CHAPTER 1

INTRODUCTION

This chapter provides the research background broadly related to lean manufacturing and lean supply chain. The organization of the remainder of the thesis is also described.

1.1 Research Background

This section on research background briefly describes the following: supply chain system, supply chain integration, lean manufacturing principles, lean manufacturing tools and classification, lean manufacturing implementation in supply chain, an integrated approach of lean manufacturing: a perspective of lean supply chain, lean supply chain performance, and productivity gains using lean tools.

1.1.1 Supply chain system

A supply chain system shown in Fig. 1.1 efficiently integrates suppliers, manufacturers, wholesalers, retailers and customers so that goods are produced and distributed at the right quantities to the right locations and at right times, in order to minimize the total system cost while satisfying the service level requirements (Wang and Sarker, 2006). The supply chain cooperation is as follows (Kelle and Akbulut, 2005): For the buyers, the main advantages include reduced manufacturing and labor costs, improved quality, supply assurance, reduced inventories, and frequent deliveries in small lots. For the suppliers, the disadvantages are the risk of losing confidential information, increased communication and coordination costs. The partnership calls for frequent deliveries in small quantities that require delivery flexibility on supplier. The joint optimal shipment policy will always result in savings in the total system cost for the supply chain. Existing literature focuses mainly on internal efficiency performance like cost reduction, quality, design, administrative efficiency, and productivity (Wu, 2003).

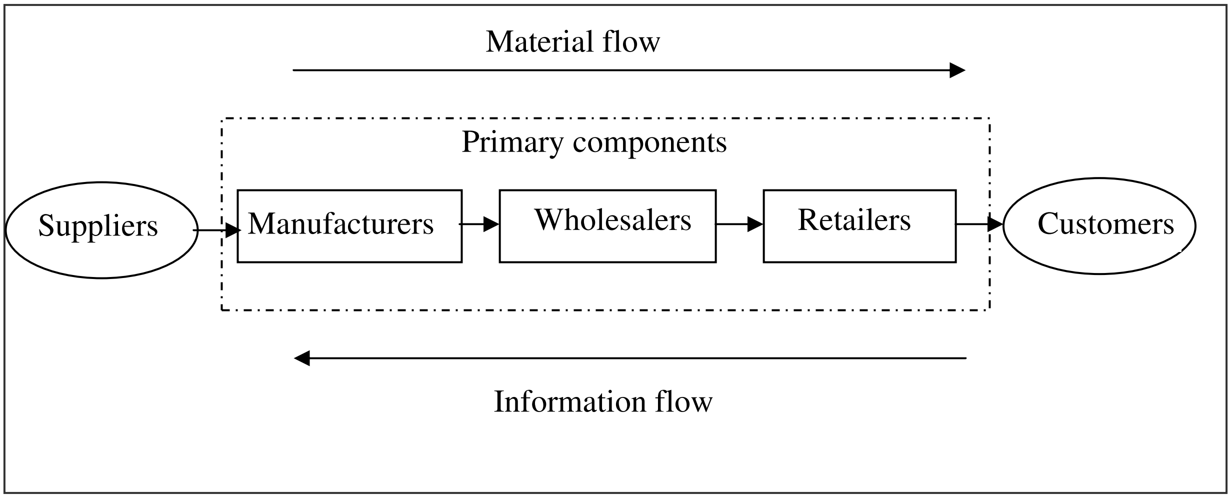

Fig. 1.1 Supply chain system

1.1.2 Supply chain integration

Business paradigm has recently changed tremendously towards business integrations or collaborations (Lee, W., 2005). Supply chain integration is a major factor in improving performance. Mitra and Singhal (2008) summarized the relevant literature and emphasized the need for supply chain integration due to higher levels of product variety, global marketplaces, shorter product life cycles, and the demand for better customer service. Suppliers have a large and direct impact on the cost, quality, technology and time-to-market of new products and effective integration of suppliers into the value chain is an important factor for customers to remain competitive (Humphreys et al., 2007). Individual businesses work together as an integrated supply chain focusing on meeting the demands of the end user or final customer of the supply chain. The goal of an integrated supply chain is to remove all boundaries to ease the flow of material, cash, resources and information. With the integrated supply chain both the information and material flows will be simplified, streamlined and optimised reducing waste and lead times (Naylor et al., 1999). In a critical review of survey-based research in supply chain integration, Vaart and Donk (2008) emphasize for focusing research on supply chain integration within individual buyer–supplier relationships and examine the impact of the relationship on performance. They provided the framework for analyzing the relationship between supply chain integration and performance taking into account attitudes, patterns, practices and interrelationships. Bagchi and Skjoett-Larsen (2005) highlighted both upstream and downstream integration of the chain. Voeth and Herbst (2006) stated that value in the supply chain is created sequentially through a series of stages: (i) developing and producing a product, and (ii) pricing and selling a product. It therefore seems that coordinating the supply chain should involve issues relating to the coordination of information, goods and pricing.

