CHAPTER 1.

Summary of work, future scope and recommendations

This industry-responses dominated work was set-out to provide a decision support framework to the industrial organizations involved in carrying out reverse logistics activities for managing product returns. In this concluding chapter, we summarize the results obtained during the course of the study (described in chapters 3 and 4) in three logical steps, so as to meet key objectives defined in chapter 1, and also as to what extent the work bridges the present work addresses the research gaps identified in chapter 1 and literature surveyed in chapter 2.

1.1 Summary of the work

We list the stage wise major outcomes of the research process:

1.1.1 Establishment of the network components in reverse logistics activity through validation based on industry survey, and recommend network configurations for key industry-sectors engaged in reverse logistics of product returns.

The base of the work was a multi-sector industry feedback that aimed to identify typical network flows in the returns’ management in each of the studied sectors. The feedback also helped in identifying alternatives (regardless of the industry-sector) exercised by the industries for carrying out three principle activity stages of reverse logistics: Collection of returns, Scrutiny classification of returns, and finally, Processing the returns. Two alternatives-each exercised by the industries were identified, resulting in to a matrix of total 8 network configurations.

The industry-survey also involved identifying industry’s weighing of two business objectives for reverse logistics and returns’ processing, in general: Cost optimization, and Maintenance of customer relations.
These principle business objectives were then classified in to sub-objectives (industry-sector-dependent). Four sub-objectives were categorized under cost optimization objective: No. of recyclable components, costing for scrutiny/test, Transportation costs for scrap handling, and Establishment costs for processing facility.

Similarly, two sub-objectives were categorized under customer relations objective: Protection of product design secrecy, and maintaining interactions with customers.

Further, resultant objective-sub objective matrix was ranked for all eight possible network configurations, to synthesize them into a solution vector through AHP methodology. AHP Excel solver was used to establish the priorities from the industry-responses.

The AHP solver established different network configuration preferences for their reverse logistics activities, as shown in Table 5.1 below. In order to reach these recommendations, all pertinent considerations for each configurations were also described and tabulated. These preferences were also aligned with business objective of the organization for the reverse logistics activities for managing product returns.

<table>
<thead>
<tr>
<th>Industry sector</th>
<th>Network configurations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automobile manufacture (Industrial, Passenger, farm)</td>
<td>Produ. managed coll. (P), Central- location s &amp; c (C), and Original facility proc.(O)</td>
</tr>
<tr>
<td>Rubber and tire (Butyl, Granules, Liquid Latex)</td>
<td>Produ. managed coll. (P), Central- location s &amp; c (C), Seco. Fac. Proc. (S)</td>
</tr>
<tr>
<td>Apparel &amp; other on-line merchandize</td>
<td>TP Coll. (T), Central- location s &amp; c (C), and Original facility proc.(O)</td>
</tr>
<tr>
<td>Plastic (Polypropylene Terephthalate-PET, PVC, Low density Polyethylene-LDPE, Acrylonitrile butadiene styrene (ABS), Polypropylene)</td>
<td>TP Coll. (T), Central- location s &amp; c (C), Seco. Fac. Proc. (S)</td>
</tr>
<tr>
<td>DC Batteries</td>
<td>TP Coll. (T), De-Cent. Loc. S &amp; C (D), Original facility proc.(O)</td>
</tr>
<tr>
<td>Paper and packaging, Building material</td>
<td>TP Coll. (T), De-Cent. Loc. S &amp; C (D), Seco. Fac. Proc. (S)</td>
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</table>
This stage mapped conceptual framework with validation through sector-independent industrial data, whereby different network configurations could be associated with different industry sectors, as tabulated above.

1.1.2 Formulation of a real-life reverse logistics network for existing returns’ processing arrangement for the most representative industry-sector

In this stage, we partly adapted a MILP formulation that represented a comprehensive real life eight-entity reverse logistics framework for application in tire manufacturing reverse logistics. Importantly, the chosen industry-domain represents present-day’s need-of-the hour, environmental considerations in the geographical area in particular, which is facing severe air pollution problem.

