On the attractiveness of product recovery: The forces that shape reverse markets

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Abstract

Product recovery is a major contributor for implementing sustainable business practices. Within such operations, which are either driven by legislation or economic rationales, practitioners face strategic issues concerning reverse market entry and positioning. Although the complexity of acting on reverse markets is widely acknowledged, a comprehensive framework to facilitate decision-making in this area is lacking. In an attempt to fill that gap, we develop a model that supports Original Equipment Manufacturers' (OEMs') assessment of the attractiveness of reverse markets. We identify, from a comprehensive literature analysis, in-depth interviews, and engagement with a dozen companies from different countries, factors that influence key characteristics of reverse markets, and consolidate this lengthy list into a comprehensive model intuitively applicable to business practice. The model combines five forces that drive reverse markets: Access to recoverable products, Threat of independent recovery companies' (IRCs') market entry, Rivalry for recoverable products, Adverse effects on core business, and Remarketing opportunities. We propose for each a set of attributes that influences its power and direction. To demonstrate the efficacy of the model, we apply it in two industry settings, recovery of white goods in the United Kingdom and paper recycling in Germany. The present research enables OEMs to understand the structure and forces that drive reverse markets, identify levers to influence those markets, anticipate market developments, and formulate resilient strategies for product recovery.

Keywords: Reverse logistics; Closed-loop supply chain management; Strategy development; Market analysis; Sustainability; Case studies

<heading level 1> Introduction

Product take-back and recovery have been shown, in numerous implementations of sustainable business operations, to generate significant revenue streams (Maslennikova and Foley 2000). Original Equipment Manufacturers (OEMs) that extend their core business through product recovery operations are usually seeking either to generate profits from replacement of primary inputs (recycling, retrieval) or to enter new market segments with reprocessed products (reuse, remanufacturing, refurbishing) (Stindt and Sahamie 2014). On the downside, product backflows increase the complexity of supply chains (Kapetanopoulou and Tagaras 2011), posing management challenges associated with, among other things, acquisition of collectable goods in sufficient volume and of suitable quality, peculiarities of the secondary market, and interplay with the marketing of new products (Nuss et al. 2015). The uncertainties that attend such considerations frequently discourage OEMs' active involvement in markets for recoverable goods, which we term reverse markets.

Informed decision-making on the part of OEMs regarding entry and repositioning in reverse markets would benefit greatly from a structured assessment of the attractiveness of reverse markets, yet prior research has paid scant attention to the development of relevant models. Absence of this knowledge is posited as one reason "many companies are unwilling to enter the reverse logistics" arena (Krumwiede and Sheu 2002, 325) and thus miss profitable business opportunities (Geyer and Jackson 2004) that could enhance their competitiveness (Toffel 2003).

The present article attempts to fill this knowledge gap by systematically identifying, analyzing, and integrating, from the perspective of the OEM, the forces that shape the attractiveness of reverse markets. This research is informed by existing literature and by interviews and information gathered in industry projects conducted over the past decade

involving a dozen companies in diverse industry sectors located in different countries. The fundamental strategic decisions being evaluated are whether an OEM should generally engage in product recovery and how it should position itself on respective reverse markets. These decisions are strongly connected to the attractiveness of a reverse market, which in turn is a function of influencing factors that shape these markets. The research process was guided throughout by the following research question:

How can an OEM evaluate the attractiveness of a reverse market to support strategic decision-making?

Specifically:

Question 1 (Q1): What factors influence the attractiveness of a reverse market?

Question 2 (Q2): How can these factors be integrated into a comprehensive model?

Question 3 (Q3): How can such a model be integrated into a strategic decision-making process that considers both market knowledge and corporate capabilities?

These questions, which drove our development of what we have termed the "Reverse Five Forces" (R5F) model for assessing the attractiveness of reverse markets, are addressed successively in the article. The factors (Q1) are identified at the beginning of the section headed "Forces in Reverse Markets" and are subsequently developed into the R5F model (Q2) in the remainder of that section. The model's value for strategic decision-making with respect to reverse market positioning is demonstrated in the section headed "Empirical Validation: Case Studies," and insights into its integration into a holistic corporate decision-making process

informed by a thorough understanding of target markets and corporate capabilities (Q3) related in the section headed "Discussion."

<heading level 1> Assessing the Attractiveness of Reverse Markets – Review and Outlook

A well-established model for analyzing the attractiveness of markets in the traditional "forward-oriented" supply chain exists. "Porter's Five Forces" model (Porter 1979; Porter 2008) characterizes a market's attractiveness in terms of five forces—threat of new entrants, threat of substitute products or services, rivalry among existing competitors, bargaining power of suppliers, and bargaining power of buyers—that can be further subdivided into different factors. This model can help a company match core competencies and capabilities with market characteristics to reveal business opportunities and lay the foundation for strategic (re-) positioning as well as generate insights into how these forces can be influenced to actively reshape the market. But although widely accepted for traditional markets, the model cannot be directly applied to markets for recoverable products, as we explain below.

Within a closed-loop supply chain (CLSC) system, supplier, primary, and secondary markets are all perceived as traditional markets that follow similar principles (figure 1). Reverse markets exhibit substantially different characteristics (Wu and Cheng 2006), as shown below (see also table 1).

----------Insert figure 1 approximately here----------

In reverse markets, both business-to-business (B2B) and business-to-consumer (B2C) customers offer recoverable goods, such as end-of-use products, to recovery companies, including OEMs and independent recovery companies (IRCs). The actors' roles are thus reversed, the consumers of traditional markets becoming suppliers to corporations, which effectively become the consumers. In contrast to traditional supply chains, however, consumers

do not perceive themselves as suppliers and often do not actively participate in such markets. This presents increased difficulties for OEMs with regard to both identification of potential suppliers and relationship management in the reverse market. Common procurement measures like contracting are hardly applicable in reverse markets characterized by large numbers of diversified suppliers, few demanding actors (Fleischmann et al. 2000), and limited goods availability. Moreover, "[t]he collection of goods from the marketplace is a supply-driven flow, rather than a demand-driven flow" (Guide et al. 2000, 137), the quality of returned products is non-uniform, mostly unknown, and dependent on both initial product design and utilization patterns, and some obsolete products do not enter the market at all due to dissipations such as export or improper disposal. As well, the definition of market scope differs. Traditional markets are commonly defined by a distinct function provided with specific products. For instance, the market for portable music entertainment comprises all devices that satisfy the respective demand of customers, including MP3 players, smartphones, and iPods. In this sense, traditional markets are functionality- or customer-oriented. Contrastingly, reverse markets are defined by the focal product or material that is targeted for recovery. A metal smelting company may choose a broad market definition that encompasses all materials that contain significant amounts of steel, while a computer OEM may consider a much smaller market focusing on its own end-of-life products.

----------Insert table 1 approximately here----------

These differences in key characteristics between traditional and reverse markets lead us to conclude that models for assessing the former, especially Porter's Five Forces, will be more useful for OEMs considering product take-back if tailored to the reverse market. Nor do specific models exist, prior research on strategic decision-making in product recovery having focused almost exclusively on frameworks that support company-specific analyses (e.g., de Brito and

Dekker 2004; Geyer and Jackson 2004; Nuss et al. 2015; Subramoniam et al. 2010), and the broader field of sustainable supply chain management as well being devoid of models or frameworks that address the focal challenge (Brandenburg et al. 2014; Carter and Easton 2011; Carter and Rogers 2008; Seuring and Müller 2008). To the best of our knowledge, the only attempt to evaluate the profitability of remanufacturing industries is presented in a book chapter by Ferguson et al. (2010). The authors list a set of descriptive categories motivated by three existing frameworks including Porter's Five Forces. We extend previous research in developing, from close examination of what constitutes and shapes reverse markets, a tool, amenable to integration in OEMs' corporate decision-making processes, for making structured assessments of forces that shape such markets.

