CHAPTER 7

CONCLUSION

Reverse logistics, as a part of effective supply chain management, provides a useful context of analyzing models for network design and the proper management of product returns. Producers need to design their reverse logistics network tailored to both their business needs and cost savings. The value to be recovered from returned products was estimated to be in excess of $50 billion in the United States alone (Guide and Van Wassemhove 2003). Nevertheless, reverse logistics involving returned products was not considered a company’s core “value-creating” business. To reverse this mindset and better comply with tougher environmental standards, three models were developed in this thesis that can help the firm not only salvage the value of used products, but also control the costs of collecting, transshipping, handling and process returned products for reuse and recycling.

Initially a model based on spatial consolidation was developed for solving CRAB-SP with the use of a decomposed methodology in which location, allocation and routing decisions were considered in a sequential manner. Since the actual information of the problem may be lost during transition phase of the decomposed methodology, the same CRAB-SP was solved by developing a model based on combined location, allocation and routing decisions with the use of an integrated methodology. Since the availability of single product is very rare in real RL environment, this model based on the combined location, allocation and routing decisions was extended to a multi-product RL problem (CRAB-MP) environment, and was solved with the use of the integrated methodology. The proposed models for solving the CRAB-SP and the CRAB-MP were validated in a real-world setting in India. Through a series of model experiments and sensitivity
analyses, the proposed models were proven to be useful for gaining insights into the reverse logistics operations involving recyclable bottles.

The current study goes beyond earlier RL studies by tackling the combined location-routing problem under capacity restrictions and avoiding the workload disparities among CRCs through balanced allocation, and taking into account the multiple-product varieties with the incentive-based product collection system.

The major outcomes of this thesis are:

- In particular, the balanced allocation of the workload among CRCs can help the firm reduce the need for backorders, extra storage spaces, labor idle time, and rush shipments.
- The proposed clustering approach helps to determine quickly the desirable locations of the ICPs.
- The results of the sensitivity analysis revealed that both balanced allocation and clustering had a significant impact on total reverse logistics costs.
- It was discovered that the varying degrees of returned product quality influenced total costs.
- The usage of randomized inspection of returned product quality levels incorporates real RL scenario.
- The integrated methodology outperforms the decomposed methodology in terms of solution quality and exposes the real characteristics of combined LRP model in the RL context.
7.1 FUTURE DIRECTIONS

Despite the consideration of many realities and complexities, the proposed model points to a number of other avenues for future work. This section addresses the scope of future work in three separate aspects such as reverse logistics, location routing problem and combined LRP in RL context.

7.1.1 Future Scope in Reverse Logistics

It has been found that even though the closed loop models received more attention in the current trend, some stages may have been omitted in most of the articles. In order to obtain a real RL scenario for industrial application, all the stages that actually happen in real life environment have to be considered.

Future research in RL should be in terms of demand or supply of return products with due consideration for the uncertainty effect. As already mentioned in section 3.2.2, the success of an efficient reverse networks is “highly dependent on ensuring sufficient volumes of input materials”. The uncertainty regarding the number of returned products creates complications when it comes to scheduling the different processes and planning efficiently the transportation required. More research has to be carried out to study the effect of uncertainty on RL network design and to use the stochastic demand for implementing it in a real life scenario.

Another direction of research in RL could be to assume the time horizon for demand and other parameters in multiple periods. This will reflect the periodic changes in the characteristics of the RL network that will result in a dynamic RL environment.
The most important area of research in RL is the management of the product collection process. Many companies hesitate to implement RL concept due to the complication involved in the returned product collection process by their own effort. Outsourcing the collection activities by 3PL is the best option for companies to get into a new business, a new market, or a reverse logistics program without interrupting forward flows which in addition reduces logistics costs. Similarly, an incentive based product collection system would be the best method to enhance the efficiency of the product collection process. Hence more research has to be conducted to find the impact of the 3PL and incentive on the RL network design and also to find the ways for effectively implementing it in a real scenario.

In future, the focus of research in RL could be to consider other objectives rather than cost minimization such as profit or revenue maximization, maximization of customer responsiveness, and minimization of environmental impact. While analyzing the impact of the objective type on RL network, it has been found that pure cost minimization objective was less effective in reducing the volume of environmentally harmful waste. In order to obtain an efficient RL network, more research has to be done that considers the impact of single or multiple objectives on the RL network design.

7.1.2 Future Scope in Location Routing Problem

It was found that the use of a sequential method leads to worse solutions than a combined method that has been focused in a very few cases of LRP.

The simultaneous treatment of location, allocation and routing decisions ultimately reveal the real characteristics of any research problem even though it has more computational complexity. Hence more efficient heuristic or meta-heuristic algorithms may be developed to reduce the
computational complexity involved in the simultaneous treatment of location, allocation and routing as well as to produce the solutions in a very quick manner.

7.1.3 Future Scope on Combined Location Routing Problem in the Reverse Logistics Context

As the concept of an integrated logistics systems is today’s managerial focus, an integrated location-routing approach may help the firm in developing more efficient logistics networks. The availability of less standardized and more complicated reverse channel in RL networks distinguishes the important role of LRP in the RL context as compared to FL networks. Hence more research has to be conducted on LRP in the RL context to gain better insights into its implementation.

Location-routing-inventory is the next level of problem which combines location, allocation, routing and inventory decisions and has to be focused in the RL context to obtain the real RL network characteristics.

Since the integrated location-allocation-routing model with many realistic aspects would be very challenging to solve, the effective clustering procedure has to be found and may be used as a way to ease the computational complexity which has received little attention in the RL context. Also the nature of the reverse channel makes it clear that clustering is more suitable for RL networks than FL networks.

The establishment of the initial collection points for returned product collection is the most important decision that is to be considered in the RL network design. In order to take an appropriate decision on this establishment, balanced allocation may be used in RL networks which may project under utilized ICPs and will check for the availability. Hence more
research is to be conducted on BAP in the RL context to find the utilization rate of the ICPs.

Very few attempts have been made on the incorporation of incentive payments based on product quality levels in RL networks. More analysis has to be conducted on this area with the inclusion of the customer willingness factor, and the product collection rate in order to obtain a real RL scenario.

The proposed models can be extended to include other variants such as in-transit inventory carrying costs during transfers, consolidation costs at the CRC, the random nature of the returned product volume, dynamic pricing incentives, and a possibility of direct shipment from ICP to PC.

The model formulation can be refined to consider time-sensitive parameters such as cost inflation in the multi-period framework.