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Review on Automobile Remanufacturing Supply Chain in Indian Context

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ABSTRACT: Remanufacturing has developed into a critical business domain in developing nations in the last three years. Take-back obligations, disposal constraints, monetary benefits, inventory of disassembly components/parts and interest in spare parts in the post-product life cycle are key factors that enable this business sector to develop. In this study, an effort to review on Automotive Remanufacturing Supply Chain in Indian context is carried out. The study compares how the Indian remanufacturing industry fares against other established markets like USA, Europe, Japan etc. The research study also explores the factors which are hindering the growth of the remanufacturing sector in India. The secondary data responses of OEMs and Suppliers were collected due to the current pandemic and statistically analysed to propose the factors to be considered for designing remanufacturing supply chain. Since, there is limited researchconducted in India with lack of established remanufacturers, the study relies mostly on the secondary data.

Key word: Take-back obligations, Disposal Constraints, Monetary Benefits, Inventory of Disassembly components

I. INTRODUCTION

Even though India is one of the biggest automobile markets in the world there is a meagre presence of established remanufacturing industry. As on 2014, the Indian automobile industry has produced nearly 21 million vehicles. It is estimated that during 2020-2025, almost 5 million cars and two-wheelers would reach their end of useful life and these vehicles will be ready for disposal**(Sinha 2017)**. In the view of this situation, there is a big opportunity for the manufacturers to be a part of this remanufacturing industry and establish a stable sector. Combined with the way Indian Client's value low cost of ownership, remanufacturing holds critical potential for the Indian market **(Sinha 2017).**

The remanufacturing idea has acquired significant significance due to the increased understanding and changing Government regulations among corporate leaders**(Govindan 2019)**.

Remanufacturing can be defined as "the reconstruction of a product to details of the original manufactured product using a mix of reused, repaired and new parts"**(Sinha 2017)**. The growing global need for such electronics and automotive products has raised major concerns about how to make the remanufacturing of end-of - life products sustainable and profitable**(Kafuku 2016)**.

A number of companies have recently developed environmentally sustainable policies and procedures relating to Product Design, Manufacturing and Distribution Practises, End-of - Life (EoL),Inventory Management and their strategies to derive some value from the goods used. Remanufacturing is one of the EoL techniques that can be seen as an opportunity for business with a major effect on the economy **(Govindan 2019)**.

While the supply of remanufactured goods continues to increase, consumers typically remain ignorant of the processes of remanufacturing and of the products generated from them**(Wang 2018)**.

On the other hand, Climate change by humans has caused a significant pressure to preserve our natural resources. Thus, remanufacturing is one of the options to avoid burning and land filling by waste materials **(Sinha 2017)**.

The remanufacturing process includes disassembly, washing, testing, repair and reassembly of a product 's components in order to return it to "as new" state. It can also relate to adding new and improved value to used goods **(Matsumoto 2016)**.

Among many other methods of recovery, remanufacturing is the best way, since it can maximise material usage, minimise production

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costs and increase waste recovery. Automobile industry is the predominant division in remanufacturing which accounts for almost 66% of the remanufacturing business in the world **(Sitcharangsie 2017)**.

As remanufacturing maintains the structural shape, it retains both the quality and the value added contained in the original product. Remanufacturing is typically better than material recycling, and energy savings against recycling are in the ratio of six to one proportion significant **(Matsumoto 2016).**

According to Automobile Parts Remanufacturing Association (APRA) the market for remanufactured automobile parts is valued at USD 85-100 billion worldwide and in USA alone the remanufacturing sector is worth USD 35 billion**(Sinha 2017)**.

The US remanufacturing sector has nearly 73,000 companies that employ almost 480,000 people. But the Sector's size is just 0.4 per cent of US GDP, compared to 10 per cent for new product manufacturing, which gives the sector plenty of growth opportunities in USA **(Mitra 2015).**The same analogy can be extended to India as well.

Development of financial, administrative and competitive scenarios, demands from customers and environmental guidelines have intensified the attention towards developing a sustainable supply chain and reverse logistics activities**(Luthra 2016).**

In view of this, Organizations are confronting overwhelming pressure to bring down the emissions throughout the supply chain. The Organizations need to think about incorporating their business strategies in manufacturing and service sector with feasibility and reducing supply chain expenses to obtain a competitive edge over others **(Luthra 2016)**.

Background Theory

Currently, the environment pollution is outrageous, and ecological parity is disturbed. Natural resources are being severely wasted, which has resulted in resource shortages which can impact the human society and economy **(Xu 2012)**. Manufacturing industry is not only the backbone of the national economy, but is also a big cause of environmental pollution, consumes a significant amount of energy **(Xu 2012)**.

