# Automotive Remanufacturing in the Circular Economy in Europe: Marketing System Challenges

*Abstract: Circular systems of reuse and recycling may stimulate resource conservation and thereby more sustainable outcomes for marketing systems. Automotive remanufacturing serves as a specific circular marketing system of reuse. However, supply shortages challenge the European remanufacturing marketing system, and current research focuses on micromarketing perspectives in this context. This study addresses this gap by analyzing the system from a macromarketing perspective to better understand reverse channel issues and their relation to the sustainability outcomes of the system. The analysis reveals imperfections in the market that lead to a waste of resources and other environmental impacts. A macro-perspective of the European marketing system for supply and procurement in automotive remanufacturing offers relevant insights, which better explain the observed inefficiencies. The study contributes to a more complete understanding of remanufacturing marketing systems and provides implications for policymakers and for marketers concerned with the design of such systems.*

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Abbreviations

| | |
|---|---|
| DMCA | Digital Millennium Copyright Act |
| ELV | End-of-Life Vehicle |
| IR | Independent Remanufacturer |
| OE | Original Equipment |
| OEM | Original Equipment Manufacturer |

## Introduction

An increasing awareness of environmental impacts (Ferguson and Toktay 2006) and issues related to increasing material demand (UNEP 2013b) motivate industries to consider material supply alternatives and to improve waste management. The release of the 'circular economy strategy' of the European Commission (EC 2015a) has further increased awareness of sustainable resource use. Policy interventions aim to reduce the environmental impact of end-of-life products (EU 2000) or to reduce negative outcomes, e.g., regarding the trade of conflict minerals (Dodd-Frank Act 2010). The EU introduced laws and regulations to build a circular economy, which is an economy that aims to improve resource efficiency by preserving product and material value through circular flows (EC 2015a). Some regulations apply to end-of-life vehicles (ELVs) in particular (EC 2015b; EU 2000, 2008). The EU refers to the model of the waste management hierarchy to outline its preferences with regard to waste treatment (EC 2015a). In relation to products at the end of their lives, the waste management hierarchy focuses on reuse and recycling as preferred strategies over recovery and landfills, respectively. Reuse covers strategies that extend the lifetimes of products or components. Recycling is the process of recovering materials from waste. Here, recovery refers to energy recovery, i.e., waste incineration (EC 2015a). Landfilling is inevitable, but it should be avoided as much as possible (EU 2008).

The reuse of end-of-life products is preferable from both economic and environmental perspectives due to previously added value in the form of raw materials, labor, time or energy (Agrawal, Atasu, and van Ittersum 2012; Barnes 1982). Reuse comprises different strategies, for example, the direct reuse of car components as spare parts or as a resource for remanufacturing (Thierry et al. 1995). The remanufacturing of used products regularly conserves more of the pre-

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vious added value than material recycling (Östlin, Sundin, and Björkman 2009). The remanufacturing of used products involves a manufacturing process aimed at restoring products to the same specifications as the corresponding new product (APRA Europe 2014).

Optimistic estimations of market potential and increasing demand support remanufacturing (APICS 2014; EC 2015a). With a global share of approximately two-thirds of all remanufacturing activities (USITC 2012), automotive remanufacturing is considered an important contributor to sustainable development (EC 2015a). In the EU, remanufacturing falls under the umbrella of circular economy initiatives, and, in the US, remanufacturing was passed into law via the Federal Vehicle Repair Cost Savings Act of 2015. Moreover, China made remanufacturing a national strategy as part of their five-year plans (Tan et al. 2014).

The reduction of raw material extraction and the reduction of emissions are sustainability-related challenges in environmental terms, and sustaining regional labor is a challenge in societal terms (ERN 2015b). The sustainability-related economic challenges addressed by remanufacturing are, for example, resource scarcity and the wastage of recoverable added value. The outlined scope of sustainability—as an economic, environmental and societal objective—frames the present study on remanufacturing in Europe.

Remanufacturing requires reverse channels that provide even better sorted reverse material flows than material recycling. Marketing challenges in reverse channels and reverse logistics were recognized earlier (as in this journal discussed by Barnes 1982 or Fuller, Allen, and Glaser 1996, *inter alia*), but they have seemingly been "largely ignored," as Benton (2015, p. 111) emphasized in a commentary in this journal. Furthermore, while recycling markets and legislation solved some of the reverse channel issues, new issues continue to surface. As Barnes (1982) cor-

rectly predicted, new or changing incentives in the reverse channel system change channel structures and, in turn, may cause new reverse channel issues; the effects of such incentives are not always clear.

Ownership issues and the conflicting interests of actors at the end of life challenge the collection and further supply of used products. Interests differ between the end-of-life channels of reuse, recycling and recovery, and they even differ within these channels (e.g., in remanufacturing supply channels). For example, recyclers mainly look for value of the raw materials in used products, while 're-users' look for working products or spare parts, usually regardless of their suitability for remanufacturing. Hence, the value of raw materials is usually lower than the sales value of a used but working component. Remanufacturers, in turn, focus on products or spare parts that will be suitable for their remanufacturing processes. Remanufacturers and OEMs determine the value of used components based on their previously added value. The assessment of this value is case specific; it relates to the saved steps of value creation, though it depends also on the technologies and knowledge required to restore added value. The authors refer to this value as 'intrinsic value' following the use of this term by recycling- and remanufacturing-related literature (Reynolds and Pharaoh 2010; Subramoniam et al. 2013). Different actors, objectives, and strategies characterize the strong competition for used products. Automotive remanufacturers generally report supply shortages for components as the central challenge (Weiland 2012). Findings from the distribution channels support a focus on supply issues because research indicates that garages will install more remanufactured components if they are available (Steinhilper 2012).

These persistent supply shortages in remanufacturing markets may hinder circular flows of components. The absence of circular flows, in turn, may hinder the preservation of added

value and eventually the potential contributions of remanufacturing to sustainability. Therefore, the motivating research questions are as follows: (1) Why do (new) reverse channel issues arise, and how do such issues relate to sustainability outcomes? (2) How can reverse channel-oriented marketing systems prevent negative outcomes and improve their contributions to sustainability? This article will describe and explain the different levels of system aggregation to analyze imperfections in the remanufacturing market and discuss their influence on system outcomes. The article concludes with implications for the remanufacturing marketing system and an outlook on future research.

## Marketing Systems and New Institutional Economics

Despite recognizing shortages in the remanufacturing supply, the literature fails to address the contemporary systemic connections in remanufacturing markets. Therefore, this study aims to address this gap to better understand remanufacturing marketing systems, which are analyzed as economic systems. Such systems consist of institutions and organizations and concern their interactions and potential interdependencies with other systems. This analysis seeks to identify the systemic connections that cause current shortages and the consequent outcomes.

### *Marketing Systems Theory*

The present study focuses on marketing systems. The study analyzes how relationships and exchanges between groups of actors affect dynamics in the marketing system, such as incentives in the reverse system, which may cause new reverse channel issues. Accordingly, this study addresses the question of how the marketing system should work to support a sustainable circular economy. In general, Hunt emphasized the importance of marketing systems (1976) and later refined his perspective by underlining the role of marketing systems in macromarketing (1981). In

2007, Layton presented marketing systems at various levels of aggregation at the core of macromarketing (Layton 2007). He defines the concept of marketing system as follows:

> *"A marketing system is a network of individuals, groups, and/or entities linked directly or indirectly through sequential or shared participation in economic exchange that creates, assembles, transforms, and makes available assortments of products, both tangible and intangible, provided in response to customer demand." (Layton 2007, p. 230)*

In his work on marketing systems, Layton outlines four categories on which a marketing system study can focus: environment and boundaries, attributes, components, and outcomes (Layton 2007). Decisions about the selected categories and characteristics depend on the objectives of the marketing system study in particular. The focus on institutions and organizations in the present study emphasizes the relevance of the following characteristics. The *environment and boundaries* category pertains to aggregation levels, institutional settings, and boundary conditions such as open or closed systems. The *attributes* category concerns nodes and relationships, linkage characteristics and flows through linkages. Within the system and its subsystems, the *components* category is especially relevant, particularly the sub-categories of nodes, flows (of goods, financing and information), and transactions. Resource allocation, externalities and market failures are part of the *outcomes* category (Layton 2007).

A marketing system is not necessarily directed toward distribution to the end customer, but it may relate to reverse flows of goods (Layton 2007). Supply is central to remanufacturing because having access to used products is the key to success. Therefore, the present work moves beyond the channels of distribution to consider channels of supply and procurement. Used products, so-called 'cores,' are the central resources in this industry. In automotive remanufacturing, a core can be any automotive component considered for remanufacturing. A core is a used component of a car, such as an alternator, transmission, diesel injector, or electronic control unit. The

remanufacturing process changes the core into a 'remanufactured component' (to avoid confusion with the 'components of the marketing system,' the authors use the terms '*automotive* or *remanufactured* component'). Supply-related challenges are immanent in the circular character of remanufacturing. Supply and distribution channels eventually merge because actors can simultaneously represent suppliers of cores and customers of remanufactured components.

The present paper mainly considers "the study of…marketing systems" in terms of Hunt's three criteria for macromarketing (Hunt 1981, p. 8). In his first criterion, Hunt identifies a "level of aggregation criterion which allows the inclusion of topics like … the institutional structure of marketing and power relationships in channels of distribution" (Hunt 1981, p. 8). Hunt's second criterion addresses "the impact and consequences of marketing systems on society" (Hunt 1981, p. 8). Among the impacts are not only economic outcomes but also environmental impacts or quality of life (Layton 2007). In principle, the contributions of reuse and recycling markets to sustainability demonstrate the connection of market system issues and sustainability, for example, the environmental impact of and labor provided by the marketing system of remanufacturing.

