CHAPTER VIII

CONCLUSION AND FUTURE RESEARCH

This dissertation studies inventory routing problem with multiple item multiple depot system. The goal of solving this problem is to determine replenishment quantity of all items at each outlet and to schedule delivery route to serve these replenishment quantities during finite planning horizon. In this dissertation, three heuristic algorithms are developed to solve considered problem. The performance of proposed algorithm is compared with solution obtained from exact solution technique for small-sized problem and compared with the solution from Lot-for-Lot policy for medium-sized and large-sized problem.

In this chapter, conclusion is stated in the first section. Then, discussion of this research is presented. Finally, future research is discussed in the last section.

8.1 Conclusion

In this research, a multi-item multi-depot inventory routing problem is considered. This problem includes inventory holding cost, vehicle fixed-charge, and routing costs in the objective function. Three algorithms are developed to handle this problem. These methods are applied to problem with a fleet of identical vehicle that have limited carrying capacity. Another capacity is the storage capacity at outlet store. The restriction of this problem is all demand at outlet must be satisfied throughout planning horizon.

This dissertation contributes to both academic and business aspect. The first contribution of this study is that the vehicle fixed-charge cost with a certain number of vehicles is added to the traditional inventory routing problem. Moreover, the multi-item multi-depot system is the extension of the original inventory routing problem also.

The second contribution is that three heuristic algorithms are developed to solve the multi-item multi-depot inventory routing problem. These algorithms show reduction on total cost compared to Lot-for-Lot policy and yield a near-optimal solution within acceptable computational time.

The final contribution is the proposed model and solution approaches can be implicated in distribution system to manage supply chain inventory control and transportation planning. This dissertation studies the effect of many parameters on solution quality in order to be applicable to different situation of distribution system.

In Chapter I, this dissertation introduces the multi-item multi-depot inventory routing problem. In addition, the general background and motivation of the problem are described. Yet another, the research questions and research contributions are presented. Finally the methodology and expected outcome are provided.

In Chapter II, this research conducts a literature review. In that chapter, various inventory routing problems are presented according to following elements: number of depot, number of item, nature of demand, associating cost, vehicle characteristics, depots and outlet network, main decision, objective function and planning horizon. That chapter also reviews the solution approach which all of them are heuristic algorithm, because of the complexity of the inventory routing problem.

In Chapter III, the detailed description and assumption of problem are outlined. That chapter presents the characteristics and main decision of the problem and its mathematical model representation. Furthermore, the example of problem is shown to clarify the model. The associating cost and objective of the problem which is to determine replenishment quantity and delivery schedule with minimal total inventory routing cost are described in the chapter.

Chapter IV introduces heuristic solution concepts for solving the single item single depot inventory routing problem, the simplified version of multi-item multi-depot inventory routing problem. This chapter is provided for understanding of the reader for the problem and solution approach for MMDIRP. The chapter presents problem description of the single item single depot inventory routing problem. After that, the description of heuristic is presented. Finally, the heuristic procedures are described step-by-step in last section. The computational experiment is conducted to evaluate the performances of proposed heuristic.

Chapter V introduces a heuristic solution for solving the multi-item multi-depot inventory routing problem. The chapter presents the extension and modification of the heuristic proposed in chapter IV to solve the problem in multi-item multi-depot setting. After that, the description of heuristic is presented. Finally, the heuristic procedures are described step-by-step in last section. The computational experiment is conducted to evaluate the performances of proposed heuristic. The results show that the proposed heuristic can not perform well due to some characteristics.

Chapter VI introduces the modified version of heuristic proposed in chapter V. The weakness of the heuristic proposed in chapter V is presented and the improvement concept is developed to avoid the case that the solution can not be improved from Lot-For-Lot solution. After that, the modified of heuristic is presented. The computational experiment is conducted to evaluate the performances of proposed heuristics and it shows the better improvement from Lot-For-Lot solution.

Chapter VII introduces another heuristic for MMDIRP. The heuristic add some process from the heuristic proposed in chapter VI by considering additional group of item-outlets which are in the same vehicle. The computational results show the better improvement.