The End-of - Life Vehicles (ELV) Directive is a useful tactic to tackle the large quantity of waste automobiles produced annually within the EU, with approximately 59 million tonnes reported between 2006 and 2014 by EU Member States**(Paterson 2018)**.

Remanufacturing is not only profitable in terms of cost savings for the manufacturer, but also for the environment and society**(Kafuku 2016)**.

Manufacturing companies now find it more cost-effective to recycle goods that have reached their useful life for many purposes (e.g. environmental issues, regulation, lack of natural resources, and energy) than to dispose of them in landfills or by other methods**(Hasanov 2019)**.

Because of its benefits for both the organisation and the environment, remanufacturing has become a widely accepted method of sustainable production**(Kafuku 2016)**.

The Massachusetts Institute of Technology began work into the reuse of waste products in the late 1970's. In the 1980s, the U.S. officially sponsored the re-modelling or reuse of waste materials and called it "remanufacturing"**(Xu 2012)**.

The remanufactured inventory included parts of the vehicle, machine tools, construction machinery, railroad supplies and some electronic items.

II. LITERATURE REVIEW

This is the age of global climate change and every country in the world has a moral responsibility to contribute towards a greener environment **(Choudhary 2011)**.Conventional manufacturing is unsustainable because of its impact to the environment. Manufacturing produces more than 60% non-hazardous wastes annually which affects the environment by causing pollution and increasing landfills **(Choudhary 2011)**.

Some of the technical problems relating to remanufacturing in India are listed below:

- There is no particular remanufactured product market in India and there are not many customers in the market looking for remanufactured products as well.
- Remanufactured products are viewed as goods of lower quality compared to a newly manufactured product.
- The attitude of Indian consumers towards remanufactured products is not the same as that of Western countries. Hence people are hesitant to purchase remanufactured products.
- The Indian remanufacturing industry lacks professional expertise.
- The timing, quantity and quality of the products that are returned for remanufacturing is unknown and not clear on the process.
- Low acceptability of remanufactured products among the customers due to scarce awareness

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about its quality and pricing. **(Choudhary 2011)**

On the other hand, environmental pollution has legally mandated OEM companies in the EU and North America to take back used goods for recycling or safe disposal**(Mitra 2015)**. Reduced land-fill and incineration areas have helped the manufacturers to focus more on remanufacturing. This has economic benefits and the OEMs are also able to portray their 'green' corporate image by being active in remanufacturing. The demand for environmentally friendly goods is estimated at nearly USD 200 billion globally **(Mitra 2015)**.

India is seen as a restricted market for remanufactured product. There are certain restrictions enforced on international trade of remanufactured products. In a previously conducted research by **Vernekar and Wadhwa (2008)**, the authors highlighted the importance ofmanufacturers in accepting responsibility for the overall lifecycle of the product post their EoL. The manufacturer responsibility should ideally be throughout the life cycle of the product. For instance,the Indian Cartridge Remanufacturers and Recyclers Association (ICRRA) is involved in the development, promotion and strengthening of the Indian remanufacturing sector**(Sharma 2016)**.

The availability of cheap and large man power, price sensitive market and increased impact on environment due to growing economy could be some of the reasons which will make way to establish an industrial scale remanufacturing business **(Sharma 2016)**.

According to**(Matsumoto 2016)**the process of remanufacturing involves six steps:

1. Disassembly
2. Cleaning
3. Inspecting
4. Repairing
5. Replacing
6. Reassembling

The main issue with marketing a remanufacturing product revolves around impression and perception of low quality by the customer. **Alqathani and Gupta (2017)** considered warranty to be a key marketing factor for remanufactured products.

Customer behaviour and inclinations are considered critical in promoting the markets for remanufacturing products. From the point of view a consumer **(Sharma et al., 2010)** quality fills in as the most important factor when buying a remanufactured item **(Govindan 2019)**.

III. OBJECTIVES

The objectives of the study include:

- To identify and establish the current status of automobile remanufacturing supply chain in International and Indian scenario.
- To determine and analyze the key factors influencing the design of supply chain.
- To verify and validate the existing supply chain models from Indian perspective.
- To ascertain the viability of the implementation from Indian perspective.

IV. PROBLEM STATEMENT

The remanufacturing industry in India is currently executed as a disorganised market**(Sinha 2017)**. Despite the fact that India's automotive industry ranks tenth in the world, second in bikes and fourth in commercial vehicles, there are no significant efforts by the state or industry to pursue the remanufacturing phase as a separate business entity**(Sinha 2017)**.