Hunt's definition of macromarketing comprises a third criterion, namely, "the impact…of society on marketing systems" (Hunt 1981, p. 8). Despite the admitted significance of societal norms in marketing systems, this perspective is not considered in detail. In terms of the demand for remanufactured components, the final customer's behavior only has an indirect influence on the marketing system. Regular car owners usually delegate car maintenance to repair shops. Repair shops act as intermediaries between consumers and remanufacturers in the procurement channels. They are experts who advise the final customer on the appropriateness of certain spare parts. Rather than the final customer, repair shops handle the core exchange, thereby initiating

the supply for remanufacturing. Therefore, the identified issue of supply shortages seems to not be an immediate effect of low demand by final customers. Hence, this study does not consider the final customer in detail.

The first and second of Hunt's criteria outline the macro characteristics of this study. Furthermore, the study of different levels of marketing system aggregation explicitly allows an examination of micro- and macromarketing systems to understand how actions at the micro level affect the system at the macro level. The recognition of various system levels represents the linkage between 'micro' and 'macro' (Layton 2007). Therefore, this study considers the marketing system design and the characteristics of the system's immanent exchange transactions.

*Theory Linking Markets and Institutions*

The study of market efficiency stems from a neoclassical perspective that relies on Pareto efficiency. Neoclassical theory considers the institutional setting to be static and exogenous; it thereby neglects the role that institutions play in transactions. New institutional economics, which developed from critics of neoclassical theory, establish a dynamic perspective on institutions and acknowledge the influence that institutions have on the effectiveness of markets (Richter 2015). Less effective markets do not necessarily fail; for better market outcomes, they instead may need a combination of coordination principles along the market-hierarchy continuum. However, the outcomes of such markets might become socially undesirable which in turn could demand a regulatory response (Harris and Carman 1983). Regarding the outcomes of such markets, Layton and Grossbart (2006) refer to Harris and Carman, who state the following:

> *"By market failure (the reader might prefer to substitute market "imperfections"), we mean those possible instances in which the ideal conditions for a market success do not hold. We do not mean*

> *to suggest that in each instance a regulatory response is desirable." (Harris and Carman 1983, p. 52)*

The present study refers to market imperfections in the sense of Harris and Carman, i.e., when indicating that institutional settings may cause shortages or undesirable outcomes, admitting that imperfect markets may still provide better outcomes than regulatory responses.

New institutional economics consider markets to be a means of coordination. Therefore, market imperfections such as high transaction costs may change the coordination principle from market to non-market types of coordination (Arrow 1969; Williamson 1971). Transaction costs comprise "search and information costs, bargaining and decision costs, and monitoring and enforcement costs" (Dahlman 1979). In addition to transaction costs, new institutional economics include other theories that can be applied to identify the potential causes of market imperfections. Among such causes are the information asymmetries associated with the principal–agent problem and information economics (Akerlof 1970; Stigler 1961; Stiglitz 2002). In addition, the way that property rights are defined and their relation to transaction costs affect the way that markets work (Alchian and Demsetz 1973; Demsetz 1967). In response to these causes of inefficient markets, organizations tend to integrate vertically (Arrow 1969; Williamson 1971). Integration can result in greater power because of, for example, the consequent increase in control over resources (Williamson 1995).

The *components* category of marketing systems indicates the usefulness of "transaction and related costs" in a macromarketing study (Layton 2007, p. 238). New institutional economics provide theories for the analysis of dynamic institutional environments and relations between organizations. New institutional economics thereby support the interpretation of the rather static description of the marketing system and the identification of reasons for particular outcomes at a

higher system aggregation level. Due to this dynamic system perspective, this analysis puts emphasis on transaction costs with references to the principal–agent problem, property rights and information economics. These theories from new institutional economics serve as references for the analysis of shortages on the market, which are also referred to as market imperfections.

The analysis of market shortages takes on the following concepts to derive marketing and policy implications for the marketing system. Harris and Carman (1983) classify market failures/imperfections in their work on public regulations and marketing activity. For this study, side effects, imperfect competition, and imperfect information are the most relevant types of imperfections among those that they identify. The framework of Harris and Carman and the impact of information problems on the degree of market imperfection help provide a better understanding of the system (Redmond 2014). Further market imperfections may stem from power structures and the competitiveness in the marketing system. Therefore, the discussion considers the concepts of power and the characteristics of relationships in marketing systems (Fligstein and Dauter 2007; Layton 2015). The characteristics of particular relationships can describe the structures of actors that emerge from the analysis (Fligstein and Dauter 2007). Power is a theoretical construct that can contribute to a better understanding of these relationships. In a marketing context, power is a firm's ability to potentially affect another firm's behavior (Gaski and Nevin 1985). The perspective on power structures intersects with the resource-advantage theory perspective on competition (Hunt and Arnett 2001; Hunt and Morgan 1996). Firms with a competitive advantage over a resource may also have a more powerful market position and intend to remain in this advantageous position, while rivals with a competitive disadvantage seek to overcome their disadvantageous positions through acquisition or innovation (Hunt 2011; Hunt and Arnett 2001). If

such a "disequilibrium-provoking process" of competition exists, it may facilitate innovation and thereby contribute to social welfare (Hunt 1999).

The analysis of exchange relationships and related institutional conditions identifies and evaluates the system outcomes. System structures and relationships may result in outcomes such as the system's assortment or others in the form of positive or negative environmental and societal impacts. With the marketing system analysis, marketing system theory provides a means to study the impacts that groups of actors and their strategies have on a marketing system.

*Marketing System Analysis*

The automotive remanufacturing industry regularly raises concerns about the shortage of cores. Researchers have addressed this shortage with operations research on closed-loop supply chains (Guide and van Wassenhove 2008), the relationships in remanufacturing supply chains (Lind, Olsson, and Sundin 2014; Östlin, Sundin, and Björkman 2008), and pricing strategies (Xiong et al. 2014), among other topics. Furthermore, the micro perspective seems predominant in research on remanufacturing (Prahinski and Kocabasoglu 2006). The persistence of supply shortages motivates this marketing system analysis to identify the potential reasons for these shortages that go beyond the micro perspective.

This study focuses on procurement channels to analyze the marketing system of automotive remanufacturing in Europe. Therefore, this study refers to the systems theoretical perspective of Meade and Nason (1991) to model and analyze marketing systems as exchange systems. This systems perspective combines a physical systems perspective on material and energy with an economic perspective of exchange. This perspective is thereby consistent with the objectives of macromarketing because this approach supports the identification of performance issues in the system. System outcomes can reveal or indicate such issues. The approach further investigates

interactions between organizations within the exchange system and analyzes how design changes can improve the functioning of the system (Meade and Nason 1991).

Graphical representations describe the marketing systems under study by showing the relations between nodes of the system and by highlighting relevant channels. The examined relations comprise material, monetary and information flows. The characteristics of the channels, including the power therein and whether the channels establish open or closed systems (Meade and Nason 1991), may indicate the causes of system imperfections.

A study of marketing systems requires definitions regarding the level of aggregation, the links to other systems, and the boundaries of the system (Layton 2007). The focal study is located at a medium level of aggregation, as it describes and analyzes the procurement market for automotive remanufacturing as a subsystem of the automotive end-of-life marketing system of reuse and recycling. This analysis requires some lower-level aggregation to specify problems and to highlight the role of some of the nodes. Therefore, the analysis will depict different levels of the system in "varying levels of detail" (Layton 2007, p. 235). Therefore, it will include references to marketing systems at the component level to explain relations, dependencies, and influences with the higher, more aggregated marketing system. At the component level, an analysis of transaction and information costs supports the overall analysis (Layton 2007).

First, the boundaries of the system under study are defined by describing the included and excluded nodes, parts, or systems. The definition of the system boundaries will also show the influences of and relations with external marketing systems. Second, the analysis of different aggregated systems and their material, monetary and information flows will provide explanations for shortages. Therefore, this study analyses different perspectives such as power, competition and innovation at the medium and lower levels of system aggregation, as well as outcomes at the

highest level of aggregation that result from the actions taken at lower levels. Finally, this approach may lead to implications for policy and industry that move toward a more sustainable market design. Although the examination of cases of particular companies represents a micromarketing perspective, this perspective addresses the evident influence of single firms or groups of firms on the macro system, which supports a more complete analysis and highlights specific links between micro- and macromarketing.

## A Mixed-Methods Approach

The complex and still blurry system under study justifies an explorative, mixed-methods study approach (Corbin and Strauss 2015). A combination of attendance and observation at trade fairs, interviews and case studies methodically support this approach (Samuel and Peattie 2016). The chosen approach leads to the reconstruction of the marketing system (identifying actors, institutional structures, and transactions). Thereafter, the authors draw on the theoretical framework in accordance with the research objectives to analyze and interpret the marketing system. Fig. 1 provides an overview of the study process.