1.1.3 Lean manufacturing principles

A wealth of literature has been written regarding the impact of lean manufacturing and lean supply chain. The performance benefits of the lean systems are often remarkable, greatly improving quality, cost, and delivery. Most applications have been to high volume, and relatively standardized products. Lander and Liket (2007) illustrated that it is possible to adapt the lean tools and use them in different environments. However, it is not the use of a particular tool, but a deep principle-based understanding of lean concepts combined with a structured method for improving and learning, which will sustain the lean journey in the future.

There are five basic concepts that define lean thinking and enable lean production: specify value, identify the value stream, flow, pull, and perfection (Womack and Jones, 1996). Obviously, lean thinking emphasizes quality and value for each product from the perspective of the end-customer. Lean manufacturing, pioneered by Toyota, involves inventory and quality control, industrial relations, labor management, and supplier-manufacturer practices that differ fundamentally from traditional business practices (Wu, 2003).

Lean principles emphasize on integration rather than on individual performance (Oliver et al., 2007). Focusing on improving manufacturing, Womack and Jones (1996) summarised the approach into five key lean principles, namely:

1. Specify value. The value is defined from the end customer’s perspective in terms of specific product/service capabilities, price and availability.
2. Identify the value stream. The core set of actions required to produce a product.
3. Make the value flow. The method of aligning the value creating activities to facilitate the material and information flow continuously through the system
4. Let the customer pull. The customer should begin to ‘pull’ product on an ‘as needed’ basis.

5. Pursue perfection. Continual improvement of processes in pursuit of perfection.

The principles of lean manufacturing are summarized as (Åhlström, 1996): Elimination of waste, Continuous improvement, Zero defects, JIT, Pull instead of push, Multifunctional teams, Decentralized responsibilities/integrated functions, Horizontal and vertical information systems. The goal of lean manufacturing is to reduce waste in human effort, inventory, time to market and manufacturing space to become highly responsive to customer demand while producing quality products in the most efficient and economical manner. This approach centres around the elimination of waste. Waste may be found hidden in policies, procedures, process and product designs, and in operations. Waste consumes resources but does not add any value to the product (Seth and Gupta, 2005).

1.1.4 Lean manufacturing tools and classification

Lean manufacturing is a collection of principles, rules, tools, and techniques and their application in a production system is an aspect of implementation, it cannot be restricted to a set of projects (Houshmand and Jamshidnezhad, 2006). Lean manufacturing has emerged relatively recently as an approach that integrates different tools to focus on the elimination of waste and produce products that meet customer expectations (Sullivan et al., 2002). Lean manufacturing uses tools such as kaizen, one-piece flow, cellular manufacturing, synchronous manufacturing, inventory management, pokayoke, standardized work, workplace organization and scrap reduction to reduce manufacturing waste (Russell and Taylor 1999). Lean manufacturing tools proposed by Pavnaskar et al., (2003) is structured around seven levels: system, object, operation, activity, resource, characteristic and application. The research and application scope increases many times as these tools can be applied individually or in combination depending upon the requirements of value streams in different areas such as manufacturing or supply-chain management (Seth and Gupta, 2005).

Lean manufacturing classification scheme suggested by Hines and Rich (1997) is as follows: process activity mapping, supply-chain response matrix, production variety funnel, quality filter mapping, demand amplification mapping, decision point analysis and physical structure mapping. Lamming et al. (2000) suggested a classification scheme of supply networks using lean concepts. Childerhouse et al. (2002) contributed regarding the analysis of the factors affecting real-world value stream performance.