With this study, an effort to proposed supply chain framework for an automotive remanufacturer in India is carried out. The study compares how the Indian remanufacturing industry fares against other established markets like USA, Europe, Japan etc. The research also explores the factors which are hindering the growth of the remanufacturing sector in India. Since, there is limited researchconducted in India and also lack of established remanufacturers, the study relies mostly on the secondary data.

V. METHODOLOGY

The key methodologies include techniques like: Literature Survey, Secondary Data Collection, Hypothesis Testing andExperts Inputs.

5.1 Current Status of Automobile Remanufacturing Supply Chain in International and Indian scenario:

Korea: In the international scenario, Korea was the first country in the world to create a national system for remanufactured product quality certification to improve the product and the reliability of the remanufactured product to the consumer. The market size is around Korean Won 750 million **(Kang et al., 2016)**. The major remanufacturing sectors are vehicle components, toner cartridges and chemical catalysts. Yet with less than 50 employees, 99 per cent of producers are small and medium-sized companies. Most of them have low technology rates and inadequate production management which leads to difficulties to create knowledge of the demand and durability

for remanufactured goods. The Korean market is very limited compared to established economies, such as the United States and Europe.

United States of America: The United States of America has the world's best-established market for the remanufacturing. This sector was created by the impulsive demand of the industry. Remanufacturers are formally licensed by the Federal Trade Commission in 1998 to mark their goods as 'Remanufactured in USA'. Several laws are introduced to govern the ease of use of remanufactured goods and some states are also promoting via public procurement laws and the tax advantages of remanufactured goods**(Kang et al., 2016).**

China: By supporting a policy to expand industrial waste management by helping the remanufacturing industry rise, China is emerging as a major remanufacturing market.The Chinese Government officially sponsored remanufacturing activities through the views of State Council on accelerating the development of the circular economy' in 2005. The National Key Laboratory for Remanufacturing Technology was developed by the Department of General Armaments in 2001 to develop core remanufacturing technologies**(Kang et. al., 2016)**. The Chinese Academy of Sciences established the Science Technology Roadmap in 2009 for 18 key areas, like electricity, human health, maritime protection, information as well as public safety, and selected disassembly, recycling and remanufacturing technologies for electronic goods and automobiles as essential innovative technologies. By offering economic benefits, setting up monitoring and management structures, the Chinese government has encouraged the growth of the remanufacturing industry by cultivating experts and improving public relations**(Kang et. al., 2016).**

Japan: The private sector dominates Japan's remanufacturing industry, and there is a shortage of remanufacturing laws and guidelines implemented by the Government of Japan. By 2012, the demand for repair parts for automobiles stood at Japanese yen 238 billion, of which Japanese Yen 129 billion for reusable parts and Japanese Yen 109 billion for recycled parts**(Kang et. al., 2016)**. 3Rs (Reduction, Reuse, and Recycling) programs got underway as the Japanese Government's environmental policies raised waste treatment expenses. These efforts were further promoted as a way of enhancing health and increasing economic growth. Japan 's environmental policy is based on the Basic Law passed in 1967 and 1972 to control Environmental Pollution and Nature Conservation Act**(Kang et. al., 2016)**. TheEnvironment Law (1993), the Environment Plan (1994) and the Act for the Creation of a Sound Material Cycle Society (2000) preceded those legislation**(Kang et. al., 2016)**. The Recycling Law for Home Appliances (2001) and the Recycling Law for EoLVehicle (2001) alleviated the lack of sites for landfilling by recycled materials, but progress in the remanufacturing sector is still difficult for OEMs.**(Kang et. al., 2016).**

Europe: Europe's remanufacturing market is most successful in both Germany and the UK. Remanufacturing areas include automobile, aerospace, ink and toner cartridges, and machinery with a diverse consequence and unique purpose. Europe's total industry size was not officially available to the investigating team, but the value of UK remanufacturing industry is about £2.4 billion (estimated). The European Commission has led, through EC directives, for the European remanufacturing industry to expand**(Kang et. al., 2016)**. EoL Vehicles (ELV) have made it possible to use remanufactured parts for vehicles. The Block Exemption Regulation (BER) aims to expand the OEMs involvement, which ensures an equal competition between OEMs and remanufacturers. Centre for Remanufacturing & Reuse (CRR) in the United Kingdom provides technical information services and public research is being conducted - Bayreuth University, Germany, Linkoping University, Sweden and Delft University of Technology, Netherlands, but there lacks a coordinated effort from the EU to facilitate the remanufacturing industry **(Kang et. al., 2016).**

