Chapter-4

Data Analysis
4. Data Analysis

4.1 Analysis of issues for various class of Automobile:

Once the responses are received, the scale reliability of the issues (i.e., the study variables) is tested through Cronbach’s Alpha value. It is found to be 0.724, which is well above the conventional reliability criterion of 0.7. The descriptive statistics of the 77 issues considered in this study are shown in Table 4.1 (shown in Appendix II). As the first step of data consolidation, the list of issues has been shortened by rejecting unimportant issues. One-sample t-test is applied to test whether the mean values of issues are significantly greater than or equal to 3 (Important issues) and also for mean values of issues significantly greater than or equal to 4 (Critical issues). A total of 47 issues are thus identified as Important issues and 13 as Critical issues for automobile companies in India (shown in Figure 4.1). Further, Important and Critical issues are subsequently classified as per the responses from different classes of automobile companies, namely; OEMs, Suppliers, HCVs, LCVs, Cars, Two-Wheelers.

(a). Critical issues as identified by the automobile sector in India (Overall Class):

The issues with average value being greater than or equal to 4 (Critical issues) are mentioned below.

Economic Issue:
- Technology/machine/capital cost

Governmental Policies:
- Take-back policies
- Land fill & incineration restrictions

Reverse Logistics:
- Reverse distribution network design
- Deciding buy-back price of the used product
- Uncertainty in quantity of return

Inventory Management:
• Balance of demand with return

*Prod. Planning & control:*

• Complex scheduling & capacity planning

*Design Issue:*

• Complexity in product design

*Marketing Issue:*

• Green image as marketing element
• Price of remanufactured product
• Identification of potential customers
• Relatively few customers in the market

The Critical issues are depicted in the figure 4.1 below marked with (#) notation along with the Important issues for overall class of automobile companies. The same pattern is followed for various classes of automobile companies.
Figure 4.1: Important issues controlling feasibility of automobile remanufacturing for overall class

**Governmental policies**
1. Take-back policies #
2. Landfill & Incineration restrictions #
3. Prevention & control of pollution
4. Restriction on use of hazardous substances

**Economic**
1. Technology/machine/capital cost #
2. Cost of reverse logistics
3. Disposal cost
4. Collection of used product/cores
5. Cost of product & process design

**Reverse Logistics**
1. Reverse distribution network design #
2. Deciding buy back price of the used product #
3. Uncertainty in quantity of return #
4. Uncertainty in quality of return
5. Complexity in planning for return flow
6. Uncertainty in time of return
7. Problem of locating the used products
8. Database management of customers
9. Collection centre location

**Inventory management**
1. Balance of demand with returns #
2. Push/pull strategies
3. Lot sizing problem
4. Uncertainty in demand
5. Serial number mismatch
6. Storage facility location
7. MRP based system
8. Problem in buffer stock maintenance

**Prod. planning & control**
1. Complex scheduling & capacity planning #
2. Mismatch between demand & supply
3. Technology for manufacturing
4. Uncertain demand rate
5. Homogeneity of product range
6. Lead time variability
7. Location of remanufacturing facility

**Design Issue**
1. Complexity in product design #
2. Design for remanufacturing
3. Homogeneity in product
4. Assembly/disassembly problem
5. Skill of employees
6. Serial number of specific parts

**Marketing Issue**
1. Price of remanufactured product #
2. Identification of potential customers #
3. Green image as marketing element #
4. Relatively few customers in the market #
5. OEMs perception about remanufacturing
6. Customer’s attitude towards remanufactured product
7. Remanufactured product promotion through offers
8. Trade barriers

# Issues found Critical for feasibility of automobile remanufacturing in India for overall class (mean, μ ≥ 4)

Figure 4.1: Important issues controlling feasibility of automobile remanufacturing for overall class
The analysis is further extended to the two different class of automobile sector i.e., OEM and the supplier to know their perception about automobile remanufacturing. Firstly, we applied t-statistics for OEM and found 56 significantly important issues with mean values being greater than or equal to 3 (Important issues). Further, the analysis is carried out for the issues with mean value being greater than equal to 4 (Critical issues). Besides that there are 14 issues which come under the Critical issues category. Thus, all the Important as well as Critical issues are sorted out under each of the seven issue categories and are depicted in Figure 4.2 for the class, OEM.

(b). Critical issues as identified by OEMs:

The issues with average value being greater than or equal to 4 (Critical issues) are mentioned below.

