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How is value created in the circular economy? Evidence from remanufacturing and repair businesses

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Abstract. The circular economy refers to a cluster of strategies which are necessary in the pursuit of more sustainable production-consumption systems. In despite of the importance of repair and remanufacturing in the context of circular economy and sustainability, research in value creation within this sector is limited. There is little empirical evidence pertaining to the different ways that repair and remanufacturing activities can contribute to value creation across firms. This study therefore aimed to investigate value creation in the circular economy, particularly in context of fifteen repair and remanufacturing firms. Through a multi-method approach, data pertaining to value creation strategies were collected in both original equipment manufacturers (OEMs) and non-OEMs, and inductively analyzed with the aid of mapping tools. As a result, four generic patterns of value creation were identified, expanding upon previous literature by highlighting that 'OEM status' and 'servitization' are important variables of value generation.

Keywords: remanufacturing, value creation, business model, circular economy.

1 Introduction

The circular economy is frequently interpreted as a set of strategies to implement the concept of sustainable development, including reducing, reusing, repairing, remanufacturing, and recycling materials. Although these strategies have the potential to transform business models, the literature pertaining to the various forms that repair and remanufacturing firms create value remains limited. One of the most significant studies was conducted by Lüdeke-Freund and colleagues [1] who identified a generic pattern of value creation asserting that repairing, remanufacturing, and upgrading allow companies to offer greener products at lower prices. The authors highlighted that value is generally captured through reduced material costs and additional revenues from price-sensitive customers seeking functionality. Nevertheless, it was acknowledged that additional costs are required to establish the required reverse logistics and labor skills [1]. Whilst it can be useful to generalize remanufacturing and repair organizations through a broad pattern of value creation, the authors themselves noted that not all firms capture value in the same way [1]. Their framework, created from a literature review rather than own empirical data, was more applicable to an original equipment manufacturer (OEM) rather than an independent remanufacturer (or non-OEM).

Indeed, a bias towards the OEM perspective in the limited body of literature pertaining to repair and remanufacturing business models has been previously identified [2]. Additionally, there is a dearth of empirical evidence regarding the relationship between the circular economy and value creation. This includes a lack of comparisons across several repair and remanufacturing firms, with most articles adopting theoretical lenses or conducting one to four case studies. We therefore sought to address these knowledge, contextual, and methodological gaps within the literature. Specifically, this study aimed to answer '*how is value created across repair and remanufacturing business models?'* through a comprehensive empirical approach including fifteen case studies.

The remainder of this paper is structured as follows. Section 2 provides a literature review on value creation in repair and remanufacturing business models. Section 3 describes the method employed in this study, followed by analysis in Section 4 and discussion in Section 5. Finally, Section 6 provides a conclusion.

2 Literature Review

The literature pertaining to repair and remanufacturing businesses models is skewed towards the perspective of OEMs. Their primary concern when adopting such models is the risk of cannibalizing the sales of new products, although this is assessed against the profit potential of repair and remanufacturing and the risk of third parties conducting such activities [3]. Consequently, several studies have attempted to identify factors that OEMs should consider when deciding whether to engage with repair and remanufacturing. Matsumoto et *al*. [4] asserted that product characteristics are an important factor arguing that suitable products contain subparts with a physical lifetime significantly longer than the product usage time and have stable product and process technologies. Repair and remanufacturing are challenging from the operations management standpoint due to uncertainties related to the volume, timing, and conditions of returned products. Therefore, it was suggested that OEMs consider the product lifecycle and branding strategies to determine the most appropriate moment to introduce remanufacturing [5]. In addition to the right timing, decisions such as the ratio of new and remanufactured products and pricing of rebates might vary across the product lifecycle [6].

OEMs must guarantee that the costs for reverse logistics and re-processing are lower than the cost to produce new goods to make repair and remanufacturing viable [7]. Underpinning this idea is the assumption that consumers will misperceive remanufactured products as being of lower quality thus requesting a lower price. Consequently, if costs were not lower, the OEM would lose profitability. As revenues from the sales of reprocessed products are typically lower, OEMs seek to maintain the demand for new products stable whilst using reprocessed products to expand sales to new price-sensitive markets [8]. Such approach promotes growth at the firm level; however, the overall environmental impact might increase as the total of products created is higher [9].