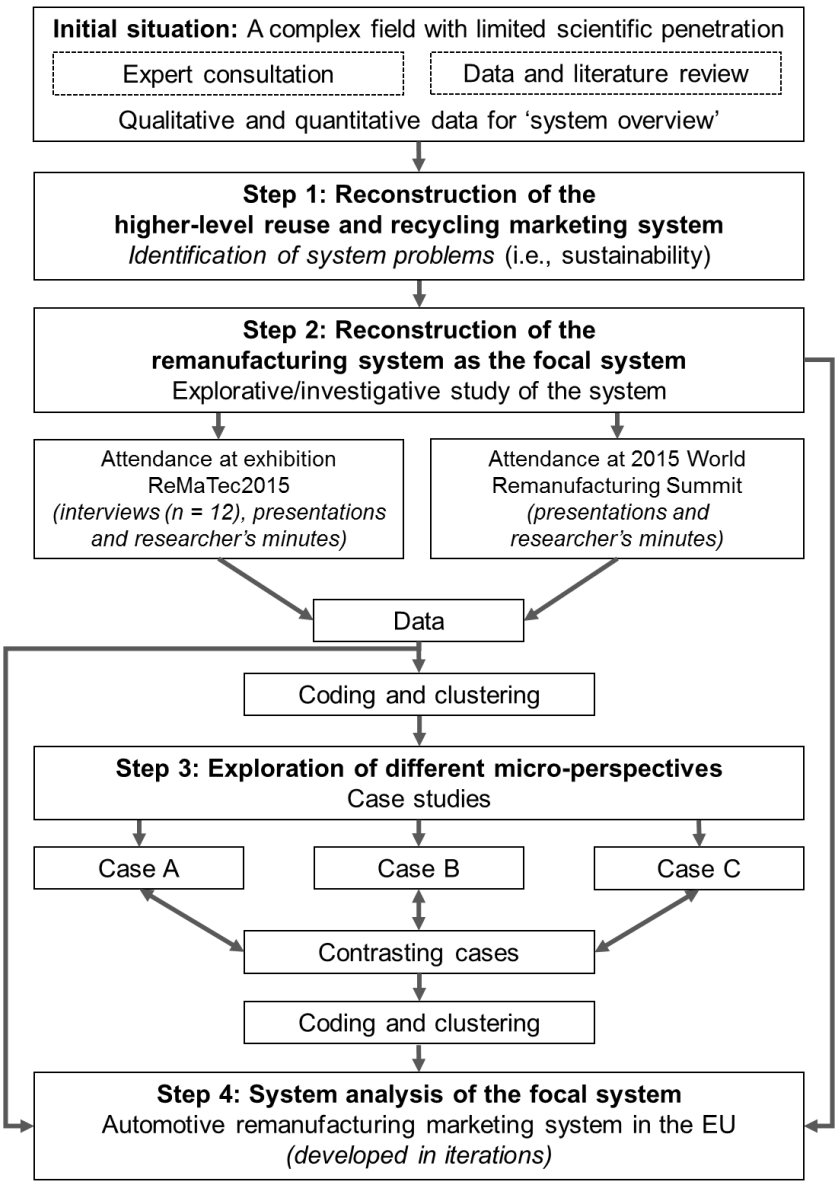


Figure 1: Mixed-methods research approach

The reconstruction of the marketing system distinguishes between a higher-level system of reuse and recycling marketing in the EU and the embedded focal system of automotive remanufacturing. The depiction of the higher-level system derives from the initial situation revealed by a scan of quantitative market data, a literature review, and an expert consultation. Concerning the focused European remanufacturing marketing system, little information is publicly available (Weiland 2012). By contrast, in the United States, the US International Trade Commission has

issued an investigation of the US remanufacturing market environment (USITC 2012). In terms of the literature, operations research takes a very technical perspective of the issue; in addition, although relationship management research addresses remanufacturing supply chains, both fields typically focus on individual cases and assign specific relationship types to the relationships among actors in the system. In fact, the expert consultation suggested some specific limitations of existing research on reverse channels in remanufacturing. These limitations include the lack of an explanation of the interdependencies between the actors and indicate problems in the system.

The identified limitations motivate a system reconstruction through an 'investigative exploration.' Market observations and interviews provide mainly qualitative data. These data were collected in June 2015 during ReMaTec, the world's biggest remanufacturing exhibition, and the World Remanufacturing Summit, which were both held in Amsterdam. The field of the market exploration included the opinions and remarks by company and market experts from all over Europe during presentations and face-to-face discussions. The authors also conducted interviews with industry experts representing different market actors (n = 12) from four Western European countries and one Eastern European country; two of the interviewees represented North American companies that also conduct business in Western Europe. The interviews were semi-structured and documented in the form of minutes taken from memory immediately afterwards. Such interviews took between 15 to 40 minutes, depending on the interviewees' willingness to discuss selected aspects of the remanufacturing market.

Data from the initial situation, i.e., the system overview and step 1 of the research design, together with data from the exploration in step 2 built a system model that developed iteratively through the study of additional data and literature (Fig. 1). Data sources included market studies,

policy documents (for example, white papers) and legal documents (for example, laws and regulations). Some references regarding the legal environment or groups of actors concerned countries such as Austria, the UK, and Germany, thereby indicating where phenomena that were relevant to the analyzed system were observed and showing that these references did not favor a particular country.

Through data coding and clustering, the market observations from step 2 unveiled three distinct groups of automotive components in remanufacturing. The technical characteristics regarding the degree of implementation of electronics distinguish these three groups. Correspondingly, in the third step, the model of the marketing system was analyzed in detail from the different perspectives of three case studies (Fig. 1). These cases are based on three companies that cover three distinct groups of automotive components: starters and alternators (case A), automatic transmissions and parts (case B), and mechatronics and electronics (case C). The degree of implementation of electronics within these three component types increases from case A to case C, although technological development might limit their distinctiveness. This approach allows for the comparative analysis of different product types in the observed marketing system and may indicate whether corresponding organizational settings exist. The three case studies involved on-site field research (interviews and observations from production and logistics operations) at three companies in two Western European countries between October 2014 and September 2015, and case-specific literature and document studies, where available, were consulted. Interviews within the scope of the case studies were recorded digitally and lasted between 75 and 150 minutes. The case studies focused on aspects such as (a) procurement and distribution channels (suppliers and customers, the incentives used in procurement, the use of and experience with deposits, relationship characteristics, and the commercial relevance of and relationships with

core dealers), (b) competitors (who they are, whether they are direct or indirect competitors, and related challenges), and (c) the legal environment (legislation and EU involvement). In addition, general information was collected about the companies (company size, the type of remanufactured components, etc.). These cases provide valuable insights into the procurement marketing system of automotive remanufacturing. Together with earlier findings, these insights are merged into the analysis of the focal system, which is the fourth step in Fig. 1. The cases serve as exemplary micromarketing perspectives to substantiate the system analysis and to explain imperfections in the focal marketing system.

Per the explicit request of the interviewees, the expert interviews and the case studies are anonymized. Due to anonymization, some information is intentionally excluded. For example, indicating countries in the context of company type and components would allow those interested to draw conclusions regarding the identity of some companies. Table 1 provides an overview of the case studies and interviews conducted.

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Table 1: Details on the case studies and interviews conducted

| Case studies* and interviews | Company type | Components | Interviewee role | Dependency | Date |
|---|---|---|---|---|---|
| **A*** | Remanufacturer/wholesaler | Starters and alternators (S&A) | Managing director | Independent | Oct. 2014 |
| **B*** | Remanufacturer supplier | Transmissions | Sales manager | Independent | Sep. 2015 |
| **C*** | Remanufacturer | Electronics/mechatronics | COO | Independent | Sep. 2015 |
| **D** | Core broker | | n/a | Independent | June 2015 |
| **E** | "Market expert" | | n/a | Independent | June 2015 |
| **F** | Core broker | | Owner | Independent | June 2015 |
| **G** | First-tier supplier with remanufacturing | S&A (among others) | Core broker | OE integrated | June 2015 |
| **H** | First-tier supplier with remanufacturing | Brake systems, steering | n/a | OE integrated | June 2015 |
| **I** | Remanufacturer | S&A (among others) | Core manager | Independent | June 2015 |
| **J** | Remanufacturer | | Founder | Independent | June 2015 |
| **K** | Remanufacturer | S&A | Prod. Manager | Independent | June 2015 |
| **L** | Core broker | | n/a | Independent | June 2015 |
| **M** | Core broker | | n/a | Independent | June 2015 |
| **N** | Remanufacturer supplier | Transmissions | Sales Manager | Independent | June 2015 |
| **O** | Remanufacturer | Electronics/mechatronics | CEO | Independent | June 2015 |

## EU Marketing Systems for Automotive Reuse and Recycling

The higher aggregation level of the marketing system, here referred to as the 'end-of-life marketing system,' comprises the focal marketing system of this analysis: the EU marketing system for automotive remanufacturing. The following two subsections describe both systems.

### *Passenger Car Reuse and Recycling Marketing System*

In the current end-of-life marketing system for ELVs in Europe, nodes represent discrete markets rather than specific groups or legal entities. This higher system aggregation level is relevant to

the focal system due to the important relations between the recycling and reuse markets that affect resources shortages and thereby system outcomes. Fig. 2 provides a system overview. Within the system, the different markets depict a cascade from production down through the aftermarket (use of the product), reuse and recycling. Except for the production phase, which is simplified due to the focus of the study, this cascade follows the waste management hierarchy. Therefore, it eventually involves energy recovery and landfills. For remanufacturing in general, products or parts become available at some point during their product life, regularly during maintenance (the aftermarket), or at the car's end-of-life (the recycling market). The production and recovery/landfill markets, represented in a gray shade in Fig. 2, are part of the system observations underlining the general circularity and its boundaries. The focal marketing system discussed below concentrates on the reuse market with its relations with actors in aftersales and recycling markets (the dashed box in the middle of Fig. 2).