<heading level 1> Methodological Approach

Our exploratory research follows an inductive approach that progresses through three stages (figure 2). We ensure academic rigor in the first and second stages by applying Strauss and Corbin's (1990) proposed methodology for qualitative research, which requires open, axial, and selective coding of information.

----------Insert figure 2 approximately here----------

The first stage involves two parallel analyses that identify relevant factors that influence the attractiveness of a reverse market. We review the literature on obstacles to, and drivers and dynamics of, reverse markets. For this purpose an archival research (Searcy and Mentzer 2003) following the structured approach presented by vom Brocke et al. (2009) is implemented. In a first step, we conduct a keyword search in Google Scholar and Web of Science limited to peer-reviewed management science journals. The initial selection process encompasses a review of title and abstract. Afterwards, a content analysis was conducted with at least two of the involved

researchers evaluating each article. In parallel, we adopt a mix of case study approach, using the interview method, and action research. This way, we combine what Coughlan and Coghlan (2002) define as research 'in action' with research 'about' action. We employed theoretical sampling to select studies that span multiple types of reverse market players that differ with respect to industry sector, organizational structure, and business model. The rationale for such an approach is to strengthen the validity of the findings, as asserted in Voss et al. (2002) and Boyer and Swink (2008). It is worth noting that our approach is qualitative in nature, as defined by Ketokivi and Choi (2014), i.e. our intention is not to quantify each of the forces described in this paper, but rather to outline the factors that affect the attractiveness of the reverse market.

The first source of industry experience involved four, 4- to 16-month projects, transformational in nature, in which at least one of the authors participated. Eight semi-structured interviews with corporate decision-makers involved in product recovery comprised the second source. The 12 companies from which we drew experience were divided between OEMs (8) and IRCs (4), the latter included because they provide perspectives on reverse markets that are relevant but commonly not recognized by the former. An anonymized overview of the participant companies along with key information, involved roles and implemented method is provided in table 2.

----------Insert table 2 approximately here----------

Having compiled the factors identified in the literature and case studies (open coding), we commenced the second stage of developing the model, through consolidation of the insights generated. We first classified, after eliminating redundant and merging similar, factors into logical groups that affect similar areas of reverse markets (axial coding). We then developed a

two-level hierarchical order to represent interrelations between these factors (selective coding), the top level, the forces that shape the market, the lower level the underlying attributes.

Validation of the R5F model through observational field cases in two reverse markets, white goods and paper and pulp, was performed in the third stage.

We accounted for both scientific and multiple case perspectives to assure the development of a generalizable model adaptable to manifold applications, and employed an international and interdisciplinary research team in order to account for common patterns across industry sectors, business models, and regional peculiarities.

<heading level 1> Forces in Reverse Markets

We elaborate here the first and second stages of our research methodology (figure 2). Please note that our arguments are backed up by either prior research, our case studies and industrial collaborations, or both. To improve readability, we refer to the companies as C1 to C12 (table 2).

In the first stage, we identify factors that influence the attractiveness of reverse markets. For this, we supplemented with industry insights and interviews analyses of frameworks for company-specific strategic decision-making and further studies of CLSC decision-making that casually mention relevant factors. The lengthy list of factors generated by these activities yielded the attributes we aggregated into the forces that shape reverse markets (table 3).

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In the second step, we build on the insights gathered in the first stage and consolidate the identified factors, which results in five forces—Access to recoverable products, Threat of IRCs' market entry, Rivalry for recoverable product, Adverse effects on core business, and Remarketing opportunities (figure 3)–as well as a set of subordinate attributes that determine the

power and direction of each force. We depict the influence of a particular force in a given instance in terms of a positive or negative connector; for example, increasing threat of IRCs' market entry reduces (a "minus" sign), access to an abundance of recoverable product increases (a "plus" sign), the attractiveness of a reverse market. Descriptions of these forces, which in the aggregate determine how attractive recovery of a given product or product group is from the perspective of OEMs, are provided below.

----------Insert figure 3 approximately here----------

<heading level 2> Access to recoverable products

The effort expended on the acquisition and collection of products by companies involved in reverse markets is well documented (Matsumoto et al. 2010) and constitutes a critical issue (Geyer and Jackson 2004; Jayaraman and Luo 2007; Ravi 2012), hence the importance of identifying the factors that influence the accessibility of these products.

We designate as **reverse market potential** the total volume of end-of-life and end-of-use goods in a market. This number represents the upper bound of products that is theoretically collectable and can be approximated from a product's lifecycle and average length of use (Geyer et al. 2007). Long lifecycle products in a mature stage are likely to generate a steady flow of recoverable goods, especially when the period of use is relatively short. The metal and steel industry, for instance, obtains secondary raw material largely from the building and automotive sectors, both extremely mature industries that generate a constant and predictable flow of material that can be collected at any time (C3). We analyze below factors that influence the reverse market potential.

Customer structure in the primary market exerts a major influence on ease of access to goods (Li et al. 2011; White et al. 2003). The complexity of the collection process is reduced in B2B, relative to B2C, segments because the former produce substantial quantities of recoverable goods at fewer sites, thereby improving the ability to forecast the timing, quantity, and quality of backflows and facilitating active management of the reverse market suppliers (Knemeyer et al. 2002; Lebreton and Tuma 2006). That service agreements are common accounts, in part, for this circumstance (C7). Acquisition and backflow forecasting are perceived as less challenging for products commonly bought by corporate customers (C6; C8). Although IT equipment as well as scrap metal and steel are supplied by both the B2B and B2C segments, C1 and C10 rely mostly on corporate customers to feed their reprocessing systems. Companies that rely on B2C segments (C9) should expect to collect smaller fractions of reverse market potential.

Product design and degree of degradation as well as length and intensity of customer use affect the **quality of returns** (Oraiopoulos et al. 2012; C1; C7). The influence of these factors varies widely across customer segments. Some indemnification of supply risks is possible in the presence of **3rd party sourcing opportunities** interposed between recovery companies and the customer segments (Galbreth and Blackburn 2006). Reverse markets for such commodities as metals (C3; C10) and plastics (C5), and goods discarded to the municipal waste stream, rely almost entirely on collection by 3rd parties.

Access to recoverable goods is also determined by the **mobility of a product**. Smaller, lighter weight products facilitate handling and transportation, but dissipate through use (e.g., mobile phones), becoming difficult to trace and localize, which complicates supplier targeting and product acquisition. Dissipation may accrue to trade among customers or improper disposal.

Lesser degrees of dissipation are observed for immobile products like server racks (C1) and computer tomography scanners (C8).

Dissipation is also a factor in **customers' perceived marginal value** of a recoverable product (Morana and Seuring 2007). If, for example, marginal value is perceived to be higher than actual market value, consumers are likely to offer end-of-life products to one another (C9), negotiate with various demanding actors (C1), or simply store products at home (C12).

The dominant **forward business concept** of the involved OEMs may also affect reverse market potential. Leasing contracts and product-service-systems, such as are observed in the aerospace (C7) and mechanical engineering industries (C6) and IT sector (C1), limit the free flow of goods in reverse markets. Equally important are **established take-back channels**, which may be constituted by means of OEMs' trade-in programs (C1; C6; C7) or public collection of goods like WEEE or waste paper (C1; C2). Established take-back channels may limit the number of products freely offered in reverse markets, even as they reduce transaction costs and generate a steady flow of core for those involved. Further analysis of take-back channels may yield insights relevant to the development of promising take-back concepts (Morana and Seuring 2007).

Regulation & policies have also been determined to "impact the amount of product returns to a great extent" (Srivastava and Srivastava 2006, 534). As regulations, we refer here to mandatory laws that may limit access to particular products for purposes of reprocessing or constrain collection, as for reasons associated, for example, with toxicity (C1; C12). Policies are somewhat less overt attempts to influence market patterns or alter the mindsets or behavior of market actors (Tan et al. 2014). Policy initiatives may increase **customers' willingness to**

return products, an example being "Dual system Germany" (www.gruener-punkt.de), a plastic waste collection initiative that was successfully supported by an awareness campaign in schools and using billboard advertisements, among other measures (C5). Customers' willingness-to-return product may also be positively influenced by (financial) incentives (Guide and Van Wassenhove 2001).