The results show that SIOH heuristic returns the worst solution among the three proposed heuristics and consumes more computational than other algorithms. Heuristic AIOOH and AIOVH are good algorithms for this problem because they can achieve the better solution with less solving time than SIOH. The results also show that proposed heuristics can obtain a good improvement from Lot-For-Lot policy even in large-sized problem up to 200 item-outlets and 5 periods of planning horizon. The comparison of performance of three proposed heuristics is shown in Figure 8.1 and Figure 8.2. The research summary of this dissertation is depicted in Figure 8.3.

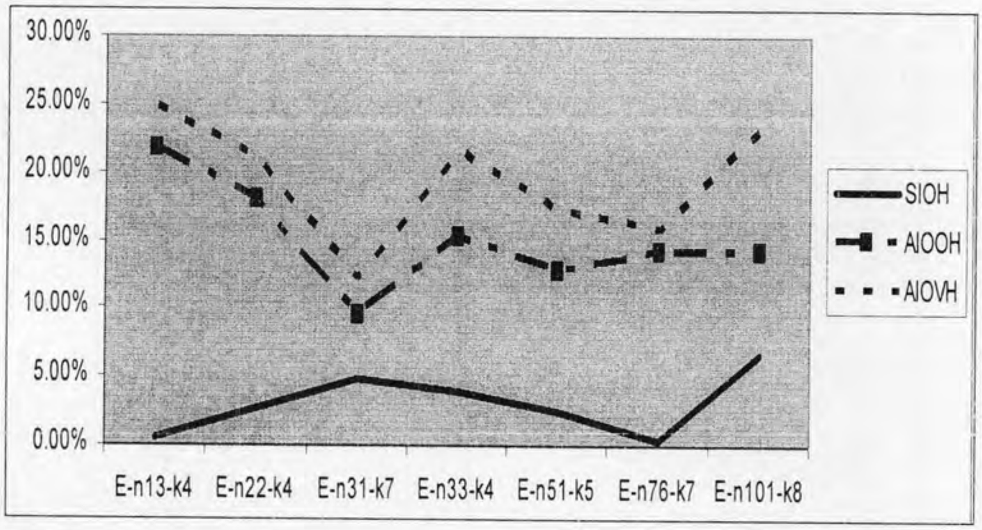