Despite findings involving increased costs and reduced revenues, the literature also suggested advantages for OEMs conducting repair and remanufacturing such as the possibility of extending contact with consumers, facilitating returns, and reducing uncertainties through leasing models [10]. This could be enabled by sensors that track the

state of components in real-time increasing the efficiency of planning, sorting, and remanufacturing processes, and that provide information for the design of new products [11]. Nevertheless, a challenge associated with leasing is that the product's lifetime costs depend on how the material is used by the customer, which is difficult to predict [12]. Additionally, leasing models shift the manufacturer's focus from production and distribution to asset management, requiring changes in customer relationships [13].

The bias towards the OEMs perspective within the literature is clear with little discussion focusing on third parties [2]. Non-OEM firms are typically treated as a threat as they can compete with OEMs. Even though third parties do not hold the prestige of the brand, they can offer long warranties, quick processing times, and proximity to clients [14]. To combat such threat, some OEMs prevent independent remanufacturing trough design and intellectual property rights [15]. Nevertheless, the rise in competition can benefit OEMs, for example increasing the perceived value of new products by up to 7% [16]. Furthermore, OEMs and non-OEMs do not necessarily need to compete, as OEMs can license their remanufacturing. Liu et *al*. [17] argued that such strategy is optimal for the OEM when the consumers' preference on refurbished product is not high - which would make the contracted company a strong competitor once authorized. However, it is not always profitable for non-OEMs to accept OEM licensing [18].

In summary, the literature review indicated the existence of limited empirical evidence pertaining to value creation in the circular economy, particularly in remanufacturing and repair business models and across both OEM and non-OEM firms.

3 Research design

A multiple case study design was adopted in this qualitative study. Qualitative case studies are useful for exploring an understudied topic and allow theory building through inductive reasoning [19]. In this study, fifteen firms that conduct repair and remanufacturing were selected based upon theory-based variation, as the literature review indicated that including both the OEM and non-OEM perspectives were essential. Therefore, care was taken in selecting a comparable number of OEMs or OEM-associated firms (7) and non-OEMs (8). Although all businesses conducted repair and/or remanufacturing, a range of types of companies was obtained, whereby firms varied in terms of the level of product complexity and demand uncertainty for their products [20].

The companies' profiles are as follows. Companies A, B, C, D, E, F, and G were OEMs or OEM-associated. Company A was associated to OEMs both in the marine sector and in the industrial sectors. Firm B was a subsidiary conducting engine remanufacturing in the aviation industry. OEM C manufactured high-end audio equipment, offering modular upgrades throughout the product's lifetime. Company D designed and assembled new pumps for mining and industrial applications; nevertheless, repair and remanufacturing services were responsible for most of the revenues, with their share having increased over recent years. Likewise, OEM E assembled pumping equipment, with the firm also offering remanufacturing services and spare parts for other brands. Firm F focused on remanufacturing and servicing high-voltage generators for the power

and oil sectors worldwide. Company G was an OEM of gearboxes for wind power and repaired and upgraded their own gearboxes or ones from other brands.

Differently than the previous companies, H, I, J, K, L, M, N, and O were non-OEMs. H and I were smaller independent remanufacturers in the automobile industry. Company H remanufactured gearboxes and transmissions, whilst firm I focused on turbocharges. Firm J was an independent remanufacturer of toners and cartridges. Firms K and L were providers of aftermarket services including repairs for the oil and marine sectors respectively, although K was a larger firm. Furthermore, companies M, N and O were also independent but focused on IT equipment, with N and O providing services for businesses wishing to dispose of equipment, whilst M offered repairs and exchanges on behalf of the OEM.

Data were collected through the multi-method approach detailed in Table 1. The inductive data analysis process focused in understanding in-depth each of the companies' business models and value creation mechanisms, making use of the business model canvas [21] and value proposition tools [20].