In chapter 4, we described an existing seven stage reverse supply chain for the tire manufacturing organization based in Delhi NCR and Haryana geography in India. The network has different entities such as customer zones, collection centers, remanufacturing centers, disassembly centers, recycling centers that proposes to embed retreading facilities), primary markets, secondary markets and disposal centers. We partially adapted the formulation [183] to minimize the total cost of the multi-stage reverse supply chain for the tire manufacturing organization.

We went on to optimize this formulation considering actual return flows at different entities, costs of inter-entity transport and obtained figures for facility establishment and return processing costs in ₹.

1.1.3 Application and configuration-decision support for the selected real-life industry sector, through optimization of return flows, costs, and facility location decisions.

We used optimization software to yield optimization results for the exercise. The MILP formulation generic model that represented an eight-echelon reverse logistics network was then optimized using optimization solver Lingo, considering actual data of returns’ quantity between different echelons of the network and inter-facility distance for facilities at different locations, different cost components at each stage, and the actual locational data, for the chosen tire-manufacturing industry operating pan-India. We limited our scope of work to one manufacturing plant (out of total two) operating in geographical region of Delhi NCR and UP.
On the premise of the optimization exercise, we further strengthened this decision support model by considering the sensitivity to fluctuation (rise) in the demand (for increased number of returns to process). We demonstrated sensitivity of the optimization results for two additional scenarios: Rise in number of returns by 20% and 30%, respectively.

All in all, the work constructed and demonstrated a decision support mechanism for optimization of reverse logistics network, primarily in present Indian context, and replicable for different industry-sectors with similar scope and scene.

1.2 Future scope and recommendations

Network design is the most critical area of reverse logistics that is assuming greater importance and interest of industry and researchers day by day. The present study has significant theoretical and practical implications in terms of the profitability of efforts, processes, environmental obligations, and economy of returns. The problem is solved for a realistic situation and a comparison of the solution under three different instances is also done. The results show the importance of the proper modelling and analysis of network design decisions.

The optimum solution obtained in one case may not be optimal in another situation with a tweak in terms of modality and capacity. The changes in the forecasted values of product return are inevitable. Hence, it is recommended that the decision makers should analyze the problem environment and its possible changes before taking a decision regarding the network design. The proposed model is a general one and with the proper analysis of the results obtained, it helps to analyze the long-term operation of a reverse supply chain. It can aid managers in taking better decisions for the network design of a reverse supply chain.

The model could be further extended for investigations under various scenarios and new emerging domains, like food processing and pharmaceutical returns, where the economy-loss would be staggering.

In this study, we considered only a single product, single-period situation and it could be further extended by considering a multi-product, multi-period situation. The uncertainty in data can also be incorporated into the study as a future research.
Moreover, inconsistencies in terms of re-manufacturability and quality assurance for re-manufactured products, especially in to booming sector like passenger automobiles, can be addressed by seeking solution through more formal and quantifiable routing and re-marketing problem. Researchers can build on the methodology adopted in this work, with necessary customization. The economic advantage achieved could be large.

It is, however, imperative to note here that the reverse logistics product return management is perennially considered a NP-Hard problem, and stochastic nature of the returns could affect and vary the expected outcomes. Different mathematical methods have been tried and tested by researchers to aid the network design decision makers, but the solutions advocated have still remained limited shelf-life solutions, and have been prone to turning pseudo-optimal or even non-optimal solutions.

Researchers have been moderately successful in proposing amicable solutions on optimal design of reverse logistics network configurations for specific product-ranges. However, future researchers can base their work on findings of this multi-sector industry study, and take it on from there to bring finesse and refinement in solution for specific sector they study. Also, it would be apt to stretch the solution-umbrella to similar and related products in the same industry-sector.

While the efforts have been made to include active industry-sectors into the scope of the study, still, our work only makes use of a few industries to ascertain its robustness of solution. Future research could study more industries to verify and further improve on the framework.

Finally, environment abiding disposal means and optimization of transportation -especially for the tire-manufacturing industry-sector discussed in the study- could help achieving the green supply chain in right vein. Researchers can base their future work on the present study and extend to other similar product returns having high environment impact.