1.1.5 Lean manufacturing implementation in supply chain

Lean manufacturing has been increasingly adopted as a potential solution for many organizations (Sullivan et al., 2002). Economic benefits attributable to lean manufacturing include reduced lead-time and higher throughput, smaller floor space requirements, and lower work-in process. Lean manufacturing performs well on efficiency, quality, and speed and pays more attention to customer product preferences through increased flexibility and employee needs through higher involvement management practices (Bowen and Youngdahl, 1998). Lean manufacturers believe that successful supplier relationships must occur over a long time period (Comm, 2000). Lean manufacturers have a very open and honest business relationship with suppliers and customers. Lean manufacturers send their personnel to assist both suppliers and customers in problem-solving exercises (Sohal and Egglestone, 1994).

Lean manufacturing avoids the requirement for robustness by calling for the demand to be stable through the use of market knowledge and information, and forward planning. Lean manufacturing by its very nature tends to reduce demand variation by simplifying, optimising and streamlining the supply chain. However, if the end-user demand is beyond the control of the supply chain it will not be possible to implement lean manufacturing at the interface with the end-user (Naylor et al., 1999). In order to react quickly to changes in volume demand and product mix on the manufacturing system level, two requirements have to be satisfied (Cochran et al., 2000): (i) marketing and sales functions are integrated with manufacturing functions by organizational structure to ensure a close communication and fast reconciliation about a feasible manufacturing strategy, (ii) manufacturing system is designed to accommodate the required volume and product flexibility. Naylor et al., (1999) analyzed strategies to adopt lean manufacturing that requires a level schedule based upon the total supply chain strategy, by considering market knowledge and positioning of the decoupling point. The nature of the end-user or market sector as a whole will have a direct impact upon lean paradigm for any supply chain or part of a supply chain. Kathawala and Wilgen (2005) identified the factors that influence the implementation of build-to-order supply chain.

1.1.6 An integrated approach to lean supply chain

Lean supply chain minimizes inventory throughout the chain. A more realistic view of a lean supply chain would be to aim at a minimum reasonable inventory where any further attempts to decrease stocks would not be worthwhile.

In order to create a successful lean supply chain, suppliers must adopt lean manufacturing and its continuous improvement philosophy and must achieve flexibility and cost reduction (Vonderembse et al., 2006). Lean supply chain integrates manufacturing, purchasing, quality and suppliers. The supplier attributes in lean supply chain involve low cost and high quality. Lean supply chain may participate in as partnerships and joint ventures at the operating level. A lean supply chain comprises of a set of well coordinated processes operating in the best ways. The relationships between suppliers and customers are crucial to achieve lean supply chain. Lean supply chain emphasizes that suppliers have to play a strategic role (Reichhart and Holweg, 2007).

Supplier input could be helpful in various stages of supply chain. Supplier involvement in the product development can diminish quality costs, development time and cost, and manufacturing costs. McIvor (2001) focused on lean supply – supplier involvement in joint buyer-supplier cost reduction. The lean supply arrangement should provide a flow of goods, services and technology from supplier to customer without waste (Lamming, 1996). Customers and suppliers share cost data to minimize costs in supply chain (Munday, 1992): (i) customers require suppliers to share component cost information as a part of process improvement and cost reduction, (ii) customers and suppliers share cost information for identifying opportunities for cost improvements, and (iii) customers and suppliers require all the costs associated with the acquisition, use and maintenance of a good or service throughout the entire supply chain. Gunasekaran and Kobu (2007) provided key performance measures and metrics in supply chain and logistics operations. Consideration of key performance measures and metrics is recommended while measuring the performance of supplier development.

A lean supply chain employs continuous improvement efforts that focus on eliminating waste or non-value steps along the chain to achieve internal manufacturing efficiencies and setup time reduction, which enable the economic production of small quantities and enhance cost reduction, profitability, and manufacturing flexibility. Lean supply chain focus on reducing lead-time, increasing efficiency, expanding manufacturing flexibility, and cutting cost. In lean supply chain, lead-time is shortened as long as it does not increase cost. Lean supply chain support setup time reduction to enable the economic production of small quantities in order to keep low inventory costs, achieve manufacturing cost reductions, and enable manufacturing operations to quickly change products, which provides a degree of responsiveness to customer needs. The use of an integrated supply chain is essential if elimination of waste is to be achieved. The elimination of all non-value adding processes will inevitably reduce the cost of the product. This indicates that reducing cost is the way in which a supply chain employing lean manufacturing operates (Naylor et al., 1999).

