2. Research Methodology

2.1 Research Approach

There are different ways to design a research problem and to carry out data collection for analyses and interpretation. In this chapter, the research objectives are described and to achieve the research objectives, a relevant research methodology supported by literature is developed.

Adoption of a scientific method is a means by which an insight into the unknown is sought through a cyclic process, and that should be approached in the following steps (Leady, 1997),

a) Simplifying the problem that defines the set goal.

b) Gathering Data, which is very important for analysis and to resolve a research problem.

c) Formulating the hypotheses for resolving the problem.

d) Empirically testing the hypotheses and checking whether the interpretation of them will resolve the question that has been initiated in the research.

2.2 The Data Sources

There are two types of data, one is primary and another is secondary (Cooper and Schindler, 1998). Primary data collection involves data used from surveys, experiments or direct observation. Primary data is the original data collected for the research purpose from certain clearly defined
respondents. Primary data is the original data collected specially for the purpose kept in mind. Primary data is unpublished data source and is more reliable, authentic and objective oriented (Bryman and Bell, 2003). Secondary data collection involves data from diverse source of documents or electronically stored information. Secondary data may be obtained from internal or external sources and in this research study, both sources of data collection are used.

2.3 The Data Collection Methods

Nature of Research may be quantitative or qualitative. Qualitative research is unstructured and exploratory in nature and is based on small samples intended to provide valuable insight to solve the problems (Malhotra et al., 1996, Creswell, 1997). Quantitative data is the collection of primary data of large population, which leads to accurate results (Martins et al, 1996). Firstly Primary data required for this research is of qualitative nature and on that basis, the questionnaire has been designed. Qualitative research is then followed by quantitative research. Primary data can be collected through mail, telephonic interview and face to face interaction. In this research most of the questionnaire data has been collected via E-mail. Most of the Automotive Parts Remanufacturers Association (APRA) members from whom the data collected were from USA, UK and other countries. Very important live data collected through eBay website was analyzed and secondary data were also collected and analyzed in the form of valuable case studies.

2.3.1 Literature Review

Literature review was carried out during the initial stage of research to understand the present scenario of remanufacturing organizations and
customer behavior. Research objectives have been formulated after vigorous literature survey. Following main areas are included in the literature survey.

a) Industrial Ecology
b) Sustainable Development and Green Growth
c) Product Recovery Systems (PRS)
d) Remanufacturing Process & Benefits
e) Remanufacturing Product Development & Challenges
f) Product Life Cycle
g) Product Cannibalization
h) Closed Loop Supply Chains

The focus of this research work overall has been the product sustainable development and product cannibalization issue in the market. Experts' opinion from primary sources greatly influenced the direction for this work at each stage.

2.3.2 Case Studies

Remanufacturing is not a very active sector in India, hence it was always difficult to collect the primary data from experts. Some case studies on cartridge and automotive sectors have been studied and data analyzed for arriving at a concrete conclusion. Case studies prepared the necessary foundation for research objectives. In chapter, 5, case studies are explained from cartridge and automotive industries. These case studies are important to elaborate the importance of remanufacturing product for industries as
well as consumers. In these case studies, cost and profit of a remanufactured product as compared to a new product and lead-time savings to accelerate production rate has been explained in the context of product sustainable development.

2.3.3 Data Collected through Auction

Many sellers keep their products for online auction. There are plenty of sellers, selling the products through online auction. Among these online websites, eBay is an important website (tool) for collecting the detailed auctions data for remanufactured as well as its new counterpart product. The collected data is useful to calculate WTP and product cannibalization issue (Guide and Li, 2010). Data collected and its analyses have been explained in chapter 7.

2.3.4 Data through Survey Questionnaire and Interviews

Questionnaire is a powerful tool to collect the primary data from the respondents, who are experts involved in the area. Questionnaire is developed based on research objectives and hence all the items in the questionnaire are related to the set objectives. Detailed information about the questionnaire has been explained in chapter 7. Questionnaire responses were collected through online link and face-to-face interview of experts in the area of Remanufacturing. There are 26 closed ended questions included in questionnaire.

