order products automatically from a large wholesaler that orders them from the contract manufacturer. It takes a week to fill the order. The forecasts made by the wholesaler are based on the sales of last year and the previous month. The contract manufacturer supplies full pallets of products about every three weeks to the wholesaler's distribution center, where the products are checked before they are placed onto shelves. All products are delivered through the distribution center to the stores. The wholesaler maintains inventories equal to about 3–4 weeks demand.

The aim of the wholesaler is to reduce inventory through increased cross-docking. The contract manufacturer would supply product pallets daily to the wholesaler's terminal, from where the products would be delivered daily to big retailers. Direct deliveries from the contract manufacturer to the stores are also an option. Electronic transactions between the chain partners will be used in the future.

Small Marketing Company (Figure 3). The small marketing company has five sales agents in Finland. The sales agents collect orders from retail stores and industrial kitchens. The long-term contracts with wholesalers are managed by the owner of the marketing company. The sales agents fax orders to the marketing company, where they are then sent daily to the contract manufacturer.

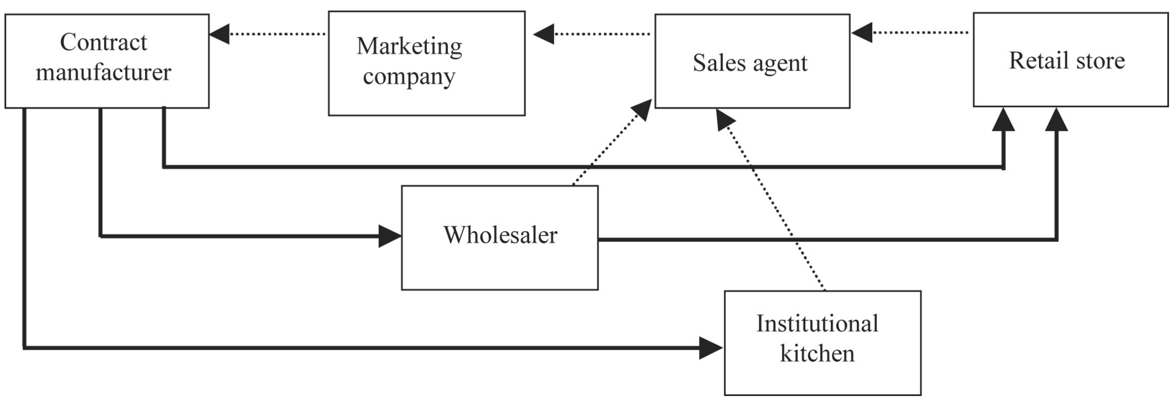
The marketing company's main assets are quickness and flexibility. Retailers get their products within 24 hours from the time of placing order. This is possible because the contract manufacturer holds inventory and makes shipments to retailers. The cost structure of the products differs from other customers' products because the marketing chain is shorter. In the future, one goal of this firm is to introduce the electronic data interchange system.

The materials flow of the small marketing company chain most resembles the lean principles. The products are stored only by the contract manufacturer and they are directly delivered to the final customers. There is also more cooperation than in



Source: Lehtinen and Torkko (2002).

Figure 2. Example of the Demand Chain of a Wholesaler.



Source: Lehtinen and Torkko (2002).

Figure 3. Example of the Demand Chain of a Small Marketing Company.