**Economic Issue:**
- Technology/machine/capital cost

**Governmental Policies:**
- Take-back policies
- Land fill & incineration restrictions

**Reverse Logistics:**
- Reverse distribution network design
- Uncertainty in quantity of return
- Uncertainty in quality of return
- Deciding buy-back price of the used product

**Inventory Management:**
- Balance of demand with returns

**Prod. Planning & control:**
- Complex scheduling & capacity planning

**Design Issue:**
- Complexity in product design
Marketing Issue:

- Price of remanufactured product
- Green image as marketing element
- Identification of potential customers
- Relatively few customers in the market

The Critical issues are depicted in the figure 4.2 below marked with (#) notation along with Important issues for the class, OEM.
# Issues found to be Critical for feasibility of automobile remanufacturing in India for OEM (mean, µ ≥ 4)

Figure 4.2: Important issues controlling feasibility of automobile remanufacturing for class, OEM
The analysis is further performed for supplier and the important issues are found out with mean value greater than or equal to 3 (Important issues) and for mean value being greater than equal to 4 (Critical issues). Firstly, we applied t-statistics for supplier and found 46 issues considered Important with mean values being greater than or equal to 3. Besides that, there are 13 issues which come under the Critical issues category. Thus, all the Important as well as Critical issues are sorted out under each of the seven categories and are depicted in Figure 4.3 for the class, Supplier.

(e). Critical issues as identified by automobile Suppliers:

The issues with average value being greater than or equal to 4 (Critical issues) are mentioned below.

*Economic Issue:*
  - Technology/machine/capital cost

*Governmental Policies:*
  - Take-back policies
  - Land fill & incineration restrictions

*Reverse Logistics:*
  - Reverse distribution network design
  - Deciding buy back price of the used product
  - Uncertainty in quantity of return

*Inventory Management:*
  - Balance of demand with returns

*Prod. Planning & control:*
  - Complex scheduling & capacity planning

*Design Issue:*
  - Complexity in product design

*Marketing Issue:*
  - Identification of potential customers
• Green image as marketing element
• Price of remanufactured product
• Relatively few customers in the market

The Critical issues are depicted in the Figure 4.3 below marked with (#) notation along with Important issues for the class, Supplier.
# Issues found Critical for feasibility of automobile remanufacturing in India for Supplier (mean, $\mu \geq 4$)

Figure 4.3: Important issues controlling feasibility of automobile remanufacturing for the class, supplier
The analysis is further extended to the various class of OEMs namely, Car, HCV, LCV, Two wheeler to know their perception about automobile remanufacturing. The descriptive statistics of all the class of automobile manufacturer are found out separately and t-statistics have been performed to find the issues most important for automobile remanufacturing with mean values of 3 and more.

(d). **Critical issues as identified by Car manufacturer:**

There are 60 important issues found out under Car manufacturer with mean value being greater than equal to 3 (Important issues). Further, the analysis is carried out for the issues with mean value greater than equal to 4 (Critical issues). There are 18 issues which come under the Critical issues category. Thus, all the Important as well as Critical issues are sorted out under each of the seven categories and are depicted in Table 4.4 for class of Car manufacturer.

The issues with average value being greater than or equal to 4 (Critical issues) are mentioned below.

**Economic Issue:**
- Technology/machine/capital cost
- Disposal cost

**Governmental Policies:**
- Take-back policies
- Prevention & control of pollution

**Reverse Logistics:**
- Reverse distribution network design
- Uncertainty in quantity of return
- Uncertainty in quality of return
- Deciding buy back price of the used product
- Problem of locating the used products
- Complexity in planning for return flow
Inventory Management:
- Balance of demand with returns
- Serial number mismatch

Prod. Planning & control:
- Complex scheduling & capacity planning

Design Issue:
- Complexity in product design

Marketing Issue:
- Price of remanufactured product
- Identification of potential customers
- Green image as marketing element
- Relatively few customers in the market

(e). HCV:

There are 69 important issues found out under HCV manufacturer with mean value being greater than equal to 3 (Important issues). Further, the analysis is carried out for the issues with mean value greater than equal to 4 (Critical issues). There are 26 issues which come under the Critical issues category. Thus, all the Important as well as Critical issues are sorted out under each of the seven categories and are depicted in Table 4.5 for class of HCV (Heavy commercial vehicle) manufacturer.

The issues with average value being greater than or equal to 4 (Critical issues) are mentioned below.