Most the respondents, who have responded to the questionnaire are from developed countries, because in India, remanufacturing is not an organized sector and only a few automotive and cartridge industries are involved in remanufacturing of their products. Few experts helped and responded to the questionnaire and gave important inputs during the interviews.
2.4 Hypotheses & Data Collection Methods

Table 2.1 shows the data sources primarily used to analyze each of the hypotheses. These eleven hypotheses have been analyzed using the case study approach, analyses of data obtained from the survey questionnaire and eBay online shopping. This methodology was adopted, as per the literature support and also by considering the limited nature of existing research studies in the area, so as to formulate a comprehensive Research Framework.

Table 2.1: Research Methodology and Hypotheses Supported

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Research Methodology Analysis</th>
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<tbody>
<tr>
<td>$H_{03}$</td>
<td>Case Study Approach</td>
</tr>
<tr>
<td>$H_{04}, H_{05}, H_{06}$</td>
<td>Questionnaire Data Collected through response of Remanufacturing Experts</td>
</tr>
<tr>
<td>$H_{07}, H_{08}$</td>
<td>Data collected through online shopping mall, providing free online auctions <a href="http://www.ebay.in">www.ebay.in</a></td>
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2.5 Research Framework

The Research Framework has been shown in fig. 2.1, the literature survey encompassing the concepts of product life cycle management and product cannibalization issues in the remanufacturing sector provided a strong foundation for formulating these Research hypotheses. All these
hypotheses are interlinked with each other and they form some of the relevant Research issues prevalent in contemporary manufacturing and market place.

Each of the Hypotheses are explained in detail below

**H01**: Profit Potential of the remanufactured product is the deciding factor whether or not to remanufacture a given EOL product.

There are several factors based on which companies take the decision about producing the remanufactured products. In the survey questionnaire, some items are included to ascertain the motivating factors for remanufacturers, while they take such a decision. This hypothesis (H01) could be addressed by taking the opinion of the experts in remanufacturing sector and is important to explore the importance of profit potential for
remanufacturers. Profit potential of remanufactured and new counterpart product is necessary to be studied to know the WTP and product cannibalization issues (Cuena et al., 2004; Guide and Li, 2010; Subramanian et al., 2010)

**H_{02}:** Quality of a remanufactured product is ‘as good as new counterpart product’.

In many of the literature on remanufacturing, it has been stated that the quality of a remanufactured product is ‘as good as new counterpart product’ (Lund., 1984; Majumder and Groenevelt., 2001; Guide et al., 2005; Guide and Van Wassenhove., 2006; Vasudevan et al 2011). This hypothesis (H_{02}) could be solved through the opinion of remanufacturing experts obtained through the questionnaire and personal interviews as these experts are the best respondents to give their opinion about the quality of a remanufactured product.

**H_{03}:** Cost incurred for a remanufactured product is less than cost incurred for a new counterpart product.

This hypothesis (H_{03}) is especially essential to know the benefits brought about by the remanufactured products. Cost of a remanufactured product is a special attraction to remanufacturer and hence the study related to this is necessary. Cost is a necessary element to decide the price of a product through which the WTP of consumer could be increased (Xu and Zhu, 2011). Cost of a remanufactured product plays a key role in the remanufacturing business. Knowing the cost of a remanufactured product is valuable to decide the fewer prices as compared to a new product (Sundin et al., 2005; Terkar et al., 2013; Guide and Jayaraman, 2000). Mainly
customers are attracted towards remanufactured products due to lesser prices as compared to new products.

**H_{04}**: Customers’ Willingness to pay (WTP) towards remanufactured product is less as compared to its new counterpart.