<heading level 2> Threat of IRCs' market entry

This force summarizes factors on reverse markets that may serve as barriers to prevent a future market entry of IRCs. Among these barriers is the need for a reverse network to support implementation of reverse logistics activities, the development of which requires investment in various assets (e.g., specific facilities and equipment) that "did not exist previously" (Dowlatshahi 2005, 3459). Such **strategic costs** may be higher for IRCs, which typically lack a forward-supply-chain-oriented infrastructure at least partly suitable for reverse logistics. As "reverse distribution is not necessarily a symmetric picture of forward distribution" (Fleischmann et al. 1997, 6), even OEMs face strategic costs in the form of investment in specialized infrastructure. Such costs being subject to economies of scale, smaller actors particularly experience this barrier. In process industries, for example, product recovery is almost entirely the domain of OEMs (C2; C3; C5), related industries naturally having invested heavily in equipment, and integration of secondary inputs into primary production being well established.

The **technical feasibility** of product recovery is a fundamental consideration, reprocessing of some goods being extremely complex or even impossible (e.g., breaking chemical bonds). Recovery of carbon fiber composites, for example, is not possible in the desired quality due to fiber length issues (C7), and gradual contamination of scrap with

undesired elements is a major problem in steel recycling (Geyer and Jackson 2004; C3). Remanufacturing of some products is rendered financially unviable for IRCs by OEMs' monopolistic price setting for spare parts (e.g., control boards) (C11).

Even for products for which recovery is technically feasible, high **technology requirements** may pose a barrier to IRCs' market entry (C2; C3; C5). This barrier mainly depends on the ease of reprocessing (C8; C11). For instance, "[s]pecialist equipment is […] required, especially for running diagnostics and testing of components" (Chapman et al. 2010, 42). Apart from equipment, product recovery may depend on product-related **specific knowledge** including particulars of product composition and utilization and location of products in use, and/or a specific skillset for inspection and reprocessing (Hammond et al. 1998). Lack of the requisite skillset can render remanufacturing by IRCs virtually impossible (C8; C11). Large complex products "often composed of tens of thousands of components and parts" pose a "technical challenge" to recovery (Guide and Van Wassenhove 2009, 13). OEMs not only enjoy an information advantage over IRCs with respect to recovering certain products (Ferguson and Browne 2001), but may also incorporate features specifically designed to deter third party remanufacturing (Hammond et al. 1998; Majumder and Groenevelt 2001).

Entry to reverse markets can also be impeded by framework conditions in the form of **certifications & laws**. Disposal of products containing noxious substances is often subject to tight control and reprocessing limited to certified actors (C1; C7; C8). Certification may also pose a barrier to entry in the sense that certified organizations tend to be trusted by consumers to recover products in a way that satisfies the ecological and societal zeitgeist (C9). A similar effect is observable in the IT industry, consumers, owing to data security issues, preferring to surrender post-use equipment to trusted market players that guarantee data deletion (C1).

<heading level 2> Rivalry for recoverable products

Rivalry aims to assess the status-quo competitive structure in existing branches. In traditional markets, rival companies offer the same or similar products or services to the same markets (Carpenter and Sanders 2007). Understanding rivalry is less easy in reverse markets, market players not being clear-cut and commonly more heterogeneous. Rivalry in reverse markets centers on demand for the same kind of recoverable product (Knemeyer et al. 2002), and rivals can include OEMs, IRCs, waste brokers, non-governmental organizations (NGOs), and second-hand trading businesses, many of which, not being active in primary markets, are frequently overlooked by executives used to forward-supply-chain-oriented analyses.

Assessment of rivalry must thus begin with a thorough, differentiated analysis of a multiplicity of actors that employ different business models. **Rivals' segmentation** can be determined by analyzing their business models. An evaluation of the overall market for purposes of market positioning is necessarily informed by an in-depth understanding of its segments, the aims and scope of the players in each, and segment-specific competitive situations. Rivalry among OEMs may be driven by take-back legislation. Collective take-back schemes tend to increase competition, individual take-back by OEMs to result in monopolistic structures (Atasu and Subramanian 2012). Rivalry is thus expected to increase more consequent to the involvement of other OEMs than to that of other types of players (Ferguson and Toktay 2006). Because IRCs and brokers collecting computers, among other goods, for purposes of retrieving and trading valuable materials like copper and silver also constitute competition (Hatcher et al. 2011), other computer manufacturers must not be considered the only rivals (C1). Brokers acquire for direct reuse a significant fraction of the functional cores available in the reverse market, and various non-profit organizations (e.g., Create UK) are also involved in electronics

recovery. More familiar, perhaps, is charity organizations' collection of used textiles and furniture (C9). A significant portion of backflows may enter non-structured sinks that, albeit not classified as rivals, should nevertheless be considered (e.g., municipal solid waste streams and landfills and other forms of dissipation).

Development of segments and business models is influenced by the availability of **recovery alternatives**. The desired quality and composition of backflows differs with the recovery alternative represented by each segment. The quality level sought by OEMs primarily interested in equipment at least partly functional to be remanufactured or used as a source of components (C1; C6; C7), for example, differs from that which is acceptable to recycling-oriented actors (C3; C5). Pure trading companies, on the other hand, collect almost exclusively reusable cores. Degree of rivalry may thus differ across quality levels.

Diversity among the actors that originate reverse market demand, referred to as the **heterogeneity of rivals**, may reduce market attractiveness by inducing greater effort with respect to monitoring competitors' actions and posing challenges with respect to projecting rivals' strategic moves (C1; C9). A qualitative understanding of rival segments and patterns must thus be supplemented with quantitative information including the **number, size & concentration of competitors** within each segment (C2; C3; C9).

Competitive structure may also be influenced significantly by the **existence of intermediaries** that may accumulate large quantities of recoverable items (C2; C3; C4). Brokers and public waste collection institutions that offer product on the reverse market tend to prefer business partners of considerable size that procure large quantities of diverse quality, rendering the market most attractive to OEMs.

<heading level 2> Adverse effects on core business

The interplay between primary and secondary products may affect the collection, recovery, and remarketing of recovered products and resources, and product recovery influence aspects of primary production and sales in primary markets. A major influence on sales of primary products is referred to as **cannibalization** (Guide and Li 2010; Atasu et al. 2010). Cannibalizing primary product sales diminishes reverse market attractiveness from the perspective of OEMs. The perceived **quality differential between new & recovered product** determines the extent of cannibalization. If the differential is marginal, reprocessed products are seen as perfect substitutes and cannibalization is not a concern if, and only if, product returns are collected exclusively by OEMs and customers cannot distinguish between the primary and reprocessed product (Atasu et al. 2010). Cannibalization becomes a problem when OEMs recover and remarket used product that is distinguishable from the primary product, which decreases customers' willingness to pay for the latter (Agrawal et al. 2012), and when recovered goods offered on the secondary market by IRCs decrease OEMs' primary sales. In the former case, the resale must be balanced with the cannibalization effect (Oraiopoulos et al. 2012), in the latter, **strategic stakes** as well as profitability may play a major role, as an "OEM may choose to remanufacture for the sole purpose of discouraging an external firm from doing so" (Ferguson and Toktay 2006, 361). In fact, the impetus for product recovery by companies active in an industry is often prevention of third-party acquisition of technology and market share (C1; C8).

Product recovery's **effects on brand image** must also be taken into account. Using recovered inputs can benefit OEMs by contributing to a positive green image (C2); those that neglect product recovery may even "seriously jeopardize their brand image and reputation" (Jayaraman and Luo 2007, 56). In some industries, however, product recovery can have an

opposite, negative effect on brand image and is scrupulously avoided by OEMs. Customers' perception that use of remanufactured components may compromise brand quality has been observed, for example, in the healthcare and automotive (C4; C8). Product recovery may incur additional operational risks as well as, for example, with respect to the earlier referenced issue of data security in the recovery of computers (C1).

