Chapter 5

Summary of the Thesis and Future Research Directions

5.1 Summary

In this dissertation, some supply chain models have been developed for various circumstances under different environments (crisp, fuzzy, rough).

In the *first model* (Model 3.1), a two level supply chain for a deteriorating item is developed with stock and promotional cost dependent demand under shortages. This model is discussed in crisp as well as imprecise environments (fuzzy, rough).

In the *second model* (Model 3.2), seasonal deteriorating item is considered for two level supply chain. The demand for this model is influenced by time, price and promotional cost. Time horizon is considered as finite.

In the *third model* (Model 3.3), a supply chain model is developed where the production rate as well as the demand are fuzzy in nature. Inflation is taken into account for this model. Promotional cost sharing between the parties of the chain is considered here. A heuristic approach multi-choice ABC algorithm is used to solve the model.

In the *fourth model* (Model 4.1), some corrections are done in Tsao's [184] and Huang et al's [78] investigations. In addition, two level trade credit policy is introduced. Also, uncertain resource in the form of budget is considered.

In the *fifth model* (Model 4.2), a multi-item supply chain with single level trade credit and two level price discount is considered. Demand of the items is influenced by the promotional effort and as well as amount of cash discount offered by the retailer to the customers. The proposed model is discussed in crisp and fuzzy environment and the existence of the optimal solution is established for the crisp model.

In the *sixth model* (Model 4.3), a two warehouse multi-item supply chain with stock dependent promotional demand is developed. In this model, items are ordered jointly using basic period policy. Demand of the items depends on displayed inventory levels, selling prices as well as the frequencies of the advertisements. Total cost due to the reduced selling prices and the advertisements is considered as the promotional cost and this cost is shared by the parties of the chain to increase individual profits as well as channel profit.

In the *seventh model* (Model 4.4), a multi-item multi-level supply chain with partial trade credit policy at each level under inflationary effect for a fixed planning horizon is developed and analysed. Demand of the items are influenced by the partial credit period given to the customers, time and the respective selling prices.

Innovations in the research works of this dissertation can be summarized as follows:

- A supply chain model for deteriorating items has been developed with stock and promotional cost dependent demand.

- The joint effect of time, price and promotional cost on demand is considered in a model of a seasonal deteriorating item.

- The planning horizon is taken as finite/infinite.

- A supply chain model with fuzzy production rate and demand is considered.

- Trade credit policy is considered in different levels (single level, two level, multi-level).

- Price discount policy is considered in different levels (single level, two level).

- Two warehouse model is developed.

- Inflation is considered in some models, where the demand is price sensitive.

- The effectiveness of promotional cost sharing is established.

- Fuzzy/rough objectives are directly optimized without transferring into its crisp equivalent using credibility/trust measure of fuzzy/rough events in a soft computing technique.

- An efficient Multi-choice Artificial Bee Colony (MCABC) algorithm is developed to solve the non-linear optimization problems.

- Also a heuristic search approach, Mixed-mode Multi-choice Artificial Bee Colony (MMCABC) algorithm is developed to solve mixed integer optimization problems.

5.2 Future research directions

Following modifications can be made in the proposed models for future extensions:

1. The Model 3.1 can be extended to three or multi-level supply chain, including trade credit policy (one or more levels), price discount policy, variable deterioration etc. Here, instead of continuous release pattern, bulk release system also can be considered between OW and RW.

2. The limitations of the Model 3.2 are that (i) it is an EOQ model, (ii) there is no lead time and (iii) demand of a seasonal product is taken as parabolic. In some cases, it is seen that the demand of a seasonal product increases with time initially, after that it sometimes stabilizes for a short period and then decreases. It is more or less like a trapezoidal type. Future researchers may try to remove these limitations.

3. The Models 3.3, 4.1 and 4.2 can be extended to multi-level credit period policy/price discount policy under multi-level promotional cost sharing in crisp and imprecise environments.

4. In Model 4.3, future researchers may propose another type of demand so that the business strategy may be improved. Also, three or higher level supply chain model can be developed under retailer's two-warehouse facility incorporating trade credit policy, inflation etc.

5. In Model 4.4, four or higher level supply chain models can be developed with partial trade credit policy at each level under inflation.

6. In this dissertation, some improved ABC algorithms have been developed and presented. Further improvements in the ABC algorithm can be done in future.