1.1.7 Lean supply chain performance

Reichhart and Holweg (2007) argue that the slow adoption of lean thinking in distribution is due to an inherent conflict between lean manufacturing techniques (related to production smoothing and kanban systems that cannot cope with high levels of variability) and the need to link the production pull signal to variable demand in the marketplace. They refer to the use of demand or market segmentation techniques to leverage the stability provided by some customer groups or products in order to enable cost-efficient and responsive production of the overall portfolio. Lean supply chain serves only the current market segments and demand can be accurately forecasted. Lean supply chain works on confirmed orders and reliable forecasts. Koh and Gunasekaran (2006) developed a quantitative method of three levels to assess the impact of supply chain uncertainty on customer delivery performance. Their results indicate that higher likelihood of occurrences of supply chain uncertainty do not necessarily result in greater impact on the downstream delivery performance.

1.1.8 Productivity gains using lean tools

Bicheno et al., (2001) started a LEAP (Lean processing programme) to manage a supply chain as an integrated method for considerable productivity gains and also to form a systematic approach to waste removal along the chain (Womack and Jones, 1996). The LEAP project involved a value stream network from steel mill to the departure of components to the automotive assembly plants. They have summarized the erratic performance of supply chains due to the following causes: demand distortion, batching, process instability within the supply chain, and steel mill delivery performance. Batching decisions were identified as a major source for distortion of the information flow. The factors that lead to a reduction in batch size are: (i) underestimation of inventory costs and (ii) reducing time variation at changeovers through standardization of operations. Also in a lean philosophy, the batch sizes should always be as small as possible so that changeover costs need not be part of any batch calculation.

1.2 Organization of Chapters

- In the chapter 2 on literature review, the research scope, research objectives, research methodology, research propositions and managerial implications are discussed related to the following: (a) analysis for coordination, pricing, order quantity and investment decisions in supply chains, (b) analysis of integrated JIT inventory model for a buyer and a vendor, (c) analysis of lot sizing, number of inspections, investments for setup cost reduction and quality improvement in deteriorating production processes, (d) analysis of optimal batch size and in a single-stage and optimal number of kanbans in a multi-stage JIT production system with rework of defective items, (e) analysis of lean manufacturing tools for productivity improvement.
- In the chapter 3 on 'pricing, investment and order quantity decisions in collaboration between a manufacturer and a retailer', various models of intra and inter-coordination between manufacturer and retailer for pricing, order quantity and investments are discussed with regard to the net profit.
- In the chapter 4 on 'JIT integrated inventory model for a buyer and a vendor considering the impact of quality improvement, setup cost and lead time reductions', models of integrated inventory for a buyer and vendor for quality improvement, setup cost reduction and lead time reduction are considered. Also various options of investment in quality improvement for a buyer and a vendor are explained.
- In the chapter 5 on 'optimal cycle length and number of inspections in a deteriorating production processes with investment on setup cost reduction and quality improvement', models for setup cost reduction and quality improvement are considered to determine the optimal production run length and number of inspections. For the deteriorating

production processes, cost reduction using time-varying lot sizes approach over common cycle approach is explained using various examples.

- In the chapter 6 on 'optimal batch size in a single-stage imperfect production system with inspection errors and optimal number of kanbans in a multi-stage JIT production-delivery system with rework consideration', models for determination of optimal batch size in a imperfect production system as a result of inspection errors are explained including the process inspection and restoration aspects. Model formulation for optimal batch size is provided for a single-stage production-delivery system with rework. Also a model for optimal number of kanbans is developed for a multi-stage production-delivery system with rework controlled by kanban mechanism.
- In the chapter 7 on 'analysis of lean manufacturing tools in lean supply chain', lean manufacturing tools used in supply chain performance are defined and analyzed based on the data related to the use of lean manufacturing tools in industries.
- Finally, the conclusions based on the research methodologies described in the thesis and possible extensions of the work done in the thesis are provided in the chapter 8 on 'conclusions and scope for future work'.