Decisions that impinge on primary products may also affect product recovery. With respect to **speed of innovation**, for example, less frequent innovation in a primary product increases the time frame during which recovered product can be remarketed (C2; C3; C10), and vice versa (C1; C12). Product recovery also has implications for **product design**. Although products are "typically not designed for end-of-life value recovery" (Geyer and Jackson 2004, 59), considering recovery issues during a product's design-phase may "significantly influence[…] the cost of disassembly, component inspection and repair, remanufacturing and recycling" (Chung and Wee 2008, 528). Planned obsolescence, notwithstanding its negative effects on consumers and the environment, as a design strategy can secure a steady flow of cores.

<heading level 2> Remarketing opportunities

Because companies' voluntary participation in product recovery hinges on the profit potential of remarketing (Quariguasi Frota Neto and Van Wassenhove 2013), the **existence of a secondary market** is essential. Secondary markets can be internal, involving substitution of recovered for primary inputs and generation of spare parts (Toffel 2003), as in the aerospace sector, in which use of recovered components enables primary product to be maintained without diverting manufacturing capabilities to spare parts production (C7), or external, in which recovered products are offered on external secondary markets. The existence of such markets depends on quality of reprocessed goods, cost structure, and price, among other factors.

Customers' willingness to pay depends on customers' perception of the value of a recovered good. Products composed of recycled metals and plastics, for example, are often indistinguishable from new products (C3; C5), whereas other recovered products are perceived to be of lower quality (Geyer and Jackson 2004; Guide and Li 2010; Harms and Linton 2015; C4). Willingness to pay for recycled commodities is largely determined by raw material prices (Rathore et al. 2011; C10). Subramanian and Subramanyam (2012), Quariguasi Frota Neto et al. (2016) and Pang et al. (2015) conducted empirical studies of price differentials between new and recovered products based on eBay data, and Quariguasi Frota Neto and Bloemhof (2012, 102) conclude that, for mobile phones and personal computers, willingness to pay "is a function of the prices of the corresponding new products at launch, and years elapsed between launch and remanufacturing." Abbey et al. (2015a) and Abbey et al. (2015b) showed that for certain products consumers would not be willing to purchase a remanufactured product, regardless of the levels of discounting. Customer segment can also influence customers' willingness to pay (Ferrer and Ayres 2000). All else being equal, business customers' focus on functionality leads them to act more rationally and, as a result, to be more likely to buy reprocessed products (Lebreton and Tuma 2006). For example, although remanufactured tires can be as-good-as-new, private consumers tend to perceive them to be of lower quality and exhibit an unwillingness to pay a price close to that for newly manufactured product, whereas business customers (e.g., truck operators and airlines) are willing to pay near new tire prices for remanufactured product (C4). Other aspects such as risk perception levels (Hamzaoui-Essoussi and Linton 2014), pricing strategies (Ovchinnikov 2011), and consumer knowledge (Wang and Hazen 2015) were also reported to affect willingness to pay.

Many secondary markets not yet being fully developed, their **potential and dynamics** warrant consideration. Market size and growth rate must be projected as well as secondary market potential including consumer sensitivity to new technologies in connection with innovation (Rathore et al. 2011). **Technology life-cycles** may also afford opportunities for remarketing secondary products. Although former technologies often become obsolete and are no longer offered on the primary market as new technologies are introduced, specific customer groups ('laggards'), antithetical to adopting new technologies or unable to do so owing to incompatibility with existing system infrastructure (e.g., VHS or cassette recorders) may demand older product. Spare parts for long-lasting products like automobiles, aircraft, and manufacturing equipment are similarly demanded long after production of the primary product has ceased (C6; C7; C8). Short technology lifecycles not surprisingly may significantly diminish customer willingness to pay for reprocessed product.

Because they also influence costs, **sinks for unwanted by-products**, which may represent a significant part of overall backflow, also warrant examination. Unwanted products include non-focal product types, focal product types that do not satisfy quality requirements, and by-products generated by reprocessing (Knemeyer et al. 2002). The availability of appropriate sinks can significantly influence the cost structure of recovery operations in either direction, by adding costs (e.g., of dissipating toxic substances in CRTs; C1) or generating revenues (e.g., from the sale of cardboard; C2).

<heading level 1> Empirical Validation: Case Studies

We demonstrate the implementation and versatility of the R5F model by applying it to two distinct markets. We analyzed the viability of white goods recovery for an OEM located in

the United Kingdom, and, for a large, global paper manufacturer in Germany, the market for waste paper.

Application of the R5F to the reverse market for white goods reveals that it could be a potentially attractive market for OEMs in the future, especially for those with high brand recognition. Major challenges are the access to recoverable products and the adverse effects on core business. Nevertheless, some levers are revealed that may help the OEM altering the reverse market to its own advantage.

Application of the R5F to the reverse market for paper leads to the conclusion that it is highly attractive for companies already involved in the primary business. One of the most important points for this assessment are the considerable synergies that can be realized between the primary and secondary manufacturing processes. These processes are not practically distinguishable, which leads to another important point of very high entry barriers as a complete set of primary manufacturing machinery is necessary to use secondary input material.

While table 4 gives a brief overview of the assessment of the according forces, detailed descriptions of the cases are provided in the electronic appendix: www.insertlinkhere.com.

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The case studies revealed the R5F model to be helpful in enabling corporate decision-makers to derive a holistic picture, and thereby enhance their understanding, of all of the relevant aspects of the respective markets.

<heading level 1> Discussion and limitations

The R5F model is a hands-on managerial tool that ensures that relevant market-shaping factors are fully addressed in strategic decisions regarding market positioning. We demonstrate in the cases how it can help OEMs develop a profound understanding of reverse markets. OEM

decision makers will find the model useful for identifying attractive and profitable segments of reverse markets, detecting internal and external risks associated with product recovery, evaluating potential market developments, and revealing levers that can be employed to favorably re-shape a particular reverse market.

The model does not, however, address every aspect of strategic decision-making with respect to product recovery. Although the forces that shape reverse markets are essentially the same for all organizations, capabilities and resources vary across them, as the resource-based view suggests (Wernerfelt, 1984). That means that the extent to which it is suitable to enter a market will also vary across companies. Thus, besides market characteristics revealed by the R5F model, company-specific characteristics must be considered. To revive results from the case studies, OEMs for white goods with a positive brand reputation are likely to benefit from entering the reverse market as customers' willingness to pay is influenced by brand reputation. In the case of paper manufacturing, primary production equipment and recycling equipment is congruent and expensive. Hence, market entry requires either possession of primary production equipment or substantial financial resources. Reverse market opportunities must be weighed against corporate strengths and weaknesses to gauge a prospective market entrant's position relative to existing and potential future players. The R5F model thus constitutes a crucial part of an extensive decision-making process that integrates reverse market analysis with a structured evaluation of corporate capabilities. Integrating resources and capabilities is a natural extension of the R5F model and an opportunity for future research. Helpful starting points for capability analysis are articles on company-specific planning and decision-making, like Geyer and Jackson (2004) and Nuss et al. (2015).

<heading level 1> Conclusion

Product recovery, as a contributor to sustainable supply chains and, potentially, greater profits, has captured the attention of decision-makers, politicians, and the general public. But notwithstanding hundreds of articles devoted to the importance of markets for remanufactured and recycled products, prior research has failed to provide a comprehensive approach to evaluating the attractiveness of reverse markets. Reverse markets exhibit significant differences that render approaches to assessing the attractiveness of traditional markets inadequate. Understanding the forces that shape these markets is vital to strategic decision-making. Hence, the present article's contribution is the development of a dedicated model for assessing reverse market attractiveness.

We identified, through interviews and industrial projects conducted with companies engaged in product recovery in different countries, supplemented by prior research, factors that affect the attractiveness of reverse markets (Q1). We then developed a comprehensive model, which we term R5F (Q2), and discuss the integration of its analysis of reverse market characteristics with the evaluation of internal capabilities and resources in a comprehensive corporate decision-making process (Q3).