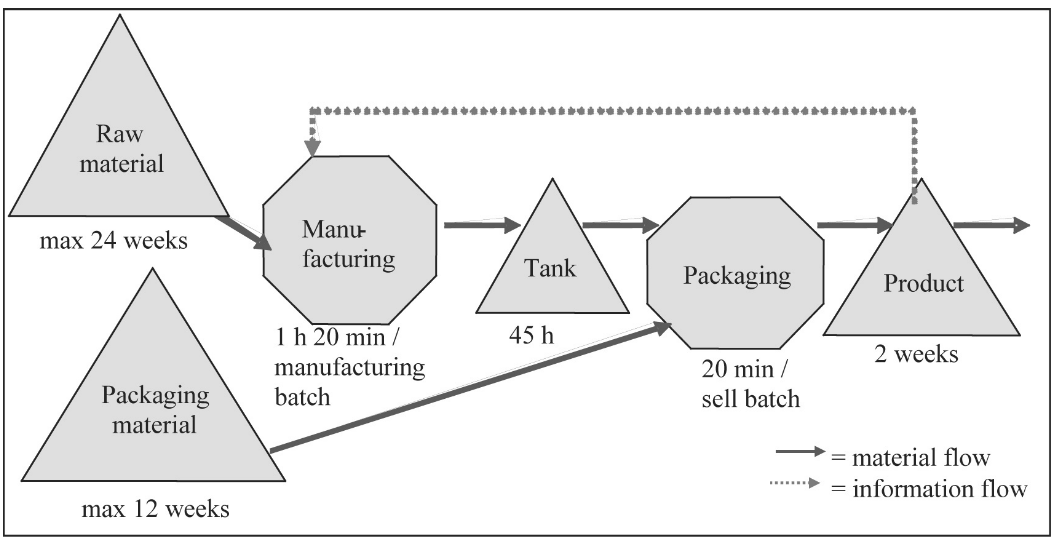
the other customers' chains, and the location of the inventory within the chain is defined together. The cooperation with the contract manufacturer and wholesalers or marketing company was very limited. As a result there were unnecessary stocks and handling in all companies. On the other hand, the companies planned to decrease inventories by using cross-docking and increasing direct deliveries. In addition, the use of EDI is making information flow more effective than prior to the EDI system introduction.

Although single-sourcing and long-term relations were used by customers, profit sharing and openness in negotiations were not common among wholesalers and marketing companies. Also, supplier-development or chain-coordination activities were unknown to customers, whereas the role of the contract manufacturer was very active. The company had a large influence over new-product and technology development. The contract manufacturer also took an active approach to improve competitiveness.

The Use of Value-Stream Mapping Tools

Three of the seven value-stream mapping tools were applied in analysis of the internal processes of the case company. Four different products were chosen for the analysis. In this paper, an analysis of ketchup that was manufactured for the small marketing company (Figure 3) is discussed. The shipments were delivered directly to the stores almost daily. Because the demand chain from contract manufacturer to stores was direct, the value-stream mapping was only done internally in the case company. The flow of the product was followed from raw materials to the deliveries.

Process-Activity Mapping of Ketchup. The aim of process-activity mapping was to clarify the value-added material flow of the product within the company. The flow of materials was examined at the factory level. Figure 4 presents the manufacturing stages. The longest that raw materials and packaging materials wait in inventory before production starts is six months and three months, respectively. As seen in Figure 4, both manufacturing and packaging are fast processes. The holding tank between manufacturing and packaging acts as a buffer that guarantees flexibility in manufacturing. End products are stored in the factory and the final inventory operates on the first-in-first-out (FIFO) principle. The mapping reveals that value-added material flows, including manufacturing and packaging processes, take very little time compared to non-value-added flows. The most important waste



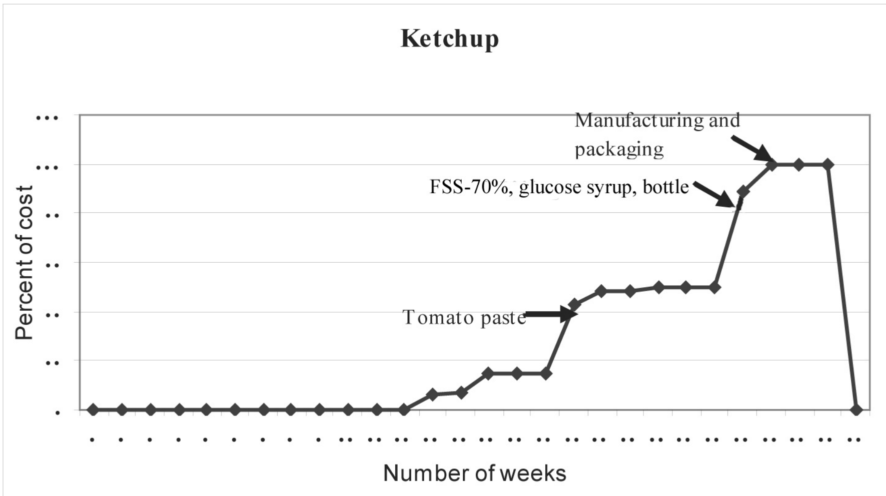
Source: Lehtinen and Torkko (2002).