India: India is the world's tenth largest automobile industry, second-largest in the two-wheeler industry and fourth-largest in the commercial vehicle market. Since 2014, the Indian automotive industry produced nearly 21 million vehicles and the forecasted annual sales growth rate is around 9%. Indian automotive Industry 's projected size in 2016 was equivalent to USD 122 million, to USD 159 million (Automotive Mission project report 2006-16)**(Sinha 2017)**. It is estimated that approximately 5 million cars and two-wheelers would be ready to be disposed after the end of their useful life between 2020-25. In the view of this, the aspiring entrepreneurs may look at this research directions to create a niche business model. **Sinha (2017)** mentioned that Indian customers prioritize low cost ownership, thus, remanufacturing holds a tremendous potential for the Indian market**.**

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5.2 Determine and Analyze the Key Factors Influencing the Design of Supply Chain:

1. Design Issues: Design for remanufacturing (DFR) refers to design process that allows the product to be used over several life cycles as the original product or at end-of-life. This makes it easier to be used as parts into remanufactured products**(Sinha 2017)**. DFR strategies include core collection, of disassembly design, multiple life cycle design, and upgrade as well as assessment design. Automobiles are complex in design and often other design considerations-such as safety make end-of -life recovery difficult **(Sinha 2017).**

2. Production Planning and Control: The remanufacturing process begins with the disassembling procedure. Disassembly is characterized as a systematic way of dismantling a product further into constituent parts, components and modules**(Sinha 2017)**. The disassembly process could be either destructive or non-destructive. One of the challenges is to decide if the collected parts should be remanufactured or recycled**(Sinha 2017)**. Furthermore, not all cores that are recovered are usable, many have to be discarded due to quality considerations. Such uncertainties in the process of disassembly may lead to uncontrolled removal of parts which could cause long waiting times at machine centers. This situation can increase the lead time and its variance in the processing of the parts. **(Sinha 2017).**

3. Acquisition and Reverse Logistics: Reverse logistics is the practice that focuses mainly on the inbound supply and distribution of used goods. It is challenging to design an effective reverse logistics network, especially given the complexity involved in managing the remanufacturing process. Such challenges include uncertainty about the timing of returns, uncertainty about the sum of returns about the nature of returns **(Sinha 2017).**

4. Inventory Management: Determining lot-sizes and the resultant cycle inventory of component parts are challenging due to the uncertainty in supply quantities and increased variation in supply lead times**(Sinha 2017)**. Integrating recycled or remanufactured component parts into traditional material requirement planning (MRP) systems is challenging given the uncertainties inherent in the procurement process. Many OEMs, even in OECD countries manage this either manually or independent of the MRP system. The uncertain flows can create an imbalance between supply (returns/used product) and demand of remanufactured product. This necessitates an inventory control mechanism that accommodates the uncertain returns process while balancing demand and supply **(Sinha 2017).**

5. Marketing Factors: Marketing strategy is based on the company's form, that is, whether the business is remanufacturing replacement parts or the whole product. The strategy also depends on whether the remanufactured product is used in the supply chain by the company itself or its consumers or suppliers**(Sinha 2017)**. Market segmentation specifically defines potential buyers for the products being remanufactured again. Since such goods are cheaper, it can be appealing to less developed markets. Companies often try to attract consumers who are environmentally conscious by labelling the remanufactured products as 'green'**(Sinha 2017).**

6. Economic Issues: The economic advantages from the remanufacturing activities are prime drivers that encourage numerous companies in the Organization for Economic Cooperation and Advancement (OECD) nations to seek after it along with conventional manufacturing processes (**Thierry et al., 1995**). The low cost of manufacturing which results in high profit margins is what makes remanufacturing a very alluring sector (**Sinha 2017**).

7. Governmental Policies: In OECD Countries, the environmental law convolutes into a roundabout as a catalyst for the method of remanufacturing. Member countries in the European Union (EU) have passed a law requiring manufacturers to reuse the vehicle and recover 95 per cent by weight in 2015 (**Eurostat, 2013**). France, Denmark, Germany and Netherlands propel the auto manufacturers to collect the used vehicles with the end goal of remanufacturing (**Doppelt and Nelson 2001).** However, existing laws in India such as the Environment (Protection) Rules, 1986 and the Battery (Management and Handling) Rules (2001) does not require the industrial reuse or remanufacture of automotive manufacturing companies (**Sinha 2017**).

5.3 Propose Appropriate Supply chain model for Automobile Remanufacturing with respect to Indian Scenario

The responses of OEMs and Suppliers were collected and statistically analyzed. The analysis is first performed for two echelons of the automotive supply chain that is, OEM and supplier to understand their observations on automobile remanufacturing.