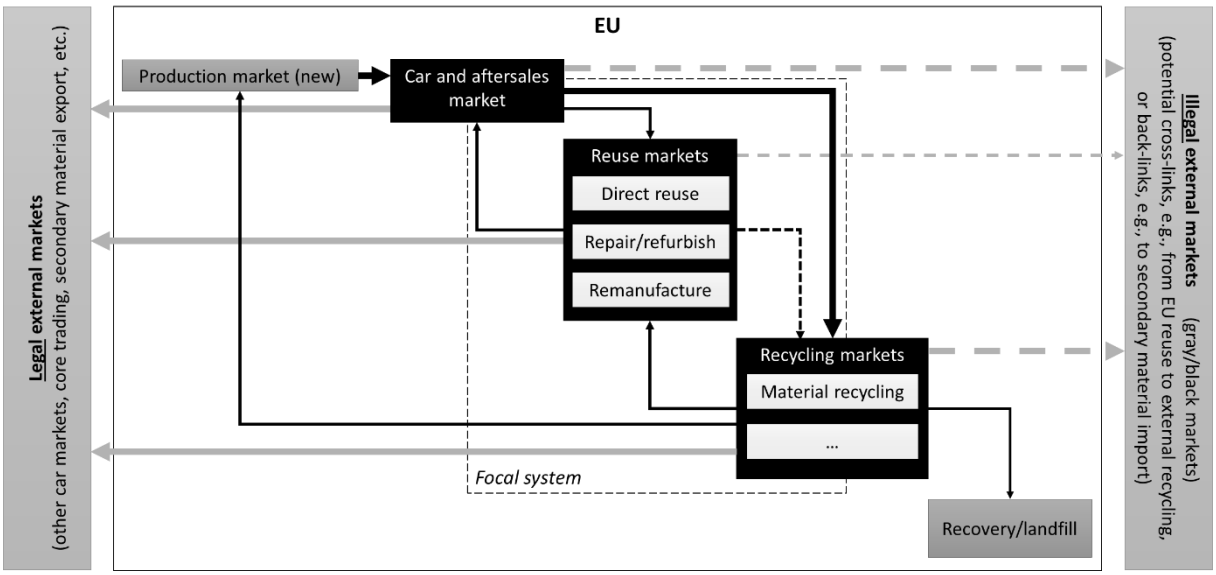


Figure 2: The EU end-of-life marketing system for passenger cars

The bold black arrows in Fig. 2 indicate the common material flows, and the thinner black arrows represent additional material flows within the marketing system. Flows represented

by bold gray arrows are leaving the EU marketing system and moving toward legal external markets. The dashed gray arrows represent the flows leaving the system and moving toward ostensibly illegal markets. The representation excludes reverse flows from external markets (imports). From both legal and illegal markets, materials can potentially flow back into the system. The arrow stretching from reuse to recycling is a dashed line because it represents a potentially undesirable flow within the system if it contains cores that can be remanufactured. In general, the objective for reuse and recycling markets in directing material flows downward might indicate potential negative outcomes within the marketing system because some of these resources may have been used at the same or higher levels of the cascade. In contrast to the downward flows, the recycling market is also a provider of resources to the reuse market (the 'upward' flow from recycling to reuse). The relations in this system also implicate financial and information flows.

This observation assumes a relatively closed system, where products and materials are supposed to remain within the system. Due to the institutional setting, the system is subject to exports and imports of materials. Exports can cause negative outcomes in the exporting market, for example, in the form of overcapacities in the recycling infrastructure or a lack of resources for reuse and recycling. Nevertheless, exports and imports are not necessarily negative outcomes. An exported used car can still run for years and provide mobility in other regional markets. If replacing an older car, *ceteris paribus*, the exported used car may reduce the environmental impact of mobility in the importing country. However, negative outcomes may occur if the local infrastructure cannot ensure environmentally friendly recycling.

The EU provides the legal environment for the reuse and recycling of used cars with defined targeted recycling rates that aim to increase the circular flow of materials (EU 2000, 2008). By law, distributors in the EU market are responsible for providing a take-back and dismantling

infrastructure for their marketed vehicles free of charge (EU 2000). Distributors regularly realize the take-back through authorized treatment facilities that makes decisions regarding reuse and recycling.

Due to the significant differences between de-registered and officially dismantled cars in the EU, a statistical gap of 'unknown whereabouts' accounts for approximately 4.6 million cars in 2008 and 3.3 million cars in 2009 (Merz and Mehlhart 2012). Reports from legislative bodies in Europe assume that these statistical gaps indicate the illegal handling of ELVs (Deutscher Bundestag 2015; MVDA 2011; Nationalrat 2013). Illegal handling includes the illegal export of cars, the export of ELVs, which is technically illegal, and unauthorized dismantling (Merz and Mehlhart 2012; MVDA 2011; Schneider et al. 2010). These unknown flows of used vehicles may contribute to the shortage of cores for remanufacturing.

*Automotive Remanufacturing Marketing System in the EU*

The automotive remanufacturing marketing system in the EU is the next level down in system aggregation. Currently, the US has the most developed automotive remanufacturing market. The overall market share of remanufactured automotive components in the US is more than double the corresponding market share in the EU (Weiland 2012). In Europe, starters and alternators reach a remanufacturing market share of approximately 80 %, representing the most developed part of the EU remanufacturing market (Weiland 2012). Other components reach a market share of approximately 50 % (APRA Europe n.d.). Overall, the EU automotive remanufacturing market is still less developed than its US counterpart (Weiland 2012). This comparison not only shows the potential of the remanufacturing market but also indicates different developments for different parts.

The nodes in this system are no longer markets; they are instead clusters of firms, i.e., groups of actors. Table 2 summarizes and describes the actors' basic business activities and their roles in the system. In this system (see Fig. 3), the actors are grouped based on (a) their function (supplier, remanufacturer, or customer/distributor) and (b) their characteristics as original equipment manufacturer (OEM)-integrated or independent market actors (from left to right) or their role within the functional environment. Both groups of actors and their characteristics are derived from the literature review and system exploration.

Table 2: Groups of actors in the automotive remanufacturing marketing system

| Group of actors | Basic business activities | Role in the remanufacturing market |
|---|---|---|
| **OE remanufacturing** | | |
| Original equipment manufacturers (OEMs) | Production of new cars (and some components for those cars) | Remanufacturing of particular (OEM) components |
| First-tier suppliers (of OEMs) | Production of new components for OEMs and car services (repair shops) | Remanufacturing of particular supplier components |
| **Independent remanufacturers** | Remanufacturing | Remanufacturing of types of components from different OEMs/first-tier suppliers |
| **Authorized repair shops** | Service for cars of corresponding OEM brands or a first-tier supplier brand | Customer for parts (new or remanufactured parts; rarely copies) and provider of cores |
| **Repair shops** | Service for vehicles of all brands (or a range of brands) | Customer for parts (new and remanufactured parts or copies) and provider of cores |
| **Scrap yards** (including dismantlers) | Treatment/preparation of end-of-life vehicles (ELVs) for reuse of components and for material recycling/recovery | Provider of cores |
| **Core dealers** | Trade with used car components (cores) | Intermediary: consolidation, sorting and allocation of cores |
| **Wholesalers** | Trade with spare parts (components) | Intermediary: Consolidating spare parts for (authorized) repair shops |
| **Integrated wholesalers** | Trade with spare parts and used parts (cores) and remanufacturing (can be outsourced) | Intermediary: consolidating cores (like a core dealer) and spare parts (for repair shops) at the same time |

The linkages connecting the nodes in Fig. 3 represent material flows, with an emphasis on supply and distribution channels. These linkages further suggest reverse monetary and information flows. The white arrows in the internal remanufacturing market represent contractual relationships at the remanufacturing level. The dotted arrow bypassing original equipment (OE) remanufacturing represents the unwanted flow from reuse to recycling (see Fig. 2). The linkages

are exchanges or transactions, depending on the stakeholders involved. Between the core dealer and linked market actors, a simpler and random exchange of cores may be the predominant linkage. Fixed transactions prevail within established reverse supply channels, such as those between authorized repair shops and OE remanufacturing.

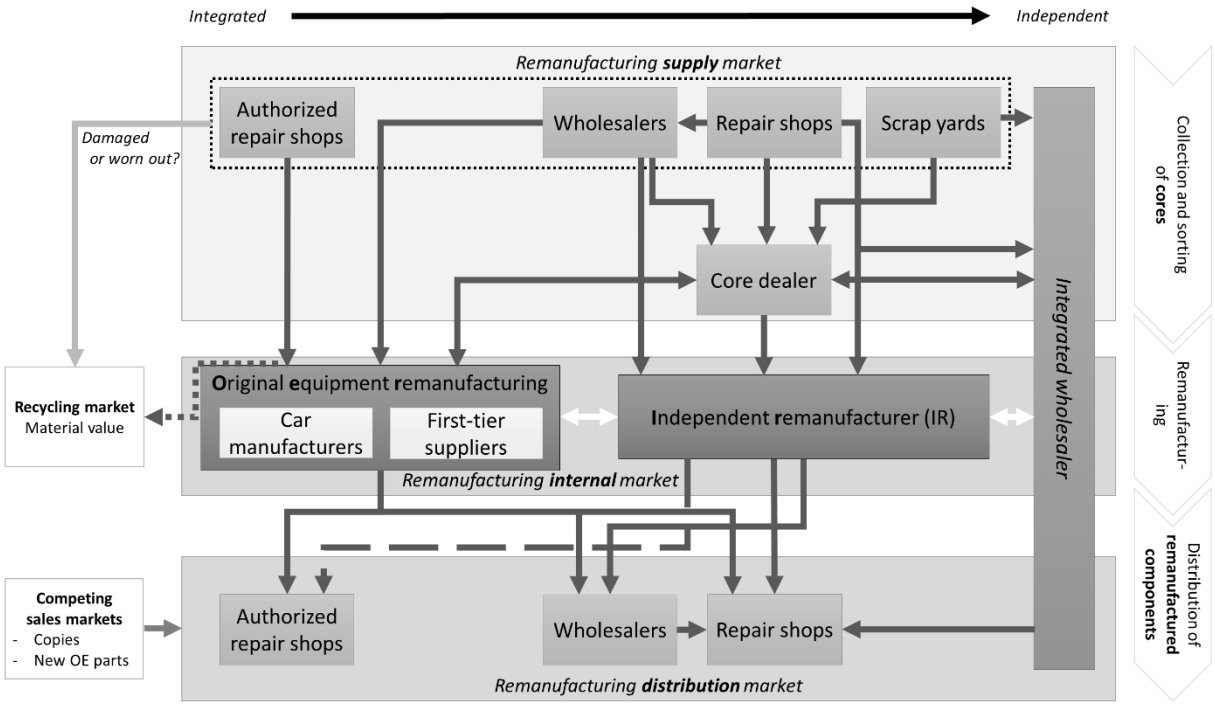


Figure 3: Identified material flows in the EU automotive remanufacturing marketing system