Table 1. Case studies and data collection approach

Company	Industry	OEM Status	Approach
A	Generators and turbines for Industrial, Power and Marine	OEM-associated	Site visits and in-company workshops
B	Engines for Aviation	OEM	Site visit
C	Hi-fi sound equipment	OEM	Several site visits
D	Mining and Industrial pumps	OEM	Phone interview with CEO
E	Oil and Industrial pumps	OEM	Primary data in Bititci [20]
F	Generators for Power and Oil	OEM	Phone interview with CEO
G	Drivetrain and services for Wind power	OEM	In-person interview with shareholder
H	Automobile gearboxes and automatic transmissions	non-OEM	In-person interview with CEO; site visit
I	Turbochargers for Automobile, Marine and Public sectors	non-OEM	Two site visits and interview with CEO
J	Toners and cartridges	non-OEM	Primary data in Bititci [20]
K	Asset management services for Oil and Renewable Energy	non-OEM	Phone interview with the company's previous CEO
L	Engineering and repair services for Industrial and Marine	non-OEM	Site visit; phone interview with CEO
M	Electronic monitors	non-OEM	Primary data in Bititci [20]
N	Asset management for IT equipment	non-OEM	Primary data in Cheng et *al*. [22]
O	IT equipment repair, recycling, and data destruction services	non-OEM	Primary data in Cheng et *al*. [22]

4 Findings

After analyzing and comparing fifteen companies, two variables emerged as drivers of value creation in repair and remanufacturing. They were 'OEM status', i.e., how much companies were able to exploit the reputation of their established brand in the

remanufacturing side of the business, and 'level of servitization', or how companies increased the level of services offered to enhance their appeal to customers. Therefore, a set of generic business models was proposed (Fig. 1). In Fig. 1, higher levels of servitization in the horizontal axis result in value creation through additional revenues, whilst higher OEM status in the vertical axis results in higher profit margins.

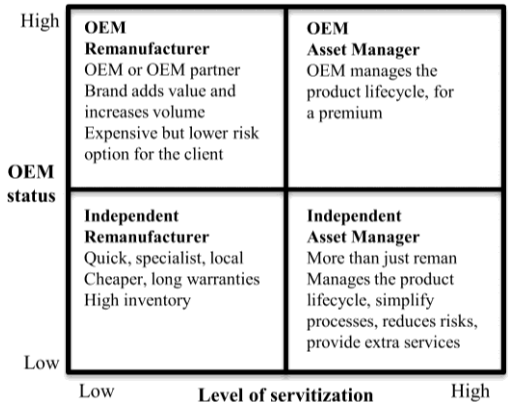

Fig. 1. Generic patterns of value creation in repair and remanufacturing

The proposed matrix identifies four patterns of value creation:

- **OEM remanufacturers:** firms that add value through OEM brand reputation and focus on clients who desire a low-risk option albeit at a higher price.
- **OEM asset managers:** firms that add value through real-time asset management of their OEM product. Customers accept paying a premium for the OEM service.
- **Independent remanufacturers:** this group creates value through operational excellence. They are generally SMEs, and offer quicker, specialist, and cheaper solutions for their customers. Interestingly, some OEMs can behave as independent remanufacturers by performing repair and remanufacturing irrespective of the product brand.
- **Independent asset managers:** this group creates value by increasing the services offered to the customer. They collaborate with other firms and simplify client processes.

The following sub-sections explain each pattern in detail.

4.1 OEM Remanufacturers: high OEM status, low servitization

Firms A and C utilized their OEM status or association to position their repair and remanufacturing unit as the brand or technology leader. Firm A targeted segments of risk-averse customers willing to pay a higher price in return for OEM warranties and for a higher residual value at the product end-of-life. Concurrently, firm C provided consumers who desired the best audio experience with high quality products, albeit for a higher price. Firm C's unique selling proposition was the durability of the product due to its modular design which allowed the product to be upgraded when a new technology became available. Due to their OEM status and premium prices, A and C achieved high profit margins in remanufacturing and upgrading. They relied on the OEM partnership and the technical capability of employees as key resources, respectively.

4.2 OEM Asset Managers: high OEM status, high servitization

As with firm A, firm B also utilized their strategic partnership with the OEM to their advantage which allowed the creation of high profit margins. However, value creation for firm B went beyond repair and remanufacturing, as the company also provided services that simplified customer processes by tracking the engine's performance in real time, which was aligned with the OEM pay-per-hour-flying service offering. Interestingly, B was the only OEM to use asset management services as a value creation strategy. As B was in the aviation sector where security is a crucial factor, they maintained dedicated resources for their real-time tracking services for their clients.