Figure 4. General-Process Activity Mapping of Ketchup Production with the Corresponding Average Inventory-Holding Period.

seems to be unnecessary inventories, especially for raw-material inventories, which was also noticed when the stock turnover was examined. The stock of raw materials turned over on average three times a year, while the end-product inventory turned over almost 28 times.

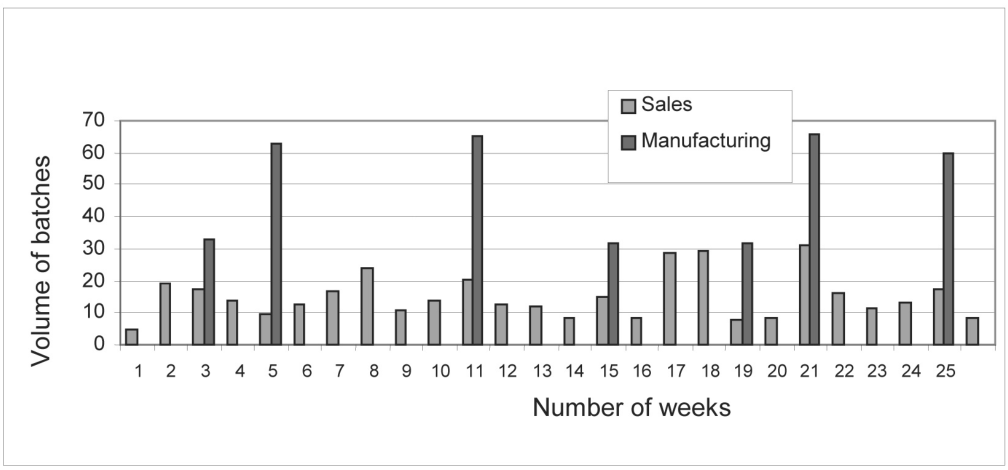
<u>The Supply-Chain Response Matrix.</u> Figure 5 shows the supply-chain response matrix. The vertical axis represents the percentage of cumulative costs and the horizontal axis shows the cumulative lead time measured in weeks.

The supply-chain response matrix shows that the impact of manufacturing and packaging processes on costs is small. Manufacturing and packaging account for only 11 percent (including water and energy) of the total cost. The share of direct work is approximately six percent. On the other hand, the materials account for more than 80 percent of the costs, which are tied up 24 weeks before produc-



Source: Lehtinen and Torkko (2002).

Figure 5. Supply-Chain Response Matrix for Ketchup Assuming the First Shipment of Raw Material Arrives at the Plant in Week 1.



Source: Lehtinen and Torkko (2002).

Figure 6. Sales and Manufacturing of Ketchup between January and June, 2001.

tion starts.

Demand-Amplification Mapping. The aim of demand-amplification mapping was to examine scheduling, batch-sizing policies, and inventory decisions. The weekly levels of sales and manufacturing of ketchup are presented in Figure 6. The final inventory level was also examined over the same time period (Figure 7).

Ketchup was manufactured seven times between January 1 and June 30, 2001. The cycle between production runs was 2.6 weeks on average, varying from six weeks to a few days. Figure 6 shows that sales are frequent, on a weekly basis. Thus the inventory level of end products could be reduced through more frequent, leveled production runs and smaller batch sizes.