The R5F model affords management a hands-on managerial tool not only for assessing market attractiveness, but also for identifying levers by which reverse markets might be reshaped such that corporate capabilities and resources can be leveraged to achieve a competitive edge. The model can also be used to justify engagement in product recovery to shareholders and other stakeholders. Our research identifies characteristics that determine the attractiveness of reverse markets, reveals the structure of those markets and levers by which they might be reshaped, and yields insights that facilitate anticipation of market developments that can guide the formulation of resilient strategies for entry and positioning. More broadly, the model can be used to inform

and suggest policy measures, beyond simple regulations, that might expand the magnitude and scope of product recovery activities within particular industries. The R5F model is, for example, currently used by the Bavarian State Ministry of the Environment and Consumer Protection in a public project aimed at facilitating development of innovative approaches to increasing product recovery quotas in southern Germany.

Our research into the forces that drive product recovery and influence reverse markets has been validated in applications in which the R5F model has been effectively employed to provide comprehensive assessment of reverse markets and it supports the formulation and execution of strategies for reverse market entry and product recovery. The model contributes "freshness in perspective to an already researched topic" (Eisenhardt 1989, 548) and may serve as a catalyst for the genesis of a theoretical foundation for evaluating the attractiveness of reverse markets.

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<heading level 1> References

Abbey, J. D., J. D. Blackburn, and V. D. R. Guide. 2015a. Optimal pricing for new and remanufactured products. *Journal of Operations Management* 36: 130–146.

Abbey, J. D., M. G. Meloy, V. D. R. Guide, and S. Atalay. 2015b. Remanufactured products in closed-loop supply chains for consumer goods. *Production and Operations Management* 24(3): 488–503.

Agrawal, V. V., A. Atasu, and K. Van Ittersum. 2015. Remanufacturing, third-party competition, and consumers' perceived value of new products. *Management Science* 61(1): 60–72.

Agrawal, V. V., M. Ferguson, L. B. Toktay, and V. M. Thomas. 2012. Is leasing greener than selling? *Management Science* 58(3): 523–533.

Atasu, A., V. D. R. Guide, and L. N. Van Wassenhove. 2010. So what if remanufacturing cannibalizes my new product sales? *California Management Review* 52(2): 56–76.

Atasu, A., M. Sarvary, and L. N. Van Wassenhove. 2008. Remanufacturing as a marketing strategy. *Management Science* 54(10): 1731–1746.

Atasu, A. and R. Subramanian. 2012. Extended producer responsibility for e-waste: Individual or collective producer responsibility? *Production and Operations Management* 21(6): 1042–1059.

Atasu, A., L. N. Van Wassenhove, and M. Sarvary. 2009. Efficient take-back legislation. *Production and Operations Management* 18(3): 243–258.

Blackburn, J. D., V. D. R. Guide, G. C. Souza, and L. N. Van Wassenhove. 2004. Reverse supply chains for commercial returns. *California Management Review* 46(2): 6–22.

Boyer, K. K. and M. L. Swink. 2008. Empirical elephants—why multiple methods are essential to quality research in operations and supply chain management. Journal of Operations Management 26(3): 338–344.

Brandenburg, M., K. Govindan, J. Sarkis, and S. Seuring. 2014. Quantitative models for sustainable supply chain management: Developments and directions. *European Journal of Operational Research* 233(2): 299–312.

Carpenter, M. A. and W. G. Sanders. 2007. *Strategic Management – A dynamic perspective*. New Jersey: Pearson Prentice Hall.

Carter, C. R. and P. L. Easton. 2011. Sustainable supply chain management: Evolution and future directions. *International Journal of Physical Distribution & Logistics Management* 41(1): 46–62.

Carter, C. R. and D. S. Rogers. 2008. A framework of sustainable supply chain management: Moving toward new theory. *International Journal of Physical Distribution & Logistics Management* 38 (5): 360–387.

Chapman, A., C. Bartlett, I. McGill, D. Parker, and B. Walsh. 2010. *Remanufacturing in the UK*. Centre for Remanufacturing and Reuse, Resource Recovery Forum.

Chung, C.-J. and H.-M. Wee. 2008. Green-component life-cycle value on design and reverse manufacturing in semi-closed supply chain. *International Journal of Production Economics* 113(2): 528–545.

Coughlan, P. and D. Coghlan. 2002. Action research for operations management. *International Journal of Operations & Production Management* 22(2): 220–240.

de Brito, M. P. and R. Dekker. 2004. A framework for reverse logistics. In: Dekker, R., M. Fleischmann, K. Inderfurth, and L. N. Van Wassenhove (Eds.), *Reverse Logistics: Quantitative Models for Closed-Loop Supply Chains*. Berlin: Springer, 3–27.

Dowlatshahi, S. 2000. Developing a theory of reverse logistics. *Interfaces* 30(3): 143–155.

Dowlatshahi, S. 2005. A strategic framework for the design and implementation of remanufacturing operations in reverse logistics. *International Journal of Production Research* 43(16): 3455–3480.

Easwaran, G. and H. Üster. 2010. A closed-loop supply chain network design problem with integrated forward and reverse channel decisions. *IIE Transactions* 42(11): 779–792.

Eisenhardt, K. M. 1989. Building theories from case study research. *Academy of Management Review* 14(4): 532–550.

Ellram, L. M. 1996. The use of the case study method in logistics research. *Journal of Business Logistics* 17(2): 93–138.

Ferguson, N. and J. Browne. 2001. Issues in end-of-life product recovery and reverse logistics. *Production Planning & Control: The Management of Operations* 12(5): 534–547.

Ferguson, M. E., G. C. Souza, and L. B. Toktay. 2010. Examples of existing profitable practices in product take-back and recovery. In: Ferguson, M. E. and G. C. Souza. (Eds.), *Closed-loop Supply Chains: New Developments to Improve the Sustainability of Business Practices*. Boca Raton: Taylor & Francis Group, 145–159.

Ferguson, M. E. and L. B. Toktay. 2006. The effect of competition on recovery strategies. *Production and Operations Management* 15(3): 351–368.

Ferrer, G. and R. U. Ayres. 2000. The impact of remanufacturing in the economy. *Ecological Economics* 32(3): 413–429.

Ferrer, G. and J. M. Swaminathan. 2006. Managing new and remanufactured products. *Management Science* 52(1): 15–26.

Fleischmann, M., J. M. Bloemhof-Ruwaard, R. Dekker, E. A. van der Laan, J. A. E. E. van Nunen, and L. N. Van Wassenhove. 1997. Quantitative models for reverse logistics: A review. *European Journal of Operational Research* 103(1): 1–17.

Fleischmann, M., H. R. Krikke, R. Dekker, and S. D. P. Flapper. 2000. A characterisation of logistics networks for product recovery. *Omega* 28(6): 653–666.

Galbreth, M. R. and J. D. Blackburn. 2006. Optimal acquisition and sorting policies for remanufacturing. *Production and Operations Management* 15(3): 384–392.

Geyer, R. and T. Jackson. 2004. Supply loops and their constraints: The industrial ecology of recycling and reuse. *California Management Review* 46(2): 55–73.

Geyer, R., L. N. Van Wassenhove, and A. Atasu. 2007. The economics of remanufacturing under limited component durability and finite product life cycles. *Management Science* 53(1): 88–100.

Guide, V. D. R., V. Jayaraman, R. Srivastava, and W. C. Benton. 2000. Supply-chain management for recoverable manufacturing systems. *Interfaces* 30(3): 125–142.

Guide, V. D. R. and J. Li. 2010. The potential for cannibalization of new products sales by remanufactured products. *Decision Sciences* 41(3): 547–572.

Guide, V. D. R. and L. N. Van Wassenhove. 2001. Managing product returns for remanufacturing. *Production and Operations Management* 10(2): 142–155.

Guide, V. D. R. and L. N. Van Wassenhove. 2009. The evolution of closed-loop supply chain research. *Operations Research* 57(1): 10–18.