In this context, OEMs comprise car producers who also manufacture components and their first-tier component suppliers. In reverse channels for remanufacturing and from a perspective on OEM-dependency, (authorized) repair shops are simultaneously suppliers and distributors/customers for remanufacturers, and authorized repair shops depend on OEMs much more than the other actors. By contrast, wholesalers or repair shops are suppliers for both OEMs and independent remanufacturers (IRs), though they are less dependent on OEMs. The scrap yards (treatment facilities and other dismantlers) and core dealers are different because they are usually

only suppliers and are generally the most independent actors in this system. Integrated wholesalers fulfill a special role, namely, incorporating functions along the supply chain and maintaining relationships with other market actors at the different steps of the supply chain to provide remanufactured spare parts and collect cores. Integrated wholesalers are further involved in imports of so-called copies (third-party imitations of spare parts, usually from the Far East). These copies challenge both new spare part manufacturing and remanufacturing (ERN 2015b; Weiland 2012) because they put pressure on sales prices.

The level of aggregation described does not reflect the heterogeneity within the groups of actors. In general, OEMs and IRs almost equally share the remanufacturing market in terms of both remanufactured units and their market shares (Weiland 2012). The different remanufactured components characterize the actors' heterogeneity; OEMs mostly remanufacture the components that they produce in-house, while the IRs remanufacture selected types of components from different OEMs. Notable differences exist in firm size and diversification. For example, independent transmission remanufacturers appear to be relatively small because many highly specialized garages remanufacture transmissions locally (Weiland 2012; case B). By contrast, there are fewer IRs of starters and alternators, which are generally medium-sized companies.

Two major marketing channels exist at this level of system aggregation. First, there are the supply and distribution channels for OEMs, for example, car manufacturers such as Volkswagen and first-tier suppliers such as Valeo and Bosch. The coordination within this channel is relatively hierarchical. Second, there are the channels of the IRs. Within these channels, potential suppliers and customers include authorized repair shops, independent repair shops, wholesalers, and scrap yards. These channels have much more market-based coordination. Apart

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from scrap yards, these suppliers also work as distributors of remanufactured spare parts to customers. Usually, the repair shops are supplied by wholesalers in the distribution channel, though some repair chains may have a direct supply and distribution channel with the remanufacturer. The customers of the wholesaler are repair shops. Remanufacturers usually focus on transactions with wholesalers and repair shops instead of dealing with final customers due to the associated management costs of having too many sources (for example, Barnes 1982). Finally, core dealers work as intermediaries in the supply channel and provide the classic assorting service (Fuller, Allen, and Glaser 1996). They also represent a link between the OEM and IR channels because they trade with almost all market actors. The core dealer's main purpose is to consolidate reasonably sized and sorted core batches for remanufacturers, mainly from repair shops and scrap yards.

The higher-level system suggests potential shortages for cores, and actors in the focal system raise shortage issues regularly. Given this situation, the following sections approach the inefficiencies that affect system performance with regard to supply shortages. Supply shortages at the focal level may well affect outcomes at a higher level as well.

## Component Types and Scenes of Shortages: Analysis and Discussion

The observation of the focal marketing system leads to distinct groups of component types and to specific market channels and their issues and characteristics. The system reconstruction reveals notable shortage phenomena—what the authors refer to as *scenes of shortages*; therefore, these scenes are worth investigating. The analysis explores the question whether these *scenes of shortages* are rooted in market imperfections (as described by new institutional economics). These *scenes* involve the following types of shortages (the keywords in parentheses represent the major clusters developed from coding):

a) material shortages at the higher system aggregation level (legal environment and institutional setting);
b) material shortages in the focal system (supply shortages, supply channels, supplier relations, and use of deposits); and
c) information shortages in the focal system (supply shortages and innovation potential).

The following subsection analyses the three distinguishable groups of remanufactured components. The subsections thereafter analyze the *scenes* by applying the theoretical framework; a short discussion concludes each scene. The final subsection discusses the findings at a more general level.

*Component Types and Distinct Characteristics*

For the further analysis of shortages in the market, the results are summarized and clustered per three distinct remanufactured component types: (A) starters and alternators, (B) transmissions and parts for transmissions, and (C) mechatronics and electronics. The capital letters (A, B, and C) represent the corresponding anonymized case studies above. The clustered groups are characterized by (1) the market volume, (2) the intrinsic value of the remanufactured parts, (3) the parts' asset specificity, (4) the parts' protectability against remanufacturing, (5) the information asymmetries regarding manufacturing knowledge, and (6) the use of deposits. The first three characteristics are the determinants of transaction costs; the fourth characteristic corresponds to property rights; information asymmetries influence information costs; and the use of deposits corresponds to property rights and transaction costs. An additional characteristic, 'exchange type,' relates to the specificity of cores and components, which is an attribute that represents the degree of interchangeability in the reapplication of remanufactured components in different cars

or models of cars. The 'exchange type' kept separate for the sake of a clearer presentation. Table 3 summarizes the following characteristics of the remanufacturing cases.

For starter and alternator remanufacturing, the market share is among the highest in European automotive remanufacturing. The intrinsic value of starters and alternators is relatively low due to their well-known technology and materials. However, the material value depends on volatile raw material prices, e.g., that for copper. The intrinsic value also depends on specificity. The specificity of starters and alternators is low to moderate, as they can be interchanged within a product version (the same car model), though not necessarily due to design changes during their product life. Their legal protectability is low because legislation allows the production of copies; accordingly, the competition in corresponding automotive component types is high due to low cost copies from the Far East. Therefore, the information costs to remanufacture starters and alternators are relatively low for IRs. Remanufacturers of these components regularly use deposits in their customer relationships to incentivize core returns, though counterexamples for such deposit-based relationships exist as shown by case study A. However, the rise in mechatronics might soon increase specificity, protectability and information costs, even in the case of starters and alternators.

The market share of remanufactured transmissions is considered high, though exact statistics on the market share are lacking. Their intrinsic value is higher than that of starters and alternators, especially due to development and production costs. Parts of the transmission, such as the torque converter, may have a particular intrinsic value and a high specificity because mechatronics involve software and are capable of further linking a converter to one specific vehicle. Due to mechatronics, the level of protectability increases, though a transmission consists of more parts

than the torque converter. Therefore, a moderate level of protectability is found. Similarly, information costs increase because transmission remanufacturing is a highly specialized profession and requires special knowledge. Furthermore, deposits apply in the case of complete transmission replacement. In the case of local remanufacturing, deposits regularly apply only for particular parts such as the torque converter.

The characteristics change even more in the case of electronics. Mechatronic components, such as turbochargers, and electronic components, such as electronic control units, are of high intrinsic value, especially due to development costs. Furthermore, some parts contain valuable materials (e.g., gold or rare earth minerals). In addition, the specificity, protectability, and information costs of remanufacturing are very high. Electronics and mechatronics are easily configured to solely work on one specific vehicle; software increases the protectability substantially. The reverse engineering of electronics requires special skills, and remanufactured components must be frequently reprogramed by authorized dealerships. In some cases, reprogramming might be impossible without illegal interventions, which influences the specificity and protectability characteristics. Consequently, the market actors that correspond to these component types do not seem to require regular deposits due to the predominance of one-to-one exchanges of the very same unit.