Economic Issue:
- Technology/machine/capital cost
- Cost of reverse logistics

Governmental Policies:
- Take-back policies
• Land fill & incineration restrictions

**Reverse Logistics:**
• Reverse distribution network design
• Deciding buy back price of the used product
• Uncertainty in quantity of return
• Uncertainty in quality of return

**Inventory Management:**
• Balance of demand with returns
• Push/pull strategies
• MRP based system
• Serial number mismatch

**Prod. Planning & control:**
• Mismatch between demand & supply
• Homogeneity of product range
• Complex scheduling & capacity planning

**Design Issue:**
• Complexity in product design
• Homogeneity in product
• Design for remanufacturing
• Skill of employees
• Assembly/disassembly problem

**Marketing Issue:**
• Price of remanufactured product
• Identification of potential customers
• Green image as marketing element
• Relatively few customers in the market
• Remanufactured product promotion through offers
• OEMs perception about remanufacturing
(f). LCV:

There are 60 important issues found out under LCV manufacturer with mean value being greater than equal to 3 (Important issues). Further, the analysis is carried out for the issues with mean value greater than equal to 4 (Critical issues). There are 35 issues which come under the Critical issues category. Thus, all the Important as well as Critical issues are sorted out under each of the seven categories and are depicted in Table 4.6 for class of LCV (Heavy commercial vehicle manufacturer).

The issues with average value being greater than or equal to 4 (Critical issues) are mentioned below.

**Economic Issue:**
- Technology/machine/capital cost
- Cost of reverse logistics
- Disposal cost
- Collection of used product/cores
- Cost of product & process design

**Governmental Policies:**
- Land fill & incineration restrictions
- Take-back policies
- Prevention & control of pollution

**Reverse Logistics:**
- Reverse distribution network design
- Uncertainty in quality of return
- Complexity in planning for return flow
- Uncertainty in time of return
- Uncertainty in quantity of return

**Inventory Management:**
- Serial number mismatch
• Uncertainty in demand
• Balance of demand with returns

Prod. Planning & control:
• Complex scheduling & capacity planning
• Mismatch between demand & supply
• Homogeneity of product range
• Disassembly sequence
• Lead time variability

Design Issue:
• Complexity in product design
• Corrosion/rust on used products
• Assembly/disassembly problem
• Skill of employees
• Homogeneity in product
• Design for remanufacturing

Marketing Issue:
• Green image as marketing element
• Price of remanufactured product
• Relatively few customers in the market
• Identification of potential customers
• Remanufactured product promotion through offers
• Existence of disorganized business sector
• OEMs perception about remanufacturing

(g). Two-wheeler:

There are 51 important issues found out under Two-wheeler manufacturer with mean value being greater than equal to 3 (Important issues). Further, the analysis is carried out for the issues with mean value greater than equal to 4 (Critical issues). There are 20
issues which come under the Critical issues category. Thus, all the Important as well as Critical issues are sorted out under each of the seven categories and are depicted in Table 4.7 for class of Two-wheeler manufacturer.

The issues with average value being greater than or equal to 4 (Critical issues) are mentioned below.

**Economic Issue:**
- Technology/machine/capital cost
- Disposal cost

**Governmental Policies:**
- Take-back policies
- Land fill & incineration restrictions

**Reverse Logistics:**
- Reverse distribution network design
- Uncertainty in quality of return
- Uncertainty in quantity of return
- Problem of locating the used products
- Complexity in planning for return flow
- Uncertainty in time of return
- Deciding buy back price of the used product

**Inventory Management:**
- Balance of demand with returns
- Uncertainty in demand

**Prod. Planning & control:**
- Complex scheduling & capacity planning
- Mismatch between demand & supply

**Design Issue:**
- Complexity in product design

**Marketing Issue:**
- Green image as marketing element
- Identification of potential customers
- Relatively few customers in the market
- Price of remanufactured product

<table>
<thead>
<tr>
<th>Class of Automobile companies</th>
<th>Important issues ($\mu \geq 3$)</th>
<th>Critical issues ($\mu \geq 4$)</th>
<th>Total issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over All</td>
<td>47</td>
<td>13</td>
<td>77</td>
</tr>
<tr>
<td>OEM</td>
<td>56</td>
<td>14</td>
<td>77</td>
</tr>
<tr>
<td>Supplier</td>
<td>46</td>
<td>13</td>
<td>77</td>
</tr>
<tr>
<td>Car</td>
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<td>18</td>
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</tr>
<tr>
<td>HCV</td>
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<td>26</td>
<td>77</td>
</tr>
<tr>
<td>LCV</td>
<td>60</td>
<td>35</td>
<td>77</td>
</tr>
<tr>
<td>Two-wheeler</td>
<td>51</td>
<td>20</td>
<td>77</td>
</tr>
</tbody>
</table>

4.2 Description of Critical Issues

The structure of the responses obtained from various classes of automobile manufacturers about remanufacturing are compiled and presented here category wise.

a). Economic Issue:

All the classes of automobile manufacturer considered that the technology/machine/capital cost is the most important issue while considering remanufacturing business. This may be due to the non-existence of remanufacturing business in India. They may have the common perception that the operations involved in remanufacturing specially the disassembly, inspection etc, may involve very high degree of technological investment. Due to this the OEM should have to take initiative to start with it. The second most important issue came out to be the disposal cost. Most of the OEM has the
perception that the government should impose cost for disposal of automotive waste. This indirectly compels the manufacturer as well as customer to think seriously about their used automotive waste and this may drive their insight towards remanufacturing. The third important issue considered by HCV and LCV manufacturer is the cost of reverse logistics. They might have the perception that managing reverse logistics is very crucial and one of the cost deciding issues due to uncertainty involved with the procurement of the used product/cores. So these issues are needed to be addressed on prime basis.

b). Governmental policies:

Among all the classes of automobile manufacturer take-back policies and land fill & incinerations issues are considered to be the most important. This may be due to the fact that in western countries it is the government who has taken initiative and implemented many rules and regulations related to land filling and environmental pollution. Due to this the automotive companies are compelled and initiated remanufacturing business in many sectors especially in automotive which is quite successful. The second most important issue was found to be prevention & control of pollution which is again one of the regulations imposed by the government. Overall, we can say that the government should come forward and take initiative to start the remanufacturing business.

c). Reverse logistics:

The issues, namely, reverse distribution network design, uncertainty in quantity of return, deciding the buy-back price of the used product are found to be the most important under this category. These are considered important by all the classes of automobile manufacturers. The prime reason behind this may be the uncertainty involved in procurement of the used parts. The forecasting of the raw material i.e., used part as well as the finished product is not certain in remanufactured product. This is totally the contrast situation of forward supply chain where the quantity of the end product is known with precision. Besides that, the price related issues are also considered to be important which depend upon the quality of the cores/used product and some marketing issues. The second most important issues found are complexity in planning for return flow and uncertainty in
the quality of return which is totally dependent on the uncertainty involved in the return flow. The third important issues are uncertainty in time of return and problem of locating the used products. As the data base of the customers are not easily available so it’s very difficult to locate the customer for getting used product. In this situation the OEM should take the initiative as they could easily manage to locate the genuine customers from their sales record.

d). Inventory management:

On overall classes of automobile manufacturer the issue which found most important is the Balance of demand with returns. This may be due to the uncertainty involved in forecasting the used as well as demand for a new product. In forward supply chain, where the demand is certain, the forecasting can be done with accuracy. But, in this case the demand of product is very uncertain as well as the rate of procurement of used product and the quality of cores is much undecided. So, accordingly it’s very difficult to establish the synchronization between demand and supply. The second most important issue are uncertainty in demand and serial number mismatch. Some OEM considered that the serial number mismatch is the important issue. This may be due to the reason that after disassembly of the used product it’s very tedious to maintain the track of the components as per their specification. Further, the worn out components are not in proper condition to be kept tracked off, according to their design and measurement. So, overall these issues make inventory management of used product very difficult.

e). Prod. Planning & control:

The issue which is the most important for overall classes of automobile manufacturer is complex scheduling & capacity planning. The allocation of capacity is very uncertain in remanufacturing operation. This is because the rate of cores arrival as well as the demand of remanufactured product is very uncertain. Accordingly, the lead time and processing time gets affected. The general MRP system is not applicable here rather some reverse MRP should be designed for this system. The second most important issues found are mismatch between demand & supply and homogeneity of product range. The first issue
arises due to the uncertainty involved in the process while the second issue arises due to the uneven wearing out of the product. This may complicate the process by creating difficulties in disassembly, sorting, cleaning and testing of the product. Overall these issues are needed to be addressed on a priority basis before initiating remanufacturing.

f). Design Issue:

The issue which are prime important under this category is the complexity in product design. The reason behind this is the fact that during disassembly operation most of the product gets damaged which is of great hindrance to this operation. So, the design of the product should be such that it can be assembled/disassemble for multiple life usages. In this regard, research institutes like, Centre for Sustainable Design, UK, have taken initiative to come up with such an innovative design. They have addressed this issue under design for remanufacturing where they deal specifically with design of the product. Under this, they focus mainly on the type of material to be used, type of fastener applied, tolerances and specification issues. The second important issues found are homogeneity in product, design for remanufacturing, assembly/disassembly problem and skill of employees. Some OEM consider that skills of employees is also very crucial this may be due to that they think that it require some specific set of technical skills for performing remanufacturing operation.

g). Marketing Issue:

The issues which are most important among this category are price of remanufactured product, identification of potential customer and green image as marketing element for overall classes of automobile manufacturer. The prime reason behind these may be that there are not enough customers in the market for remanufactured product. Beside that it’s also a very crucial issue that what should be the price of the remanufactured product so that more number of customers will purchase it. Obviously, it should be lesser than the new product but how it will be decided is another big challenge. Moreover, it should be promoted through some offers or discounts. In addition to this some environmental related issues are needed to be highlighted and could be used as the marketing advertisement so that environmental conscious customers will get attracted to it.
Remanufactured product promotion through offers and relatively few customers in the market are the two second most important issues. As the companies are skeptical about the selling of remanufactured product the OEM should take initiative for initiating remanufacturing business.

4.3 Identification of probable business units who can initiate automobile remanufacturing in India:

From the above analysis it has been observed, as per the perception of automobile manufacturer the main challenge starts with the procurement of raw material (used product). This is due to the uncertainty involved in their arrival rate. The extent of uncertainty gets enhanced further by the association of uncertainty in quality, quantity and arrival timing of used product. Thus, this is a very important and cost deciding issue in remanufacturing business. The automobile manufacturer must have to decide whether to manage reverse logistics operation in-house or outsource to the third party logistics provider. The other important issue is very high degree of technological investment is required to set up remanufacturing facility. So the OEM should come forward to take initiative as they already have their manufacturing facility set up in existence. The capacity related issues are also very important in manufacturing environment. But in case of remanufacturing the capacity planning is very difficult and critical as the forecast of end product is not certain. Accordingly the traditional MRP system becomes redundant in this case. So the OEM has to decide economically to outsource remanufacturing activities partially or fully to the third party remanufacturer. The product design is one of the very important issues which are basically controlled by OEM in manufacturing setting. In case of remanufacturing, product design becomes more crucial as the product is used for multiple lives. So ultimately, the OEM has to take initiative of setting up remanufacturing business as he has whole control over all sorts of design. Further, he can also make available the design of the product as well as technological skills to the existing supplier who can do remanufacturing. Potential customers for remanufactured product and green image as marketing element are also found to be very important. As the customers are not
much aware about remanufacturing, it’s very difficult to sell them the remanufactured product. Some sorts of discount or promotional advertisement highlighting green image of product should be performed to attract potential customers. Overall, there is always a risk of incurring the loss due to lack of customer base or may be the cannibalization of their original product. So this business should be initiated at the component level first and then should be done for full fledged product level production later on.

From the questionnaire (Appendix-I), literature and from the empirical investigation, five different business units are identified who can probably initiate automobile remanufacturing business in India. They are (i) Business Unit 1: OEMs who can remanufacture their own products, (ii) Business Unit 2: OEMs who may go for remanufacturing of spare parts, (iii) Business Unit 3: Suppliers who may remanufacture their spare parts, (iv) Business Unit 4: Third Party companies who may remanufacture the whole product, and (v) Business Unit 5: Third Party companies who may remanufacture spare parts.

<table>
<thead>
<tr>
<th>Notation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>OEMs who can remanufacture their own products</td>
</tr>
<tr>
<td>B2</td>
<td>OEMs who may go for remanufacturing of spare parts</td>
</tr>
<tr>
<td>B3</td>
<td>Suppliers who may remanufacture for spare parts</td>
</tr>
<tr>
<td>B4</td>
<td>Third party companies who may remanufacture the whole product</td>
</tr>
<tr>
<td>B5</td>
<td>Third party companies who may remanufacture spare parts</td>
</tr>
</tbody>
</table>

In India, automobile remanufacturing business is in a very nascent stage and mostly practiced as a disorganized business sector. As per the statistics (chapter-1), there are tremendous potential for the growth of remanufacturing business, especially in automobile sector in India. So we are further trying to find out the identification of most economical business unit who can take up the automobile remanufacturing business in India in near future. Hence, the investigation is further extended up for the identification of the probable business units who can initiate the automobile remanufacturing business. The issues
identified in this section will form the basis for the selection of most economical business unit who can start remanufacturing business in India. For this purpose it is proposed to apply Analytic Hierarchy Process (AHP) to assess the relative priorities among the business units. The detail analysis and application of AHP is discussed in the next Chapter.

4.4 Summary:

The above analysis lead to the identification of Important and Critical issues which should be addressed while going up for a feasibility analysis of automobile remanufacturing business in India. Further, it is also identified the different companies in India who can take up remanufacturing as a business proposition. In the next chapter, we further extend our analysis by ranking the 5 different business units on the level of difficulty of business operations while initiating remanufacturing business based on the 13 identified Critical issues.