Hamzaoui-Essoussi, L. and J. D. Linton. 2014. Offering branded remanufactured/recycled products: at what price? *Journal of Remanufacturing* 4(9): 1–15.

Hammond, R., T. Amezquita, and B. Bras. 1998. Issues in the automotive parts remanufacturing industry – A discussion of results from surveys performed among remanufacturers. *International Journal of Engineering Design and Automation* 4(1): 27–46.

Harms, R. and J. D. Linton. 2015. Willingness to pay for eco-certified refurbished products: The effects of environmental attitudes and knowledge. *Journal of Industrial Ecology*. In press: DOI: 10.1111/jiec.12301.

Hatcher, G. D., W. L. Ijomah, and J. F. C. Windmill. 2011. Design for remanufacture: A literature review and future research needs. *Journal of Cleaner Production* 19(17-18): 2004–2014.

Jayaraman, V. and Y. Luo. 2007. Creating competitive advantages through new value creation: A reverse logistics perspective. *Academy of Management Perspectives* 21(2): 56–73.

Kapetanopoulou, P. and G. Tagaras. 2011. Drivers and obstacles of product recovery activities in the Greek industry. *International Journal of Operations & Production Management* 31(2): 148–166.

Ketokivi, M. and T. Choi. 2014. Renaissance of case research as a scientific method. *Journal of Operations Management* 32(5): 232–240.

Knemeyer, A. M., T. G. Ponzurick, and C. M. Logar. 2002. A qualitative examination of factors affecting reverse logistics systems for end-of-life computers. *International Journal of Physical Distribution & Logistics Management* 32(6): 455–479.

Krumwiede, D. W. and C. Sheu. 2002. A model for reverse logistics entry by third-party providers. *Omega* 30(5): 325–333.

Lebreton, B. 2007. *Strategic Closed-loop Supply Chain Management*. New York: Springer.

Lebreton, B. and A. Tuma. 2006. A quantitative approach to assessing the profitability of car and truck tire remanufacturing. *International Journal of Production Economics* 104(2): 639–652.

Li, K. J., D. K. H. Fong, and H. S. Xu. 2011. Managing trade-in programs based on product characteristics and customer heterogeneity in business-to-business markets. *Manufacturing & Service Operations Management* 13(1): 108–123.

Majumder, P. and H. Groenevelt. 2001. Competition in remanufacturing. *Production and Operations Management* 10(2): 125–141.

Maslennikova, I. and D. Foley. 2000. Xerox's approach to sustainability. *Interfaces* 30(3): 226–233.

Matsumoto, M., N. Nakamura, and T. Takenaka. 2010. Business constraints in reuse services. *IEEE Technology and Society Magazine* 29(3): 55–63.

Morana, R. and S. Seuring. 2007. End-of-life returns of long-lived products from end customer—Insights from an ideally set up closed-loop supply chain. *International Journal of Production Research* 45(18-19): 4423–4437.

Nuss, C., R. Sahamie, and D. Stindt. 2015. The reverse supply chain planning matrix: A classification scheme for planning problems in reverse logistics. *International Journal of Management Reviews* 17(4): 413–436.

Oraiopoulos, N., M. E. Ferguson, and L. B. Toktay. 2012. Relicensing as a secondary market strategy. *Management Science* 58(5): 1022–1037.

Ovchinnikov, A. 2011. Revenue and cost management for remanufactured products. *Production and Operations Management* 20(6): 824–840.

Pang, G., F. Casalin, S. Papagiannidis, L. Muyldermans, and Y. K. Tse. 2015. Price determinants for remanufactured electronic products: a case study on eBay UK. *International Journal of Production Research* 53(2): 572–589.

Porter, M. E. 1979. How competitive forces shape strategy. *Harvard Business Review* 57(2): 137–145.

Porter, M. E. 2008. The five competitive forces that shape strategy. *Harvard Business Review* 86(1): 78–93.

Quariguasi Frota Neto, J. and J. Bloemhof. 2012. An analysis of the eco-efficiency of remanufactured personal computers and mobile phones. *Production and Operations Management* 21(1): 101–114.

Quariguasi Frota Neto, J. and L. N. Van Wassenhove. 2013. Original equipment manufacturers' participation in take-back initiatives in Brazil. *Journal of Industrial Ecology* 17(2): 238–248.

Quariguasi Frota Neto, J., J. Bloemhof, and C. Corbett. 2016. Market prices of remanufactured, used and new items: Evidence from eBay. *International Journal of Production Economics* 171(3): 371–380.

Rathore, P., S. Kota, and A. Chakrabarti. 2011. Sustainability through remanufacturing in India: A case study on mobile handsets. *Journal of Cleaner Production* 19(15): 1709–1722.

Ravi, V. 2012. Evaluating overall quality of recycling of e-waste from end-of-life computers. *Journal of Cleaner Production* 20(1): 145–151.

Robotis, A., S. Bhattacharya, and L. N. Van Wassenhove. 2012. Lifecycle pricing for installed base management with constrained capacity and remanufacturing. *Production and Operations Management* 21(2): 236–252.

Searcy, D. L. and J. T. Mentzer. 2003. A framework for conducting and evaluating research. *Journal of Accounting Literature* 22: 130–167.

Seuring, S. and M. Müller. 2008. From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production* 16(15): 1699–1710.

Shaharudin, M. R., S. Zailani, and K. C. Tan. 2015. Barriers to product returns and recovery management in a developing country: Investigation using multiple methods. *Journal of Cleaner Production* 96(1): 220–232.

Sheu, J. B., Y. H. Chou, and C. C. Hu. 2005. An integrated logistics operational model for green-supply chain management. *Transportation Research Part E – Logistics and Transportation Review* 41(4): 287–313.

Souza, G. C. 2013. Closed-loop supply chains: A critical review, and future research. *Decision Sciences* 44(1): 7–38.

Srivastava, S. K. and R. K. Srivastava. 2006. Managing product returns for reverse logistics. *International Journal of Physical Distribution & Logistics Management* 36(7): 524–546.

Stindt, D. and R. Sahamie. 2014. Review of research on closed loop supply chain management in the process industry. *Flexible Services and Manufacturing Journal* 26(1): 268–293.

Strauss, A. and J. M. Corbin. 1990. *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*. Thousand Oaks: Sage Publications.

Subramanian, R. and R. Subramanyam. 2012. Key factors in the market for remanufactured products. *Manufacturing & Service Operations Management* 14(2): 315–326.

Subramoniam, R., D. Huisingh, and R. B. Chinnam. 2010. Aftermarket remanufacturing strategic planning decision-making framework: Theory & practice. *Journal of Cleaner Production* 18(16-17): 1575–1586.

Subramoniam, R., D. Huisingh, R. B. Chinnam, and S. Subramoniam. 2013. Remanufacturing decision-making framework (RDMF): Research validation using the analytical hierarchical process. *Journal of Cleaner Production* 40: 212–220.

Tan, Q., X. Zeng, W. L. Ijomah, L. Zheng, and J. Li. 2014. Status of end-of-life electronic product remanufacturing in China. *Journal of Industrial Ecology* 18(4): 577–587.

Toffel, M. W. 2003. The growing strategic importance of end-of-life product management. *California Management Review* 45(3): 102–129.

vom Brocke, J., A. Simons, B. Niehaves, K. Riemer, R. Plattfaut, and A. Cleven. 2009. Reconstructing the giant: On the importance of rigour in documenting the literature search process. *Proceedings of the 17th European Conference on Information Systems*.

Voss, C., N. Tsikriktsis, and M. Frohlich. 2002. Case research in operations management. *International Journal of Operations & Production Management* 22(2): 195–219.

Wang, Y. and B. T. Hazen. 2015. Consumer product knowledge and intention to purchase remanufactured products. *International Journal of Production Economics* (in press).

Wernerfelt, B. 1984. A resource-based view of the firm. *Strategic Management Journal* 5(2): 171–180.