Figure 8.1 Comparison of solution quality between three algorithms

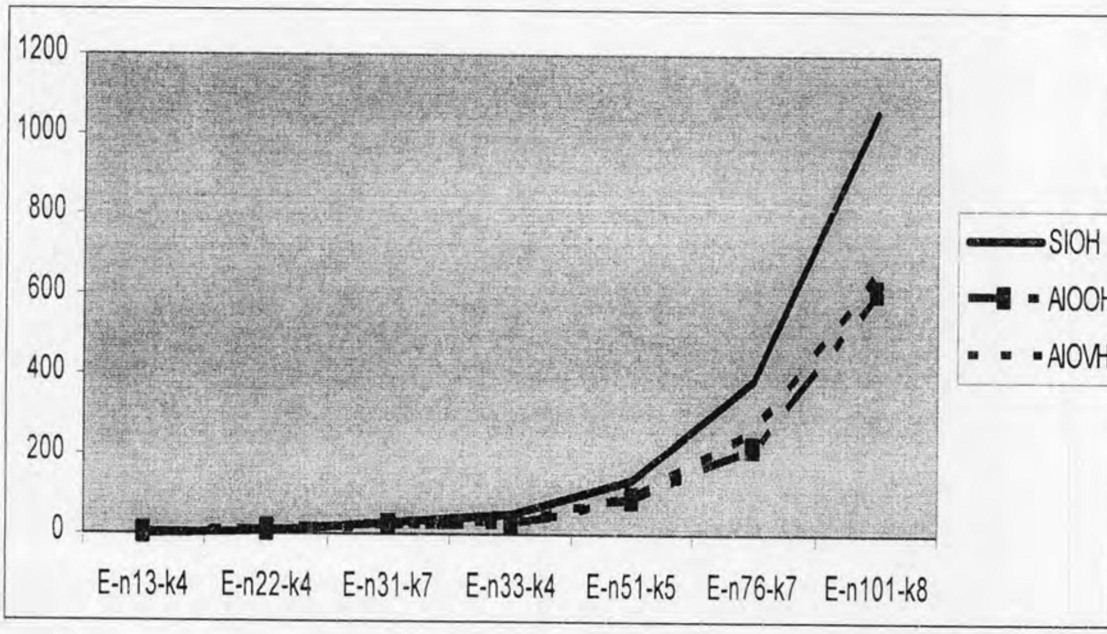

Figure 8.2 Comparison of computational time between three algorithms

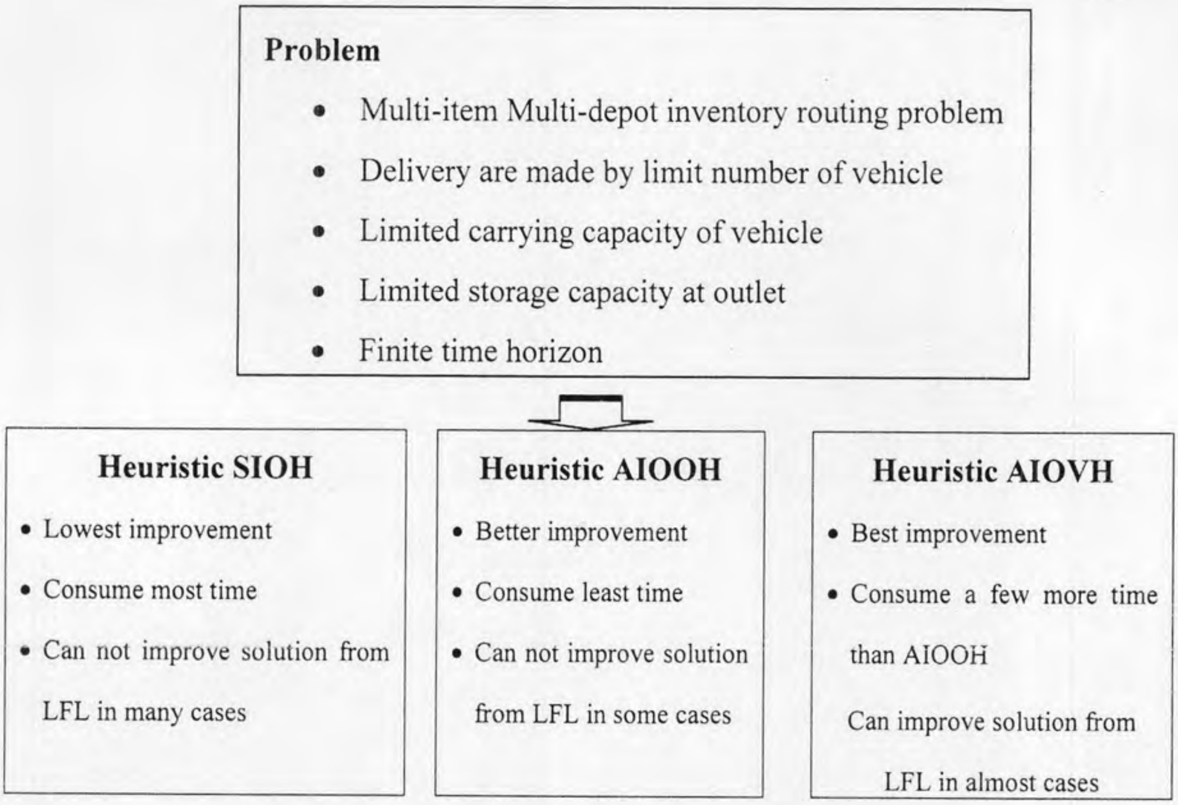

Figure 8.3 Summary of all heuristics

8.2 Discussion

To provide insight into the limitation of this research, the strengths and weaknesses of this are presented.

8.2.1 Strengths

Firstly, this dissertation formulates a mathematical model to represent the problem of the integrated inventory control and transportation planning of multi-item multi-depot system. The model can be used for finding exact solution of the problem and used as a bench mark for heuristic algorithm.

