CHAPTER 8

CONCLUSIONS AND SCOPE FOR FUTURE WORK

This chapter provides conclusions based on the results obtained for the areas of study focused in the thesis. The possible extensions of the analytical models developed in this thesis are presented in scope for future work.

8.1 Conclusions

This section provides the conclusions of the study related to the following: (i) Collaboration between manufacturer and retailer for setting a maximum-profit price, (ii) An integrated inventory optimal policy considering quality improvement, setup cost reduction and lead time reduction, (iii) Determination of optimal cycle length and optimal number of inspections using time-varying lot sizes approach in an imperfect production processes considering quality improvement and setup cost reduction, (iv) Determination of the optimal raw material ordering quantity, finished product batch size and number of kanbans (for a multi-stage production system) for production – delivery situations considering process inspection, restoration and rework, and (v) Identification of essential lean tools for the productivity gains

Lean supply chain (LSC) enable the economic production of small quantities that allows manufacturers to keep low inventory costs, achieve manufacturing cost reductions, and meet customer demands (Vonderembse et al., 2006). The research findings have indicated need for a lean supply chain system using integrated analysis and design of lean manufacturing system principles.

The conclusions of present work are described on the following areas:

8.1.1 Collaboration between manufacturer and retailer for setting a maximum-profit price

Collaboration between manufacturer and retailer for setting a maximum-profit price and improved demand potential is recommended. Collaboration of manufacturer and retailer for investment and price determination is most desirable from the manufacturer-retailer perspective, since there are no costs of coordination between the operations department. Also collaboration of manufacturer and retailer for price determination only is most desirable from the customer's perspective, since it produces the lowest retail price. Inter-organizational coordination for only price determination is desirable. Inter-organizational coordination to minimize inventory-related costs might not be worth pursuing, particularly when one considers the difficulties and organizational costs of coordination. Collaborative pricing is especially recommendable for long-established relationships.

8.1.2 An integrated inventory optimal policy considering quality improvement, setup cost reduction and lead time reduction

A joint integrated approach results in lower total cost as compared with decentralized approaches. The proportion of defective products increases with increased production lot sizes. Quality considerations can lead to significant reduction in production lot sizes. Quality improvement can lead to a large reduction in production lot sizes while constraints on the quality improvement yield a higher total relevant cost. Since in a JIT environment a major thrust is to continually reduce set-up costs, implementation of the integrated replenishment policy in conjunction with a set-up reduction program will result in smaller lot sizes. Suppliers should not only be delivering to retailer's just-in-time but also matching this delivery with JIT production.

Lead time is an important element in any inventory management system and lead time can be reduced by an additional crashing cost. An integrated inventory optimal policy considering quality improvement, setup cost reduction and lead time reduction that can result in significant economic benefits is recommended. The integrated inventory model with quality improvement, setup cost and lead time reduction, provides a lower total cost, lower order quantity and lower number of deliveries as compared with the model of Yang and Pan (2004). Success of just-in-time production is partly based on the belief that quality improvement, setup cost and lead time reduction can be achieved through various efforts.

8.1.3 Determination of optimal cycle length and optimal number of inspections using time-varying lot sizes approach in an imperfect production processes considering quality improvement and setup cost reduction

Optimization of investment on setup cost reduction in general results in (i) significant reduction in the optimal production run length, and (ii) marginal reduction in the average cost per unit time. Also optimizing the investment in quality improvement in general results in (i) reduction in the optimal number of inspections to unity, (ii) increase in the optimal production run length, and (iii) significant reduction in the average cost per unit time. Investment on setup cost reduction is recommended under the conditions of low restoration cost of the process from the out-of-control state to in-control state, small deterioration rate of the production process and low inspection cost. Investment in quality improvement is not recommended for small deterioration rate of the production process and low restoration cost of the process from the out-of-control state to in-control state. Investment in quality improvement is recommended under conditions of high deterioration rate, high restoration cost, and high inspection cost of the process, as it results in reduction in the number of inspections and increase in the optimal production run length. Under the scenario of investment in both setup cost reduction and quality improvement, investment in quality improvement but not in setup cost reduction is recommended under conditions of high deterioration rate and high restoration cost of the process. Similarly under this scenario of investment in both setup cost reduction and quality improvement, investment in setup cost reduction but not in quality improvement is recommended for low value of deterioration rate of the process and low value of restoration cost. Reduction in the optimal production run length means small lot size and improvement in the process quality are some of the prerequisites of just in time (JIT) production system.