White, C. D., E. Masanet, C. Meisner Rosen, and S. L. Beckman. 2003. Product recovery with some byte: An overview of management challenges and environmental consequences in reverse manufacturing for the computer industry. *Journal of Cleaner Production* 11(4): 445–458.

Wu, Y.-C. J. and W.-P. Cheng. 2006. Reverse logistics in the publishing industry: China, Hong Kong, and Taiwan. *International Journal of Physical Distribution & Logistics Management* 36(7): 507–523.

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Figure 1: Markets in closed-loop networks.

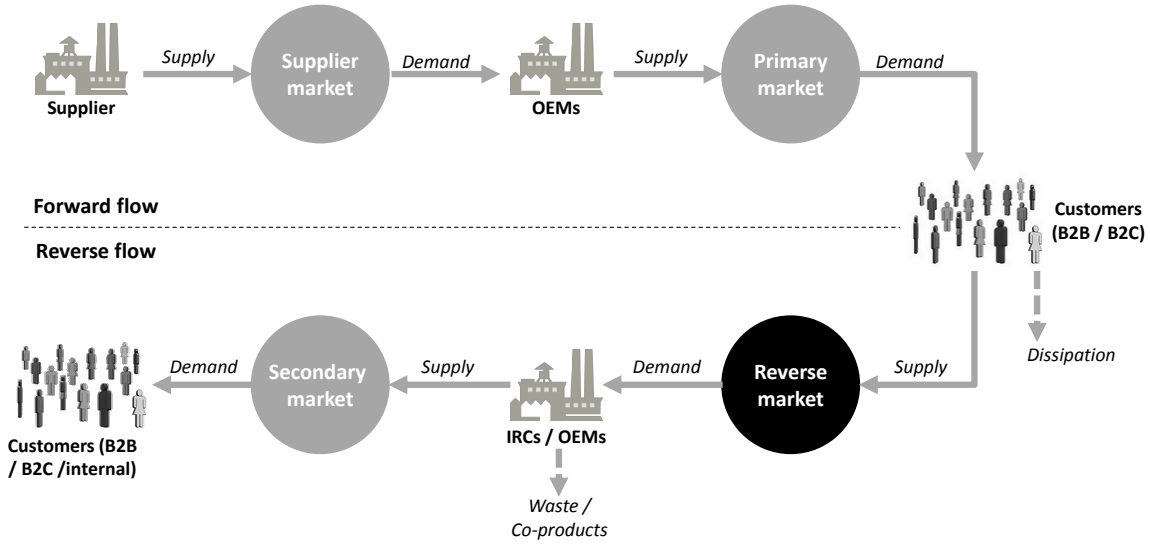

Figure 2: Methodological approach for development of theoretical model.

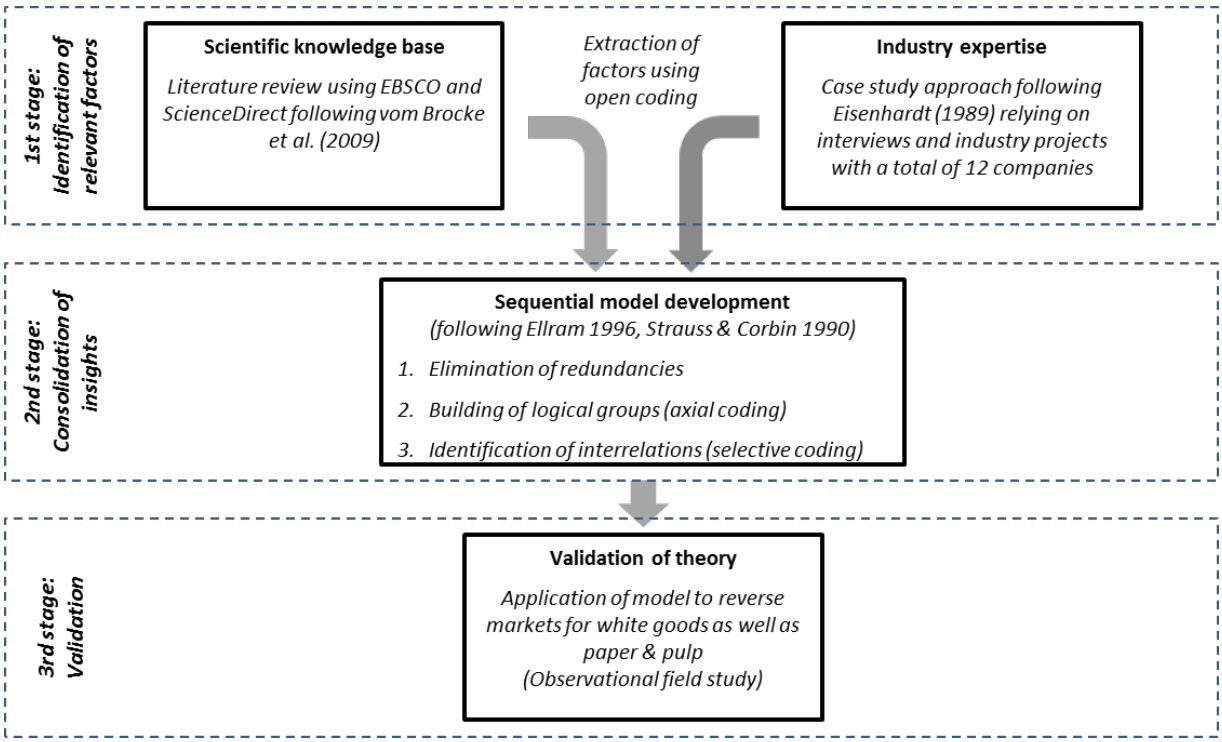

Figure 3: Reverse Five Forces Model (R5F).

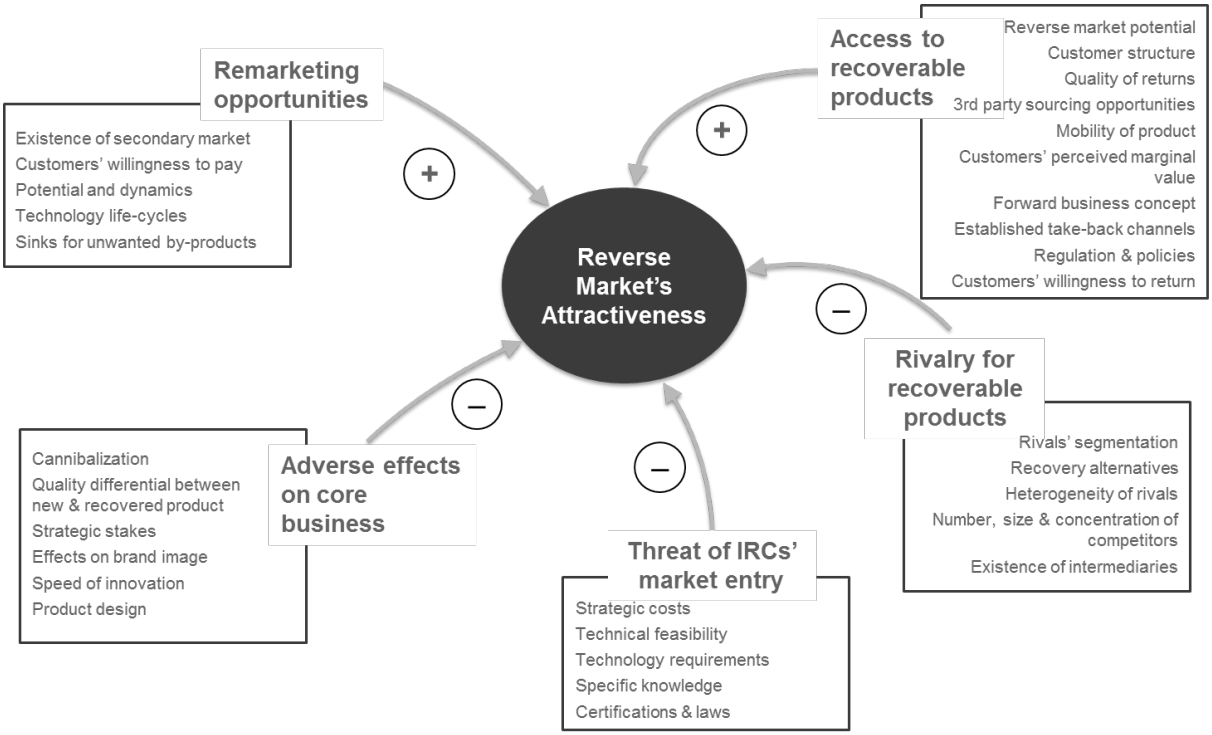

Table 1: Comparison of market characteristics.