Customers’ willingness to pay towards a remanufactured product is necessary to be checked to get an insight into the product cannibalization due to remanufactured product. If remanufactured products cannibalize the new counterpart product, then the willingness to pay towards it is high. In product cannibalization process, customers’ willingness to pay plays an important role (Atasu et al., 2010, Atasu et al., 2008, Camacho-Cuena et al., 2004). Customers’ WTP comparison between remanufactured and new product can be known through the online auction data collection through eBay as well as data collected through questionnaire.

**H_{05}**: Quality of a remanufactured product and customer’s willingness to pay are related to each other.

This hypothesis is required to be checked to find the correlation between quality and WTP. If the quality of a remanufactured product is good, it shows a positive impact on WTP. In the questionnaire, items related to quality of remanufactured product and consumers WTP are addressed to the experts (see Appendix). Chi-Square test was applied to test the correlation.

**H_{06}**: Price saving due to remanufactured product as compared to its new counterpart product and consumers willingness to pay are related to each other.
Customers’ willingness to pay as well as the price of the product influence each other (Atasu et al., 2008, Assmus and Wiese., 1995). It is important to check this correlation in remanufactured product. This correlation causes a strong product cannibalization of new counterpart product, hence these two parameters are important in this study. This relation can be calculated through the opinion of remanufactured experts; hence questionnaire analysis with Chi Square test is conducted.

\textbf{H}07: \textit{Existence of remanufactured product will reduce the end bids/bidders of new counterpart product.}

Number of auction bids received for new product in the presence and absence of a remanufactured product is an important parameter to be studied to know the product cannibalization issue (Atasu et al., 2010). Through the online eBay, the auction data with details of number of bids and bidders are available. This data is useful to check the hypothesis \textit{H}07. Online data collection is a very powerful tool to analyze the hypothesis (Guide and Li., 2010; Atasu et al., 2010). This hypothesis is an important step to understand the issue of product cannibalization and customer’s willingness to pay.

\textbf{H}08: \textit{Existence of a remanufactured product will cannibalize the sale of its new counterpart product.}

This issue is very important and is a problem faced by remanufacturing industries. Many experts from remanufacturing industries feel that a remanufactured product will cannibalize the sale of new counterpart product. Many OEMs in the market do have the fear of cannibalization of new counterpart product (Guide and Li., 2010). This hypothesis is addressed
with the opinions of remanufacturing industry experts and online live auction data from eBay.

\( H_{09} \): **Product Cannibalization of new product due to sale of counterpart remanufactured product and customers' willingness to pay are related to each other.**

Customers' willingness to pay plays an important role in the sale of a remanufactured product (Guide and Li., 2010; Atasu, 2010; Majumder and Groenevelt., 2001). Online data from eBay website and questionnaire are analyzed to find the WTP towards remanufactured products. For this hypothesis \( H_{08} \), experts' opinion plays an important role and Chi Square test was conducted to analyze the same.

\( H_{10} \): **Product Cannibalization of new product due to sale of counterpart remanufactured product and price saved due to remanufactured product are related to each other.**

Price saved due to remanufacturing gives a huge boost to customers to purchase the remanufactured product. If the customer is buying the remanufactured product due to lesser price, then question arises as to whether remanufactured product would cannibalize the sale of a new product or not (Guide and Li., 2010; Atasu, 2010; Mason and Milne, 1994). It is necessary to find the correlation between product cannibalization due to remanufacturing and price saved due to remanufacturing. Questionnaire analysis is important to evaluate this hypothesis \( H_{09} \).

\( H_{11} \): **Product Cannibalization of new product due to sale of counterpart remanufactured product and quality of remanufactured product are related to each other.**
If the quality of a product is good, then customer’s WTP of product increases and it may cannibalize the sale of new product, hence it is necessary to check the correlation between the quality of remanufactured product and cannibalization due to the sale of remanufactured product. This hypothesis is addressed through the remanufacturing expert’s opinion from industries. Chi Square test was conducted to get the correlation factor between Product Cannibalization due to sale of a remanufactured product and quality of remanufactured product.