Table 3: Characteristics of remanufacturing cases according to component types

| **Cases**<br>**Characteristics** | **(A) Starters and alternators** | **(B) Transmissions and parts** | **(C) Electronics** |
|---|---|---|---|
| **Exchange type** | 1:x (a unit for another unit) | 1:x (as with starters and alternators; exceptions apply in local remanufacturing) | 1:1 mainly (the same unit) |
| **Aftermarket share** *(Weiland 2012)* | High (~80 %) | High | (Still) Low (~14 %) |
| **Intrinsic value** | Low (–medium) | Medium | High |
| **Specificity** | Low–medium | Medium | High |
| **Protectability** | Low | Medium | High |
| **Information asymmetries** | Low | Medium–high | High |
| **Deposit use** | Yes; exceptions documented | Yes; in the case of local repairs, deposits applied to parts | No (in the case of 1:1 exchanges) |

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*Material Shortages at the Reuse and Recycling System Level*

The system description of the higher system aggregation level indicates known and unknown, as well as legal and illegal, exports of vehicles, which can cause a shortage of cores. Presumably, statistical gaps in the vehicle fleet balance are influenced by economic incentives. These incentives derive from exporting used cars or ELVs to foreign markets or from dismantling without obtaining official certification. The phenomena experienced due to a scrap premium support this assumption. The most prominent example in Europe was Germany, although other European countries experienced similar phenomena (for example, Rief 2009). When the German government introduced a scrap premium in 2009, the number of officially recycled ELVs rose significantly from approximately 0.4 million in 2008 to 1.8 million in 2009 and then fell to 0.5 million in 2010 (UBA and BMUB 2014), as the premium payment depended on the presentation of a certificate. In the context of the scrap premium, one expert (interview E) explicitly complained that the number of available core was still low; in particular, some well-preserved cars had been declared dismantled, but they were then exported. This complaint is in line with press information on ELV exports in the aftermath of the scrap premium, which could have circumvented the end-of-life dismantling of up to 50,000 vehicles (Dougherty 2009); notably, extra-EU exports were not necessarily illegal, but they resulted from a regulatory loophole (Landsberg and Latsch 2010). Hence, the scrap premium may not have significantly increased the number of available cores.

In the context of used vehicle exports, cross-border trade between Mexico and the US showed that used vehicle exports might result in positive outcomes in terms of sustainability in the importing country because the substitution of older vehicles might reduce emissions. However, a scrap premium in the exporting country can raise the prices of used cars, which decreases

the trade of used cars and thereby increases emissions in importing countries because older cars are then used for an extended lifetime (Davis and Kahn 2010).

Car exports, whether illegal or legal, are among the most prominent side effects at this system level. These side effects can cause positive and negative outcomes. In addition to negative outcomes in terms of resource losses, exports from the end-of-life marketing system may also cause environmental damage or negative health impacts in the importing regions. The treatment of e-waste in Africa (Hagelüken 2007; Huisman et al. 2015), where there may also be car electronics involved, serves as an example of such outcomes. Another example is the loss of platinum metals from catalytic converters. Due to the export of used cars, their catalytic converters may never reach end-of-life treatment for platinum recovery (Hagelüken 2012). The external marketing systems encompass material flows that the EU can hardly monitor. In particular, negative environmental outcomes due to unwanted material flows leaving the system show that the legislation and regulation of the marketing system does not achieve its intentions. Unwanted exports might be one reason for resource shortages, including the shortage of cores for remanufacturing.

At this scene of shortage, property rights and transaction costs may further elucidate the causes of the shortage and ultimately help solve this problem. Usually, private car users own their cars. Hence, in the absence of stricter regulations, car owners strive for a competitive price when they dispose of a car. Finding price offers for an ELV affects the transaction costs of car owners. However, selling an ELV to a car dealer might overcompensate for additional transaction costs, which makes this option more attractive than legal dismantling, where price offers are usually lower. Some EU member states have already implemented de-registration procedures that incentivize the correct treatment of ELVs. Such incentives are of indirect monetary benefit,

as the car owner is only exempted from the vehicle tax when he or she presents a certificate documenting its whereabouts (Wilts et al. 2014). On the one hand, the coupling of tax and certification is less costly than premium payments. On the other hand, this coupling will prohibitively raise the transaction costs of car owners in the case of illegal dismantling because continuous tax payments eventually overcompensate for the achieved sales price of the vehicle. Therefore, the end-of-life vehicle marketing system may conserve more resources, and the supply shortage in remanufacturing may be reduced. Such an approach will still not completely solve the issues surrounding the export of used cars that should be considered ELVs, but it at least reduces the attractiveness of exports that have low sales values as used vehicles.

*Material Shortages in the Focal Marketing System*

An initial approximation of the focal system provides the channel and relational structure. Two major channels are distinct due to the value chains of their market actors. In the channel with stronger internal coordination, the OEMs have one value chain for the production of new components and another value chain for the remanufacturing of these components. In the other channel with dominant market coordination, the IRs have a remanufacturing value chain, and integrated wholesalers may have a complementary value chain for third-party spare parts (i.e., copies). Strategically, the IRs react to the assortment of the OEM channel and imitate its products by remanufacturing. However, this reactive setup does not preclude the innovativeness of IRs with regard to remanufactured products.

This observation reveals further differences in the two channels. OEMs have their own distribution networks through authorized dealerships, which they may also use for core returns. OEMs can thereby reduce search and bargaining costs, as their dealerships collect and sort the

cores per the OEMs' requirements. Not only car manufacturers but also first-tier suppliers maintain their own repair shop networks; for instance, BOSCH has a Europe-wide network (Robert Bosch GmbH n.d.). Furthermore, OEMs are important suppliers for wholesalers. Wholesalers want to provide their customers with wide assortments of products. Therefore, wholesalers depend on their spare part suppliers, especially those from the OEM channel. By contrast, the IRs and their channels depend largely on other market actors such as core dealers, wholesalers, and repair shops. The outlined differences, especially that related to the contractual relationships with repair shops in the OEM channels, indicates the greater power of OEMs in the system relative to the IRs.

The existing relationships within the marketing system are relevant to understanding how and to what extent the two channels influence the effective operation of the marketing system. Admittedly, determining the individual characteristics of the relationships between each of the actors in the remanufacturing marketing system is difficult. In general, contractual and relatively close relationships characterize the linkages between the OEMs and authorized retailers. OEMs might also have contractual relationships with IRs, with the latter remanufacturing cores on behalf of OEMs (Lind, Olsson, and Sundin 2014). A remanufacturer typically has different supply channels and thus maintains different types of relationships with its suppliers (for a discussion of eight different relationships in remanufacturing, see Lind, Olsson, and Sundin 2014, or Östlin, Sundin, and Björkman 2008). A closer analysis of both the OEM channel, due to its potential power, and deposit-based relationships, due to their predominance in automotive remanufacturing (Östlin, Sundin, and Björkman 2008), supports the analysis of material shortages in the focal system.

*Contradictory intra-institutional relationships in the OEM channel.* OEMs can achieve higher prices for their remanufactured products than IRs can (Subramanian and Subramanyam 2012). Automotive OEMs remanufacture their products—most likely because of the assumed increasing market shares and profit margins relative to those of new parts (ERN 2015b); the existence of IRs further indicates the profitability of remanufacturing, even though transaction and information costs and the distribution of power may challenge IRs on the market. Because of internal coordination, search and bargaining costs for specific cores are presumably lower for the hierarchy than they are for market organizations. Similarly, the OEM already has more information on the components that are necessary to remanufacture the core, which results in lower information costs relative to those of IRs.

Despite the potentially increasing market share, the co-existence of two business models within OEM channel organizations indicates internal competition. The OEMs' fundamental business models are based on the production of new components. OEMs that remanufacture have at least two general product lines in the aftermarket: new parts and remanufactured spare parts. Regardless of the specific market objectives of each product line, OEMs may still prioritize their new products in strategic decisions, which stands in stark contrast to the IRs that focus on component reuse. A remanufacturing business model subordinated to a basic business model for the sales of new spare parts, combined with strategic advantages in terms of obtaining access to cores, may be misused; thereby, these conflicting business models increase the overall material shortage.

'He who owns the core owns the market' is a truism in the remanufacturing industry. From a micromarketing perspective, pursuing and regaining control over reverse material flows

for remanufacturing is a reasonable endeavor. For example, an interviewee mentioned that authorized repair shops might be obligated to return specific cores to their related car manufacturers, although the latter do not remanufacture these particular components and are not the OEM of the components (case C). When companies incentivize core returns but do not remanufacture these components, they are obviously using a preemption strategy (Ferguson and Toktay 2006). This strategy relates to property rights because the OEM wants to 'reverse' the transfer of core ownership. The OEM's power in its relationship with dealerships facilitates this transfer and marks an important difference between OEMs and IRs. The more easily remanufacturers can reverse the transfer of ownership, the lower the associated search and bargaining costs for core procurement are. Furthermore, the destruction of cores by OEMs is an 'open secret.' At ReMaTec, an expert indicated that some IRs that remanufacture for OEMs on a contractual basis might obtain an order to destroy cores instead of remanufacturing them (interview D). This observation is in line with the statement that "there are big OEM[s] destroying their core" (Amir Rashid, cited by Casper 2015, p. 14) and a case example from a German brake system OEM discussed by Lebreton (2007). An OEM representative (interview G) remarked that they strategically decide which cores they remanufacture, which they trade with core dealers, and which they dispose of for scrapping. Case A supports the last option, indicating that "shipments for scrapping [potentially] reach the market," occasionally through unofficial channels. Interview L revealed similar observations. Although such statements are hard, if not impossible, to prove, the control of resources through scrapping is a realistic option, and operational research discusses this option (Ferguson and Toktay 2006; Lebreton 2007). In addition, the fundamental business model might cause the excessive production of spare parts to comply with spare part availability obligations during the product's life. If the aftermarket does not demand this overcapacity, an

OEM may prefer to sell the new spare parts through its remanufacturing channel and scrap cores instead. Doing so might lower its margin, but it still ensures the recovery of costs from the primary production.

The absence of legal restrictions that limit scrapping, as well as contracts in the OEM channel, may hinder the flow of cores toward remanufacturing. Although is not always clear whether fundamental business model conflicts or strategic decisions with opportunistic objectives dominate, OEMs' decisions and activities regarding remanufacturing may include resource destruction and the (indirect) use of their market power to control reverse flows of cores. Consequently, the macromarketing system suffers from shortages and, in turn, may cause negative outcomes. Furthermore, the marketing system cannot exploit its full potential, which results in a limited assortment of components. Eventually, the IRs' transaction costs rise due to the resulting shortages. Therefore, the freedom of contract between (OEM-related) remanufacturers and (authorized) repair shops should be restricted with regard to obligatory core returns that lack verifiable proof of reuse/remanufacturing treatment. As a result, repair shops would be able to sell cores to other market actors, such as core dealers or IRs.