4.3 Independent Remanufacturers: low OEM status, low servitization

Non-OEMs I and J competed through operational excellence by minimizing prices, offering quick turnarounds, and possessing knowledge across different brands. Their target segments were mainly other businesses – such as dealerships and organizations with large car fleets for I, and firms with several printers for J. Their customers prioritized low prices and speed, placing less importance on brand reputation.

It is commonly assumed that independent remanufacturers are a threat for OEMs. This appeared to be the case for firm J as they faced the fiercest competition with OEMs. Price was a crucial value driver for J, which offered a low cost per-printed-page by upgrading cartridges with bigger sponges. Due to such competition, several OEMs of printers are now introducing subscription models to acquire back used parts. Additionally, OEMs keep reinventing their technology to avoid aftermarket competition. Consequently, keeping up with OEMs' innovations was a key activity for company J and balancing revenues from cheaper sales with the costs of reverse engineering and acquiring cores was challenging for the firm. Nevertheless, the situation was slightly different for I, which maintained good relationships with OEMs as they focused on a low-price product. Therefore, it appeared more interesting for automobile OEMs to cooperate rather than to compete with I. In addition to cheaper turbochargers, firm I was known for being a specialist in sourcing rare components, and occasionally even competitors placed orders. However, to deliver short turnarounds, the company maintained large stocks, including of rare products with low probability of being sold.

4.4 OEMs under 'brand dilution' behaving as independent remanufacturers

Whereas the cases of I and J supported the literature, it was surprising to observe firms D, E, F and G not exploiting their established OEM brand in their remanufacturing business unit and competing as independent firms. Company E had a history of expansion through acquisitions that helped constantly reducing operational costs and appeared to pursue a price minimization strategy in remanufacturing. In parallel, firms D and F were innovative in their new products business unit, both engineering specialist equipment for their clients. However, the remanufacturing side of those firms competed mostly through price minimization. This dynamic was the result of an interesting phenomenon over time. Specifically, D and F were initially OEMs producing new products exclusively. With time, seeking to fully exploit their capabilities, D and F started

offering remanufacturing services to their own-brand products. As more time passed and market challenges made difficult to grow organically, they identified an opportunity to generate revenues by also servicing third-party equipment. Even though repairing other brands increased revenues, D and F observed their manufacturing of new products shrink in proportion to aftermarket services. Over time, their aftermarket services transitioned from competing through brand leadership to competing through lower prices and closer proximity to the customer, similarly to how independent remanufacturers compete. Therefore, a 'brand dilution' process and loss of focus were observed in these firms. Whilst revenues have grown as a result, their business model had changed significantly. As margins were narrower in the aftermarket services due to higher labor costs, these businesses have experienced a reduction in profitability over time, combined with a reduction in cash to invest in the development of new technology.

The challenges related to managing an OEM business whilst also remanufacturing, repairing, and upgrading products from other brands were also observed in firm G. In their case, they also started manufacturing new products, but such strategy depends on intensive research and development, which is an expensive process. As their technology aged, they too started repairing and remanufacturing; however, the OEM (centralized in Europe) and repair business (worldwide) were separate business units. In one instance, the repair unit in North America required cheaper spare parts, but the OEM in Europe refused, forcing the repair business to reverse engineer and engage with local manufacturers to produce them cheaply and quickly. This illustrated how conflicting the OEM and remanufacturing business units can be within the same organization.

4.5 Independent asset managers: low OEM status, high servitization

Similarly to company I, H was an independent firm in the automobile market, although it repaired and remanufactured higher value items (transmissions and gearboxes). Company H also offered cheaper and quicker solutions and used high stocks to cope with uncertainties and to deliver short lead times. However, the difference between H and I was that firm H demonstrated a higher level of servitization to OEM clients. The relationship between H and OEMs was cooperative. For OEMs, the benefit was the provision of a 'risk reduction' service, as company H would repair or remanufacture any returned product without additional costs during extended warranty periods. For H, repetitive orders from OEMs created economies of scale increasing productivity. In parallel, firm M was a contracted party under an agreement involving the repair of any returned computer monitor on behalf of the OEM during the warranty period. Like H, a close relationship with OEMs provided economies of scale for M, whilst M offered fixed-price contracts to OEMs in return thus eliminating uncertainties and making the warranty process less risky for the OEM, although not necessarily cheaper as the total costs depended on how many products were actually repaired at the end of the period.