Setup cost may be reduced by investing in reduced setup times resulting in smaller lot sizes and increased flexibility. The investment in setup cost reduction will result in small lot size, while the investment in quality improvement results in number of inspections undertaken to be unity during each production run. Inspection and restoration process incur lower costs and larger lot sizes because of reductions in quality control costs. The number of inspections with investment in setup cost reduction and quality improvement is reduced.

The numerical study shows reduction in the expected total cost with investment in both setup cost reduction and quality improvement for all the cases considered in this study viz., (i) imperfect process model under time varying approach, (ii) imperfect process model under common cycle approach, (iii) imperfect process model with inspection and restoration under time varying approach, and (iv) imperfect process model with inspection and restoration under common cycle approach. The numerical study also shows (i) reduction in the expected total cost of time-varying lot sizes approach over common cycle approach, (ii) reduction in the number of inspections with investment in setup cost reduction and quality improvement.

8.1.4 Determination of the optimal raw material ordering quantity, finished product batch size and number of kanbans (for a multi-stage production system) for production – delivery situations considering process inspection, restoration and rework

For the imperfect production process including inspection and restoration of the process increases the ordering quantity and expected total cost for single purchase multiple delivery (SPMD), single purchase single delivery (SPSD) and lot-for-lot (LFL) policies. This is due to the reduction in the expected number of non-conforming items produced with process inspection and restoration. And the optimal number of inspections increases with increase in the optimal batch size and ordering quantity for SPMD, SPSD and LFL policies.

The use of the kanban in process improvement includes improving the operations in the production processes with emphasis on reducing inventory costs. With rework of defective items in the same cycle, the optimal quantity and total cost increase with defects to compensate for the loss of planned products. Rework process plays an important role in eliminating waste and effectively controlling the cost of manufacturing. In both the models where defective items are reworked within the same cycle, the optimal quantity and total cost increase with defects to compensate for the loss of planned products.

8.1.5 Lean tools for the supply chain performance

The fourteen essential lean tools in the performance of the lean supply chain were identified by providing insight into organizations designing lean supply chains. The major lean tools associated with the performance of supply chain along with their percentage usage were analyzed.

The study presented in this work show that lean manufacturing is undeniably a method for increasing productivity. The study reaffirmed that adopting a lean supply chain in any manufacturing organization is significant in increasing the productivity gains. Six major lean tools emerged from this work are listed in the order of importance as follows: kaizen, 5S, JIT, VSM, kanban and six sigma. The commitment to lean manufacturing by industries at the supply chain level coupled with the employee involvement is required to realize the benefits of lean.

8.2 Scope for Future Work

Further research will be required to propose a generalized model for a lean supply chain strategy comprised of: (a) product flow, customer demand, information flow, and customer/supplier linkages, and (b) three subsystems (Houshmand and Jamshidnezhad, 2006): (i) Manufacturing conversion and service operations, (ii) Sourcing and suppliers management, and (iii) Logistics and distribution management.

The scope of future work is on the following areas:

(i) The optimal pricing, investment and order quantity decisions between a manufacturer and retailer can be determined taking into consideration of (a) random demand that is influenced by price and non-price factors, (b) profit sharing among manufacturer and retailer. An extensive sensitivity analysis of the supply chain models for manufacturer and retailer (Fig. 3.1) can be conducted based on the design of experiments (Montgomery, 2000) to study the effect of carrying all the parameters A, e, γ and λ simultaneously.

(ii) The JIT inventory analysis considering the setup cost reduction, quality improvement and lead time reduction is needed (a) in a supply chain involving multiple tiers of vendors and (b) in a supply chain where a vendor manufactures products for a multiple buyers.

(iii) The optimal production run length and inspection schedules in a deteriorating production process with investment in setup cost reduction and quality improvement can be extended to the case when the elapsed time until shift is randomly distributed. The analysis of optimal cycle length and number of inspections with process inspection and restoration considering the setup cost reduction and quality improvement for deteriorating production processes can be extended to study the economic lot scheduling problem (ELSP).

(iv) Optimal batch size in a single-stage production system with inspection errors and rework consideration can be extended to multiple products. Optimal number of kanbans in a multi-stage JIT production-delivery system with rework consideration can be extended to study the system supplied with products from several suppliers or products delivered to several buyers (converging-diverging supply chain system).

(v) Integration of lean supply chain models can be extended by taking into the joint effect of six sigma and VSM as the other major lean tools in improving supply chain performance along with JIT and kanban. The analysis of lean manufacturing tools in supply chain performance for productivity gains can be extended to a specific study only on the industries manufacturing the automotive components.