CHAPTER 9

CONCLUSION AND SCOPE FOR FUTURE RESEARCH

9.1 CONCLUSION

Four multi-period fixed charge models of practical significance are addressed in this thesis. They are:

Model – 1: Multi-period fixed charge distribution problem ‘MPFCDP’ associated with backorder and inventories.

Model – 2: Multi-period fixed charge distribution problem ‘MPFCDP’ associated with subcontract and inventories.

Model – 3: Multi-period fixed charge production-distribution problem ‘MPFCPDP’ associated with backorder and inventories.

Model – 4: Multi-period fixed charge production-distribution problem ‘MPFCPDP’ associated with subcontract and inventories.

The mathematical models for all the four multi-period fixed charge problems are formulated as PINLP and 0-1 MILP models. Multi-period fixed charge problems with suppliers’ inventory and customers’ inventory and backorder/subcontract consideration are much more difficult to solve due to the presence of fixed costs, which cause discontinuities in the objective function and are known to be NP-hard.
In recent years, Simulated Annealing Algorithm ‘SAA’ and Genetic Algorithm ‘GA’ have been increasingly applied to various search and optimization problems and has emerged as potential techniques to provide solutions with acceptable accuracy for NP-hard problems. In the light of the above consideration, this thesis proposed simple EVC heuristic, SAA based heuristic and GA based heuristic to solve the four multi-period fixed charge models to minimize the total cost.

The proposed SAA/GA based heuristics is structured to solve the multi-period fixed charge problems in two stages. Stage-I accepts the data of multi-period problem as input and transforms them as a single period data set in order to explore the solution space through SAA/GA based heuristic search. Stage-II is the application of SAA/GA that evolves the best distribution schedule to the equivalent single-period fixed charge problems.

Moreover, a typical coding system has been formulated in the proposed SAA/GA based heuristic. The string/chromosome is the permutation of cell numbers of a distribution matrix, in which each cell known as gene is identified with a unique number that assume discrete allocation values pertaining to the problem's solution. In addition, the string/chromosome has been structured as two parts. First part is framed by the cell numbers of prompt deliveries of the distribution matrix and the second part is framed by the remaining cell numbers (late/advanced deliveries) of the distribution matrix. The perturbation/evolutionary changes are made separately in the two parts of the string/chromosome.

The performance of the proposed EVC, SAA and GA heuristics for all the four multi-period fixed charge models are evaluated by comparing it with the lower bound and LINGO solution.
The comparison reveals the following:

- LINGO is capable of solving only small size test problems and the solver time grows exponentially with the problem size and hence it is not suitable to solve large size real world problems.

- EVC heuristic is able to solve all test problems in quicker time but it provides only approximate solutions that are inferior to optimal solution.

- EVC heuristic can also provide the lower bound value of the problem.

- SAA and GA heuristics generate better solutions than the EVC heuristic and are capable of providing solutions equal to optimal solution of the problem and hence it is suitable to solve large size real world problems, if implemented well.

Therefore, it is concluded that the proposed SAA and GA heuristics are effective tools for solving multi-period fixed charge problem instances.

### 9.2 SCOPE FOR FUTURE RESEARCH

This research may be extended for further research in the following directions/environments:

- The proposed heuristics (SAA and GA) are coded in Turbo C++ programming language using some simple array concepts and functions so as handle all the test problems given in this thesis. The same logic of the SAA and GA can be applied as it is to solve the real world problems by reconstructing the program code by using sophisticated program tools such as data structures, pointers and other
memory related functions. This programming expertise will reduce the performance gap between the test problems and real world problems.

- This research work concentrates on single-stage multi-period fixed charge models. The single period formulation to the proposed multi-period fixed charge problems facilitates its scope for extending this to multi-stage supply chain problems. The single period model conversion with its coding structure in the proposed SAA/GA can be integrated with the methodology proposed by Jawahar and Balaji (2009) for the two-stage supply chain transportation problem associated with a fixed charge.

- In this research, the fixed charge is considered only in transportation. In the future research, the fixed charge consideration may be extended to production (setup cost) as fixed charge production and fixed charge distribution.

- In this research, the inventory carrying capacity of the suppliers and customers, supply capacity of subcontractor and backorder limitation of customers are assumed as infinite. In the future work, these may be kept as finite.

- In all the four multi-period fixed charge models, only a fixed charge is considered. In the future research, in addition to the fixed charges, resource losses may be included. The losses may be evaporation losses when the commodity is a liquid, or deterioration losses in distribution networks involving perishable commodities such as, for example, food items.

- Another future research direction would be to extend to solve the multi-period fixed charge models for multi-objective criteria such as delivery period, production planning etc.
In addition to the above mentioned directions, research can be extended in the application of search heuristics as follows:

- The main governing parameters of GAs convergence are pop_size and n_gen (termination criteria). The n_gen is fixed based on the problem size. But pop_size is fixed approximately (pop_size=10). The solution convergence could be further improved when pop_size is fixed like n_gen.

- The proposed approaches can be applied to large scale problems, and if implemented well, often produces good results compared to traditional methods.

- As a future research, other meta-heuristics such as Tabu search, Ant colony optimization and Particle swarm optimization may be attempted in the same direction.

- The agility and robustness of the algorithms may be improved by fine-tuning of the parameters, applying other possible initial allocation strategies and changing the coding scheme of the string/chromosome.