*Moral hazard and imbalances in deposit-based relationships.* In automotive remanufacturing, deposit-based relationships are predominant, although they might increase the transaction costs of some actors. Both OEMs and IRs use deposit-based relationships to incentivize core returns. Remanufacturers call for a deposit as a surcharge on the sale of a remanufactured component and refund the deposit when a core is returned. Exchanges of cores without deposits or other incentives are referred to as 'buy-back' relationships (Östlin, Sundin, and Björkman 2008). For example, a core dealer who purchases cores is in a buy-back relationship. In the interviews, the practitioners used both 'surcharge' and 'deposit,' sometimes interchangeably, when referring to the

same incentive mechanism. Such an incentive seems pragmatic and useful, though remanufacturers regularly refund core deposits only when the returned cores are in an acceptable condition for remanufacturing. Hence, a share of the deposit surcharge remains with the remanufacturer, who thereby locks up some of the financial means of its customers. In the focal marketing system, this mechanism causes a general imbalance in the financial flows (Fig. 4). The proportions of arrows in Figure 4 represent disproportional flows of deposits between supply and distribution and especially in direct relationships with remanufacturers.

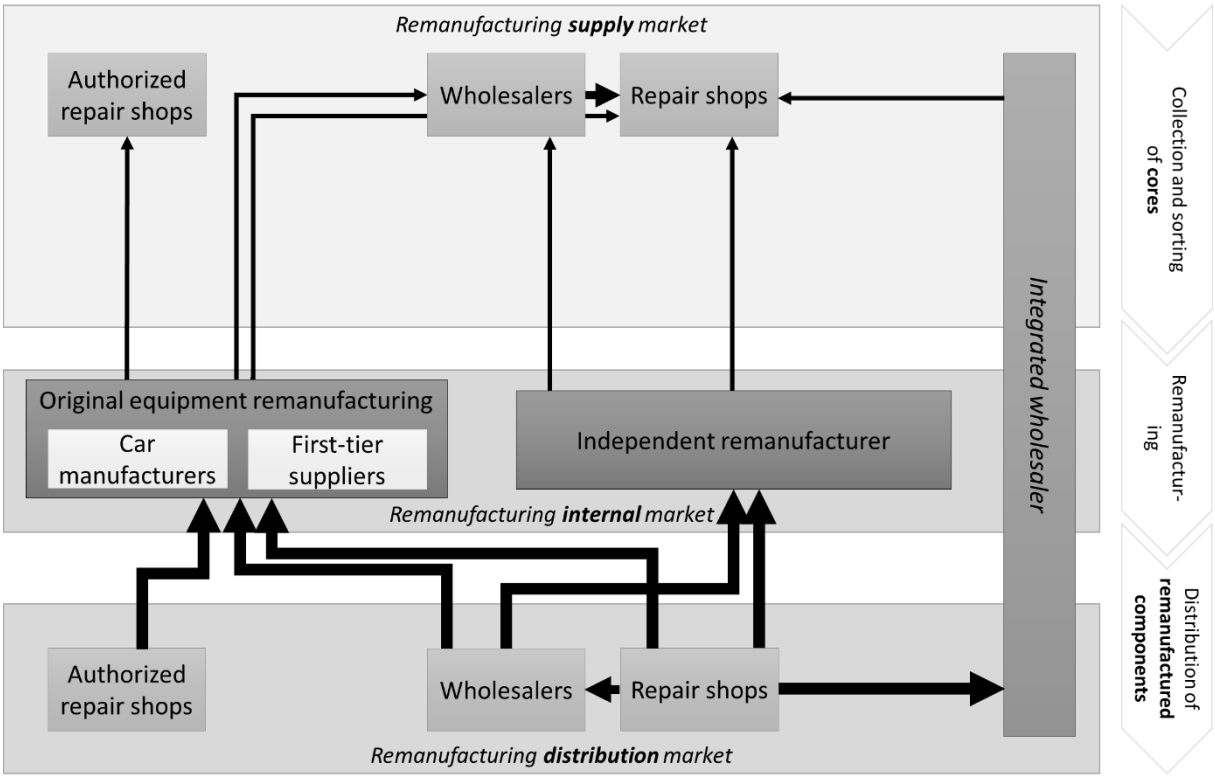


Figure 4: Unbalanced financial flows between the supply and distribution channels in common deposit-based relations

Most likely, the overall market power of OEMs allows them to charge even higher deposits than less powerful market actors such as IRs. These higher deposits thus cause an imbalance between the OEM and IR channels in favor of the OEM channel. These deposit conditions lead

to the higher returns of certain cores to OEM remanufacturers compared with those returned to IRs, probably because the potential loss of paid deposits is higher for OEM customers. A comparison of the return rates reported by OEM-related market actors and those reported by IRs supports this analysis. Return rates refer to the percentage of reusable cores relative to the number of charged deposits. At the ReMaTec 2015 exhibition, an OEM-related reverse logistics provider claimed that its return rate was greater than 85 %, while IRs reported return rates between 50 % and 70 %. Hence, the higher return rates in the OEM channel increase the immanent imbalance in material flows to the disadvantage of the IR channel.

Because of a system-specific situation in which the customers of remanufacturers become their suppliers, whether costs occur ex ante or ex post is not always easily discernable. Due to information asymmetries, especially regarding the quality of cores, the remanufacturer intends to reduce its search and policing costs by applying a deposit. However, deposit accounts and varying deposit surcharges require additional efforts in deposit management, which increase policing and enforcement costs. In some cases of starter and alternator wholesale and remanufacturing (e.g., case A; indicated by expert E), buy-back relationships replace the deposit-based relationship because of the increasing costs of deposit management. These practices defy the unwritten rules of the industry, which favor deposits, and show that the observed marketing systems can adapt to changing environments to a certain extent. Nevertheless, when IRs cannot meet the customer's demand for remanufactured components, wholesalers sell new components instead. In addition, cores have induced additional sorting and handling costs, which are related to search and information costs. Components are not easily identifiable; hence, cores need to be carefully sorted. Some components require a strict one-to-one exchange of the same unit (especially in the case of electronic parts); other parts must be physically identical at least (e.g., alternators).

In the case of the automatic transmission parts supplier (case B), even high deposits do not seem to sufficiently incentivize core returns. Instead, the case study interviewee suspects that some customers (i.e., local remanufacturers) 'shift' the deposit to their final customers by raising the total invoice amount without listing a deposit. This 'shifted deposit' seems to be an opportunistic strategy that exploits information asymmetries; because of the persistently high price differences between OEM and IR components, final customers may not notice these 'shifted deposits.'

The deposit-based relationship between remanufacturers and their customers eventually circumvents the core dealers, who act as intermediaries by performing related sorting and allocation functions (interviews F and L). Although remanufacturers usually address core dealers, the dealers come under pressure in their search for cores (case A; interview F). According to remanufacturing case A, spare part copies exert pressure on core markets. Together with the deposit-based core returns, this pressure has already led to a reduction in the number of core dealers. Fewer core dealers may increase the bargaining costs of IRs because the number of available cores in the market does not increase and the core dealers' bargaining potential increases due to less competition. The case study interviewee C supports these findings by identifying the complexity of OEM product ranges as a significant challenge for core dealers (e.g., the same product but different product IDs). This complexity further indicates that transaction costs may rise to a prohibitive level because of the phenomenon of artificially increased specificity.

The described context of deposit-based relationships in the automotive remanufacturing marketing system, together with the challenges faced by core dealers due to the shrinking size of the core market, demonstrates that the higher the power of the market actor is, the higher the deposit amounts successfully charged by this actor are. The policing and enforcement costs of de-

posit management are becoming prohibitive for smaller market actors, and they are hardly capable of improving their return rates. The described adjustment in the relationships of IRs who no longer establish deposit-based relationships illustrates how some IRs attempt to overcome a position of competitive disadvantage to challenge those in a more competitive market position.

While some independent actors substitute deposit-based relationships, others struggle because price differences undermine the incentivizing characteristic of deposits. In the case of 'shifted deposits,' the local remanufacturer does not risk its competitive position based on its lower prices relative to those of OEM components. How local remanufacturers address the cores involved in these transactions is unclear. They may dispose them or even sell them to other remanufacturers, core brokers or material recyclers to increase their own profit. Such measures would lead to a welfare loss resulting from the information asymmetries between the local remanufacturer and its customers. Moreover, this constitutes a resource loss for the remanufacturer or even a possible loss for the marketing system with respect to the flow of cores. Such characteristics show that deposit-based relationships can negatively affect the system's contribution to sustainability.

This analysis suggests that collaboration and consolidation should be facilitated in markets with many small independent actors. Doing so would support a move toward the advantages of internal coordination, which refers to collaboration and cooperation along the market-hierarchy continuum of the new institutional economics framework. For example, independent local transmission remanufacturers may improve their market power by collaborating with other local remanufacturers and their part suppliers, which may further lower their information costs. As intermediaries, the core dealers appear to play a crucial role in balancing power in the system.

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They provide an alternative for deposit-based relationships, and their ability to connect with further suppliers such as scrap yards may increase the core supply and simultaneously maintain transaction costs at a reasonable level. In the future, the marketing system should strive for a balance between the identified coordination principles of the two major channels to maintain its responsiveness. Policymakers should reassess market developments regularly and should intervene if the market's ability to adapt decreases.