Secondly, for the increasing of problem size which the mathematical model can not handle to solve the problem in acceptable time, this research proposes three heuristics to solve the problem. However there are only two heuristics that can solve the problem efficiently; the AIOOH and AIOVH. The first one, AIOOH, uses the idea of combining a set of item-outlet and considers the replenishment period and quantity of them as consider of a single item-outlet. This consideration on the group of item-outlet does not mean all items in the outlet will be combined together and will be replenished together in the same time but only the group of some items in the same outlet which are route in the same vehicle that will be replenished in the same time. Hence the heuristic AIOOH does not consider all items as a single item but considers the group of some items in the same outlet which are route in the same vehicle as a single item. It means that the multi-item still be considered as multi-item but there are some of them are considered as a single item during the procedure of the heuristic. For solving performance, the AIOOH shows much better performance than the SIOH both in solution quality and in computational time. Thank to the concept of combining a group of item-outlets and considered them as a single item-outlet to gain the saving on route cost. The second heuristic, AIOVH, is the improved version of the AIOOH. It considers more than the group of item-outlets which are in the same outlet and in the same route. It adds the consideration on all item-outlets in a route. As a result, its performance is quite better than AIOOH with some more computational effort.

Finally, the performance testing of the proposed heuristics is made by modifying standard library in all computational experiments. The use of this library can ensure the quality of solution among various system structures to analyze the heuristic efficiency. As a result, the result of computational experiments is convincible.

8.2.2 Weaknesses

Firstly, the test problems of this dissertation are modified from the standard library so there is a chance that it could not work with the real situation in some problem characteristic. However, the performance tests are made by various ranges of parameters which make the performance of algorithm for solving the standard problem more reliable. This ensures that the proposed heuristics can be used for most cases of the problem in the real world situation. Therefore the special characteristic of the problem is still the research question that may be studied in the further research.

Secondly, the problem studied in this dissertation is limited on the deterministic setting. In order to solve the real world problem it must concern about this assumption of the problem. However, the proposed heuristic can be used to solve the real world problem by estimating parameters in case that demand and other parameters can be predicted and the uncertainty of parameters do not take much effect to the solution such as the case that demand range is very tight.

Finally, the replenishment quantity from the heuristic do not allow the split delivery of an item-outlet among routes or periods so the solution can be sub optimal in some cases. The model and cases which allow this splitting policy are interesting for further research.

8.3 Future research

This dissertation has developed solution approaches for multi-item multi-depot inventory routing problem. The results of computational experiments can lead to various aspects for further research, and the guideline of data generating can be used for performance testing of the other models. On the other hand, there can be many perspectives to extent this work.

Firstly, the further research may develop some exact solution techniques to solve this problem iteratively; for instance, Branch-and-Price technique can be used to determine the delivery route instead proposed heuristic. Besides, the mathematical model can be formulated in other ways such as collection of routes in spite of decision variable of link between nodes.

Secondly, the research can be extended to stochastic setting which is more realistic to the business environment. Nonetheless, it can result in a huge computational time or more complexity of the problem. Another extension of the parameter setting can be the robustness of model under various situations of demand and parameters.

Thirdly, the proposed heuristics can be developed by using more sophisticated algorithm to establish the delivery route. This can achieve a better solution of delivery route and more accuracy of estimating the ordering cost for determining replenishment quantity phase. Additionally, the algorithms can be faster by using the estimation method to settle on routing cost in phase of examining replenishment quantity by the shortest path algorithm. The approximation of routing cost will be used to find ordering cost with less computational time.

Next, the mechanism of finding replenishment quantity can be enhanced by allowing the demand of outlet to be split over the period. This approach may develop the solution in case that the vehicle capacity is very tight and the split demand can bring about the better routing cost. In addition, it may reduce the usage of vehicle in some cases which means reducing the fix-charged cost also.

Finally, for more development on solution, the meta-heuristic or multi-start local search can explore the solution space more completely and can avoid the local optimum solution. Nevertheless, the computational time may be increased by the increasing of search space.