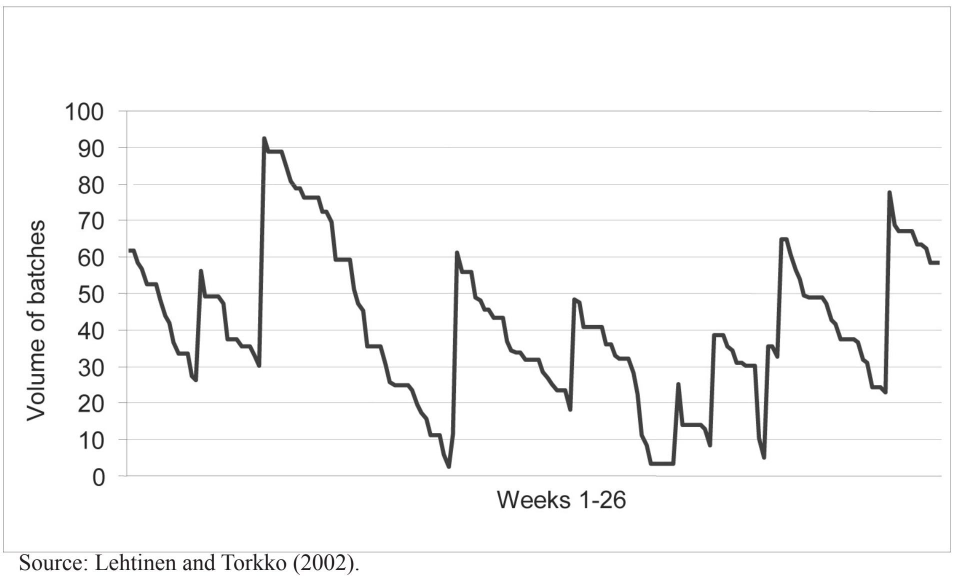
Implications

A follow-up interview was carried out in 2005. The president of the company indicated that applied lean tools provided important insights into the understanding of the problems within the production process. Based on a study carried out in 2001, the company started its own development project that aimed to improve stock turnover and production-planning system.

The mapping of the value stream, and especially the supply-chain response matrix, showed that the impact of manufacturing processes on the costs and value-added lead time is very small. The value-stream mapping analysis showed that there is a lot of waste, especially in surplus inventories. Since 2001 the company has paid more attention to inventories and developed a collaboration with material suppliers in order to increase stock turnover. The vendor-managed inventory system was put in practice with package materials suppliers.

The demand-amplification mapping indicated that smaller batch sizes would decrease the end-product inventory level and increase flexibility. Following the study, the company has redefined its production principles. The high-volume products (such as ketchup) are nowadays produced more frequently in leveled production runs. The company has also developed a visual and very simple production schedule system which helps to define production runs daily on the shop-floor level. Direct deliveries from the contract manufacturer to the stores have not increased as much as presumed in 2001. On the other hand, electronic ordering is more common today.

This case study of the Finnish food manufacturer shows that there is still a lot to do before the lean supply chain and partnership-based cooperation are achieved. Compared to lean-supply principles, the study showed no evidence of real partnerships.



Source: Lehtinen and Torkko (2002).

Figure 7. Ketchup Inventory Level Pattern between January and June, 2001.

On the other hand, both customers and the contract manufacturer have realized the importance of eliminating unnecessary inventories along the chain and shortening lead times. This puts new demands on the contract manufacturer—the delivery times will shrink from weeks to hours, and lot sizes will be reduced. The customers also expect the contract manufacturer to maintain the end-product inventories. These results highlight the changing role of subcontractors in the food industry in general. The contract manufacturer takes more responsibility for product development as well as for inventories and distribution, and thus creates more value for customers.

This study shows that the lean concept is appropriate for food companies. The lean production gives tools for a food company to analyze and eliminate unnecessary inventories and other forms of waste along the supply chain. By implementing lean production a food company can either increase customer value through cost reduction or through provision of additional value-enhanced services such as shorter lead times. In general, the analysis of the value stream for the main products is the first step toward leanness. The value-stream analysis supports the possibilities for cost reduction and often stimulates companies to work on further development projects.