*Information Shortages in the Focal Marketing System*

Another difference between the two identified channels in the remanufacturing marketing system is the innovation efforts of IRs. These efforts often are a result of their desire to overcome information asymmetries. For example, the IR case of automotive electronics (case C) shows not only that IRs remanufacture components to an 'as a 'good as new' condition but also that they may improve these components. Regarding one particular component, remanufacturer C claims that an innovation in sensors increased their resistance to vibrations. The European Remanufacturing Network (ERN) documents the remanufacturing case of steering racks, stating that their "process is often revealing weaknesses in the original product, which then, in many cases, can be eliminated during the remanufacturing process" (ERN 2015a).

IRs mentioned that they invest in their knowledge of spare parts, for example, to identify similar spare parts from the OEMs (cases A and C). The knowledge of similar or interchangeable parts is unique knowledge of the OEMs and results in information asymmetries. Some parts differ only marginally. For example, alternators may only differ in terms of their mounted pulleys or regulators, or alternators with a different casing will fit in a different car model. The interviewee from case C stated that "what we see is that the product range is big because you have

200 different part numbers, but the real range is five to six different [parts].” This knowledge reduces information asymmetries, which is essential for the competitiveness of IRs because it helps them meet certain demands for spare parts. However, this knowledge requires management, and not all IRs have sufficiently experienced staff to benefit from this innovation: “I guess fewer competitors obtain this [knowledge]…the experienced people, they are dying out” (case A).

IRs show important innovation potential because they take on the role of challengers in the market. IRs aim to lower barriers due to information asymmetries by acquiring knowledge about the remanufactured parts, which they use to improve or broaden their assortment of products. Improving product quality may lead to a longer product lifetime. Product knowledge that allows the reconfiguration of remanufactured spare parts to meet customer demands widens the assortment of components and increases reuse. These outcomes support circularity and efficient resource use and, in turn, impose a lower environmental burden. In addition, consumers may experience welfare gains due to lower prices.

IRs need to find attractive solutions that make their products more attractive to their customers. The price difference regularly accounts for the approximately 30 % lower prices relative to those of new components (UNEP 2013a). However, consumers often prefer good seller reputations over lower prices in remanufacturing, even though a seller with a good reputation may not provide the same high warranties that some sellers with less of a reputation do (Subramanian and Subramanyam 2012). Considering the importance of seller reputations, OEMs can exploit their market penetration and their brand strength in their remanufacturing activities. Therefore, IRs need to ensure the marketability of their products beyond their prices. Providing better solutions through innovation is an approach that may be able to ensure this marketability.

The struggle in the disequilibrium-provoking process of competition results in OEMs taking control over physical resources (the cores). IR strategies for cost efficiency and services again spurs OEMs to gain control over resources. For example, OE remanufacturers are involved in copyrighting. In the US, the US Copyright Office had to determine exceptions to the Digital Millennium Copyright Act (DMCA) to allow car owners the right to make car repairs involving access to electronic control units (US Copyright Office 2015). OEMs intend to control the access to their products after the legal transfer of ownership by implementing software-based solutions that are covered by copyright; in other words, they establish such solutions as intellectual property. This approach eventually strengthens their control over products and cores.

Although the legal circumstances in the automotive aftermarket in the EU are different from those in the US, mechatronics also challenge remanufacturing in the EU. While the physical remanufacturing of the printed circuit boards in an electronic control unit may be permitted, the required reprogramming of the car serial number or another unique ID frequently demands services by authorized repair shops and limits IRs' levels of service. Carefully weighted decisions, such as exceptions to the DMCA, may be a suitable approach if more universal solutions are not foreseeable.

Although copyright legislation differs between regions, the increasing implementation of software in formerly mechanical parts forces the IRs to adapt. Therefore, to improve the competitiveness of IRs, the right to reprogram an electronic control unit to a unique serial number should be treated in a similar way to the right to exchange mechanical components. Moreover, if barriers related to property rights that restrict access to product information were lower for independent actors, the core dealers would be able to further support IRs. Core dealers can use the

information exchanged with IRs to more easily identify the correct parts at their suppliers. This observation once again underlines the crucial role of core dealers in the system.

However, changes in the legal environment do not mean that IRs will no longer have to constantly search for a competitive advantage. The need to "establish relationships to their competitors, governments, and customers" (Fligstein and Dauter 2007) becomes especially important for IRs. At the policy level, IRs need to ensure that interventions do not reduce their competitive advantage. OEM-independent lobby groups are important when pursuing IR-specific interests. With their suppliers, IRs must establish successful supply channels and innovate in terms of both reverse channels and product assortments. IRs may even consider closer horizontal and vertical collaboration to strengthen their competitive advantage.

*Summarizing Discussion*

The remanufacturing marketing system is becoming increasingly relevant to reach sustainability objectives. Resource conservation, together with the demand for local and regional labor, benefits both the environment and society. A competitive environment in the remanufacturing marketing system fosters innovation that may contribute to the realization of sustainability objectives. However, OEMs' intention to control resources by increasing component specificity and protectability, actively exploiting property rights, and increasing information asymmetries may threaten the advantages of the overall marketing system. Under these circumstances, policymakers may find it difficult to identify interventions capable of balancing the power structures because of the unclear intentions of the OEMs. On the one hand, protecting mechatronics from compromising their security via third-party manipulation is a safety issue. On the other hand, this protection via increased control over resources creates shortages and thereby establishes market barriers.

Concerning the institutional arrangements in the marketing system, two coordination principles compete in the two major channels: internal coordination characterizes the OEM channel in form of stronger, contractually stipulated (at least in part) vertical integration; by contrast, market coordination characterizes the IR channel in the form of the division of labor between independent actors. The advantages of internal coordination, such as more constant circular flows due to lower search and bargaining costs, may conceal the risk of negative policies that provoke resource destruction. The advantages of market coordination, such as innovation and added value, can be accompanied by uneven material flows caused by coordination problems and information asymmetries.

The power of market actors at the OEM level influences the availability of cores in the system. On the one hand, the OEMs' ability to acquire and process more cores shows that their presence is a driver of the remanufacturing market. On the other hand, conflicting business models at the OEM level and resulting preemption strategies create barriers. These barriers create shortages and potentially cause resource destruction. Therefore, the role of independent market actors is important. IRs can contribute to better resource conservation due to their abilities to reduce information asymmetries and, in turn, lower the barriers caused by information costs. The intermediary role of core brokers can further support the reduction of costs in independent automotive remanufacturing. On a more general level, the identified imbalances of material, monetary and information flows depend on the market actors and component types involved. In addition to the destruction of previous added value, these imbalances may cause market imperfections in terms of greater environmental impacts. If policymakers consider regulating remanufacturing markets, they must acknowledge this complex marketing system.

**Conclusion**

The research on recycling markets from a macromarketing systems perspective provides an important contribution to marketing research. This paper contributes to a better understanding of remanufacturing marketing systems and the need for balanced regulatory measures therein. On the one hand, EU marketing systems for recycling and remanufacturing may hinder major contributions to sustainability due to institutional settings and related power structures. On the other hand, market-oriented organizations innovate and thereby contribute to more sustainable solutions. Thus, identifying appropriate policy measures for remanufacturing marketing systems as part of a circular economy is important.

While the intention to gain control over resources can be understood from a micromarketing perspective, macromarketers should raise additional questions about the overall benefits of such marketing systems, their potentially negative effects on the environment, and whether such mechanisms address other societal challenges. They should also ask themselves whether resource control enables more diverse product assortments. Society expects markets to provide answers to these questions as well. Policymakers and marketers should change how they approach remanufacturing marketing systems. On the one hand, policymakers should carefully observe market developments before intervening in order to understand the factors that drive particular firm behavior. On the other hand, marketers should be forced to identify whether conflicting business models that hinder circular product flows exist within their organizations. In particular, IRs should be encouraged to explore whether their market position could benefit from collaboration.

The marketing system analysis identifies some causes of potentially negative outcomes. The chosen approach further extends the body of research on marketing systems in general, as it applies methods and frameworks commonly used in macromarketing research. The marketing-

systems approach and the marketing-system analysis as a method proved useful in investigating reverse channel issues. Moreover, new institutional economics proved useful as a means of analysis. Nevertheless, the study and the approach have some limitations. Although macromarketing recognizes the impact that society has on the system, the present study considered society mainly in terms of basic sustainability objectives. Furthermore, the chosen macromarketing perspective neglects some aspects of the physical system. The conducted explorative investigation provides the data required for a qualitative theoretical analysis. However, additional data would be necessary to quantify system dimensions.

The given limitations provide opportunities for future research. Especially the acquisition of quantitative data such as market volumes, remanufacturing quantities, and employment remain a key challenge in estimating the retention of added value, emission reductions and labor effects. In addition, research on the relationship between the behavior of final customers as societal actors and the societal objective of sustainability is worthwhile. Since the study covers core dealers in a somewhat limited number and does not cover dismantlers and recyclers, research on dismantlers and recyclers would improve the understanding of the system. Moreover, the role of core dealers as intermediaries and the potential of collaboration as a means of reducing power imbalances are worth investigating. Similarly, research on the legal setting, especially with regard to property rights, in the context of the maintenance and repair of electronics would also enhance the understanding of reverse channel-oriented marketing systems.

**Acknowledgments**

The authors would like to thank the associate editor and the anonymous reviewers for their valuable comments on this article.

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