The responses were classified which had a rating of four or above as 'critical'. A total of 14 issues came under the critical category for OEM and 13 for the Supplier. The basic issues for

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OEM and the Service Provider are mentioned in Table 1.

(Source: Sinha 2017)

5.4 Hypothesis Testing and Validation of Perspectives

The hypotheses are tested individually for each of the critical issues. To determine the relevance of each of these critical issues to the supply chain. There were 33 responses from OEM's and 39 responses from Supplier's. So, degrees of Freedom (DOF) was 32 and 38 respectively (DOF = Total observations – 1).

Table 1: Table showing t-values and p-values for critical issues faced by OEM's and Suppliers

Issues	t-values (average)		p-values	
	OEM	Supplier	OEM	Supplier
Economic	2.46	3.58	0.019	0.0009
Governmental	-0.23	1.54	0.819	0.131
Reverse Logistics	-0.49	1.79	0.627	0.081
Inventory	-0.49	-1.00	0.627	0.323
Prod. Planning & Control	-0.42	-0.52	0.677	0.606
Design	5.16	3.45	0.000	0.001
Marketing	0.79	0.80	0.435	0.428

1. Economic Issues:

NULL HYPOTHESIS –Economic issues are not relevant to the supply chain model
ALTERNATE HYPOTHESIS –Economic issues are relevant to the supply chain model

As seen from the above table, p-value of Economic issues for OEM and Supplier are less than 0.05 (0.019 and 0.0009 respectively). So, the H1 is rejected and the study infer that Economic issues are not relevant to the supply chain model for both OEM's and Supplier.

2. Governmental Policies:

NULL HYPOTHESIS –Governmental policies are not relevant to the supply chain model

ALTERNATE HYPOTHESIS – Governmental policies are relevant to the supply chain model

As seen from the above table, p-value of Governmental policies for OEM and Supplier are greater than 0.05 (0.819 and 0.131 respectively). So here the H0 is rejected and conclude that the Governmental policies are relevant to designing the supply chain model.

3. Reverse Logistics:

Reverse logistics is relevant to the supply chain model (H1), p-value of Reverse Logistics for OEM and Suppliers are both greater than 0.05 (0.627 and 0.081 respectively).

4. Inventory Management:

Inventory management is relevant to the supply chain model and relevant for both OEM's and supplier.

5. Production Planning and Control

Production planning and control is relevant to the supply chain model and is relevant for both OEM's and supplier.

6. Design Issue:

The Design issues are deemed not critical to the supply chain modelfor both OEM's and supplier.

7. Marketing Issues:

Marketing issues are relevant to the supply chain model. As seen from the above table, p-value of Marketing issues for OEM and Supplier are both greater than 0.05 (0.435 and 0.0.428 respectively). So, the null hypothesis can be rejected.

VI. CONCLUSION

From the above tested hypotheses, it can be validated that Governmental Policies, Reverse Logistics, Inventory Management, Production

Planning and Control and Marketing Issues are more relevant to the supply chain model compared to Economic and Design issues which are found to be not relevant to the supply chain model.

Remanufacturing in India is still in its nascent stage. OEM's and Suppliers are reluctant to take up remanufacturing despite the economic benefits it can accomplish. Hence, remanufacturing continues to be a disorganised sector in India for the next 2-3 years. The Government needs to bring in stricter laws and policies for remanufacturing and encourage the manufacturers to undertake remanufacturing. Even the lack of awareness among customers isn't helping the cause. Most of the customers view remanufactured product as an inferior product with low quality. The Government needs to raise awareness among customers about the benefits of using remanufactured products and the perceived notion needs to be changed. Like in the USA, India needs to bring in rules and regulations to make the OEM's responsible with disposal of EoL products and take-back policies.

The benefits include:

- Encourage OEM's to collect their old/used parts and initiate remanufacturing
- Avoidland filling and polluting the environment

According to **WTO 2005: WTO 2007,**the developed and developing countries will profit from the liberalisation of trade barriers for remanufactured goods due to the economic and environmental benefits associated with this emerging field. Therefore, an organized remanufacturing industry is warranted in India to show our commitment to environment as a CSR and human responsibility.

VII. LIMITATIONS AND FUTURE DIRECTION

Due to lack of study on this specific topic of research in India secondary data was used to arrive at inferences.

There is a need for broader research in the area of remanufacturing in India. The idea of utilising the foreign technology and their methods needs to be addressed in an elaborate and critical way. There is a huge need for research awareness in the area for making people aware about the concept of remanufacturing and its benefits. India being one of the largest markets for automobiles has tremendous scope in remanufacturing. Thus, this can be started with fine-tuning of Governmental policies to help the Companies initiate remanufacturing as one of their key responsibilities.

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