Firms K, N and O also added value through servitization. By managing several assets for their clients, they offered a broader scope of services than OEMs could, providing simplification. Specifically, N and O helped businesses disposing of electronic goods by performing data security services, assuring clients that any confidential data were

destroyed. Their margin was complemented by repairing and re-selling items whenever possible. In the oil industry, K managed client's assets, keeping customers within their expensive 'day rate'. They were process simplifiers and innovators, for instance they used licensed smart glasses to provide real-time specialist advice for less-skilled repair workers on the field, helping the client reducing the costs of bringing a specialist to an offshore platform. Firm K offered remanufactured parts and services to the oil industry with very distinct gross profit margins (35-50% for parts and 20-30% for services).

Each company analysed in this study was categorized within the proposed framework (Fig. 2).

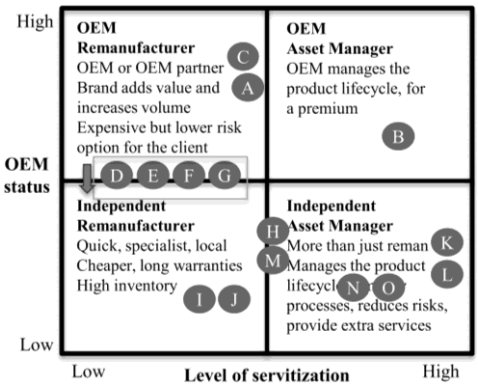

Fig. 2. Categorization of the studied firms

5 Discussion

The findings of this study contribute to addressing a knowledge gap within the literature pertaining to value creation in the circular economy, particularly in repair and remanufacturing business models. Previous studies had fragmentally identified value-adding elements in repair and remanufacturing [3, 6, 10, 13, 17, 18], and proposed a general pattern of value creation [1]; however, such pattern was not fully applicable to all companies analysed in this study. Additionally, this study contributed to addressing a methodological gap within the literature, through empirical evidence from fifteen case studies, whilst previous literature either adopted a theoretical standpoint [1, 3, 4, 6, 10, 15, 17, 18] or provided up to four cases [2, 7, 8, 11, 12, 13]. Furthermore, a contextual gap was addressed by including the perspectives of both OEMs and non-OEMs.

The framework provided in Fig. 1 differentiates how companies add value based on their OEM status and level of servitization. The identification of the first variable – OEM status – was a result of the design of this research including both OEMs and non-OEMs. It was interesting to observe that remanufacturing products of any brand destroyed value over time for four OEMs. This phenomenon was not predicted through the literature review as longitudinal case studies in repair and remanufacturing companies are rare. One of the few longitudinal studies was provided by Hopkinson et *al*. [8] which also contained negative findings describing why a company decided to move away from remanufacturing after years of conducting such activity. Such findings

indicate the need for future research to investigate value creation in the circular economy through longitudinal case studies. Furthermore, the identification of the second variable – servitization – was not surprising as product service-systems are a commonly discussed topic. Nevertheless, servitization is typically argued as a strategy favoured by leasing models [11], although only one firm (B) conducted leasing in this study. All other companies were able to repair, remanufacture and offer upgrades through traditional sales models – a finding that contributes to the empirical literature [12, 23].

6 Conclusion

This study addressed a gap within the literature related to understanding the relationship between the circular economy and value creation through empirical data from several repair and remanufacturing businesses. With fifteen cases, our comprehensive findings complemented the literature by identifying the relevance of the variables 'OEM status' and 'level of servitization' and by proposing four generic patterns of value creation (Fig. 1). Each of the studied firms were also classified within the proposed matrix (Fig. 2) and had their value creation strategies discussed in detail. Nevertheless, a limitation of this project was that, since the results were based upon inductive reasoning, the validity applies to the cases studied and therefore the suggested framework should continue to be tested in future research.

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