References

Dolan, K. A. and R. Meredith. 2001. "Cover Story." *Forbes* April 30, 106.

Ellram, L. M. 1995. "Partnering Pitfalls and Success Factors." *International Journal of Purchasing and Materials Management* 31:35–44.

Ellram, L. M. 1991. "A Managerial Guideline for the Development and Implementation of Purchasing Partnerships." *International Journal of Purchasing and Materials Management* 27:2–8.

Håkansson, P. 2000. *Beyond Private Label—The Strategic View on Distributor Own Brands.* Ph.D. dissertation, Stockholm School of Economics, Sweden.

Hines, P. 1994. *Creating World Class Suppliers*. Pitman Publishing.

Hines, P., M. Howeg, N. Piercy, and N. Rich. 2002. "From Production Toolkit to Strategic Value Creation—A Review of the Evolution of Contemporary Lean Thinking." In *Integrating Supply Chains and Internal Operations Through e-Business,* I. Sadler, D. Power, and G. P. Dapiran, eds. Proceedings of the 7th International Symposium on Logistics and the 2nd International Symposium on Operations Strategy. Melbourne, July 14–16. 199–206.

Hines, P., R. Lamming, D. Jones, P. Cousins, and N. Rich. 2000. *Value Stream Management. Strategy and Excellence in the Supply Chain.* Harlow: Pearson Education Limited.

Hines, P. and D. Taylor. 2000. *Going Lean: A Guide to Implementation.* Lean Enterprise Research Centre, Cardiff Business School, The Lean Processing Programme.

Lamming, R. 1993. *Beyond Partnership. Strategies for Innovation and Lean Supply.* Hemel Hempstead: Prentice Hall.

Lehtinen, U. 2001. *Changing Subcontracting. A Study on the Evolution of Supply Chains and Subcontractors.* Acta University. http://herkules.oulu.fi/isbn9514265459/ [Accessed June, 30, 2005].

Lehtinen, U. and M. Torkko. 2002 "A Contract Manufacturer Goes Lean: How to Analyze and Develop Value Streams." In *Paradoxes in Food Chains and Networks*. Proceedings of the Fifth International Conference on Chain and Network Management in Agribusiness and the Food Industry. J. H. Trienekes and S. W. F. Ohma, eds. The Netherlands: Wageningen Academic Publishers. 859–869.

Macbeth, D. K. and N. Ferguson. 1994. *Partnership Sourcing. An Integrated Supply Chain Management Approach.* Pitman Publishing.

Monden, Y. 1983. *Toyota Production System.* Atlanta: Industrial Engineering and Management Press.

Private Label Manufactures Association. 2005. *Private Label Today.* http://www.plmainternational.com/ [Accessed April, 15, 2005].

Schonberger, R. J. 1982. *Japanese Manufacturing Techniques: Nine Hidden Lessons in Simplicity.* New York: The Free Press.

Shingo, S. 1988. *Non-Stock Production: The Shingo System for Continuous Improvement.* Cambridge, MA: Productivity Press.

Shingo, S. 1985. *Revolution in Manufacturing: SMED*. Cambridge, MA: Productivity Press.

Shingo, S. 1981. *Study of the Toyota Production Systems.* Tokyo: Japan Management Association.

Webster, M. and R. Beach. 1999. "Linking Operations Networks that Include Subcontractors to Contemporary Manufacturing Paradigms." In *Managing Operations Networks,* E. Bartezzaghi, R. Filippini, G. Spina, and A. Vinelli, eds. EUROMA, Venice, June 7–8. 345–352.

Womack, J. P. and D. T. Jones. 1996. *Lean Thinking. Banish Waste and Create Wealth in Your Corporation.* New York: Simon & Schuster.

Womack, J. P. and D. T. Jones. 1994. "From Lean Production to the Lean Enterprise." *Harvard Business Review* 72(1):93–104.

Womack, P. J., D. T. Jones, and D. Roos. 1990. *The Machine that Changed the Word—The Story of Lean Production.* Harper Perennial.