	Primary/ secondary markets	Reverse market
Role of manufacturer	Supplier	Consumer
Role of customer	Consumer	Supplier
Origin of traded products	Manufacturer	Customer
Sink of traded products	Customer	OEM, IRC, landfill, dissipation
Product flow	Diverging	Converging
Network structure	Few-to-many	Many-to-few
Main source of uncertainty	Demand side	Supply side
Input quality	Homogeneous, deterministic	Heterogeneous, stochastic
Scope of market	Customer-/ Functionality-centered	Product-/ Material-centered

Table 2: List of companies studied within this article.

Company ID	Industry sector	Type of Company	Revenues (in USD)	Number of employees	Roles Involved	Implemented method
C1	IT-Equipment	OEM	30 – 50 bn	More than 150,000	Vice President Product Recovery	Action research
C2	Paper & Pulp	OEM	10 – 20 bn	20,000 – 50,000	Director Supply Chain Management	Action research
C3	Metal & Steel	OEM	10 – 20 bn	20,000 – 50,000	Head of Procurement (Scrap steel)	Action research
C4	Tire manufacturer	OEM	N/A	N/A	Representative of German Tire Manufacturer Lobby	Semi-structured interview
C5	Plastics & Polymer	OEM	N/A	N/A	Head of Department Plastics and Environment	Semi-structured interview
C6	Mechanical Engineering	OEM	10 – 20 bn	20,000 – 50,000	Head of Production	Semi-structured interview
C7	Aerospace	OEM	10 – 20 bn	50,000 – 150,000	Head of Strategic Capability; Defence Aerospace Project Manager	Semi-structured interview
C8	Healthcare	OEM	> 50 bn	50,000 – 150,000	Vice President Environment, Health and Safety (EH&S); Director Global EH&S; Director Refurbished Programmes	Semi-structured interview
C9	Furniture/ NGO	IRC	N/A	< 10,000	Managing Director	Action research
C10	Metal & Steel	IRC	5 – 10 bn	20,000 – 50,000	Executive Assistant	Semi-structured interview
C11	White goods	IRC	N/A	< 10,000	Company Director; Sales Manager; Technician	Semi-structured interview
C12	IT-Equipment/ NGO	IRC	10 – 20 bn	10,000 – 20,000	Director International Partners Compliance; Sales and Customer Service Specialist; Technician	Semi-structured interview

Table 3: Relevant factors influencing the attractiveness of a reverse market.

Forces / *Attributes*	Agrawal et al. (2015)	Agrawal et al. (2012)	Atasu et al. (2008)	Atasu et al. (2009)	Atasu et al. (2010)	Blackburn et al. (2004)	Chung and Wee (2008)	Dowlatshahi (2000)	Dowlatshahi (2005)	Easwaran and Üster (2010)	Ferguson et al. (2010)	Ferguson and Toktay (2006)	Ferrer and Swaminathan (2006)	Galbreth and Blackburn (2006)	Geyer and Jackson (2004)	Geyer et al. (2007)	Guide and Li (2010)	Guide and van Wassenhove (2009)	Hammond et al. (1998)	Hatcher et al. (2011)	Jayaraman and Luo (2007)	Knemeyer et al. (2002)	Lebreton (2007)	Lebreton and Tuma (2006)	Li et al. (2011)	Majumder and Groenevelt (2001)	Matsumoto et al. (2010)	Morana and Seuring (2007)	Oraiopoulos et al. (2012)	Rathore et al. (2011)	Ravi (2012)	Robotis et al. (2012)	Shaharudin et al. (2015)	Sheu et al. (2005)	Souza (2013)	Subramanian and Subramanyam (2012)	Subramoniam et al. (2010)	Subramoniam et al. (2013)	Toffel (2003)	White et al. (2003)	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Access to recoverable products																																																				
Reverse market potential			X		X	X					X				X	X		X	X	X			X	X								X		X								X	X			X					X	
Customer structure											X										X	X	X		X			X		X									X	X	X		X	X		X		X		X	
Quality of returns					X									X	X	X		X	X				X	X				X							X		X			X		X		X		X	X	X			X	
3rd party sourcing opportunities											X			X													X															X	X		X					X	X	
Mobility of product			X																X									X													X						X	X			X	
Customers' perceived marginal value										X					X			X	X			X						X								X					X							X			X	
Forward business concept	X	X	X			X					X				X					X												X			X		X			X	X				X	X	X				X	
Established take-back channels																					X		X					X			X		X		X			X	X	X	X		X			X	X		X			
Regulation & policies				X				X	X		X										X		X	X								X	X	X	X	X	X	X		X	X			X							X	
Customers' willingness to return		X						X												X	X							X				X	X			X			X				X	X				X	X		X	
Threat of IRCs' market entry																																																				
Strategic costs								X	X		X	X			X				X			X	X						X		X	X	X	X		X					X	X	X				X					
Technical feasibility			X												X				X	X				X						X	X						X	X	X			X	X	X	X	X	X					
Technology requirements							X	X	X		X							X		X				X	X	X				X			X							X		X	X	X				X				
Specific knowledge			X						X		X							X	X	X					X		X						X					X	X							X		X			X	
Certifications & laws			X																			X				X							X			X				X			X	X		X	X	X			X	
Rivalry for recoverable products																																																				
Rivals' segmentation					X						X	X							X	X			X			X		X		X	X					X	X			X		X						X		X	
Recovery alternatives												X	X						X				X	X						X										X			X		X	X						
Heterogeneity of rivals	X				X						X								X	X		X					X		X							X		X		X								X				
Number, size & concentration of competitors				X	X						X												X			X		X														X	X	X					X			
Existence of intermediaries			X																												X									X		X							X			X
Adverse effects on core business																																																				
Cannibalization	X	X	X		X							X					X	X			X		X			X			X						X	X			X	X			X			X	X					
Quality differential between new & recovered product	X		X		X				X						X	X	X						X	X											X	X			X		X	X	X	X							
Strategic stakes					X							X									X		X			X	X													X			X									
Effects on brand image	X				X				X						X						X		X			X	X			X			X	X	X	X	X	X	X		X		X									
Speed of innovation							X														X								X	X						X				X		X			X			X	X		X
Product design		X		X		X	X								X				X	X			X									X	X		X			X		X				X		X			X			
Remarketing opportunities																																																				
Existence of secondary market		X	X		X			X			X	X	X		X		X	X	X	X	X		X	X		X	X		X	X		X		X		X		X	X		X			X		X		X	X	X
Customers' willingness to pay			X		X			X			X	X					X				X		X	X			X		X	X					X	X		X			X		X				X				
Potential and dynamics					X							X	X								X					X															X											
Technology life-cycles					X		X				X						X	X		X	X		X						X	X										X					X	X	X				
Sinks for unwanted by-products											X											X														X	X			X	X			X								

Table 4: Application of the R5F to the case studies

Forces / *Attributes*	**White Goods**	**Paper & Pulp**
Access to recoverable products		
Reverse market potential	High	Virtually infinite, regenerating
Customer structure	Mostly households, geographically dispersed	Heterogeneous
Quality of returns	Significant fraction of bad condition	Highly heterogeneous
3rd party sourcing opportunities	Collection points run by municipalities, brokers and other third parties with strong position on the market	Municipal waste system
Mobility of product	Low to moderate	High, but negligible because of small value and high amounts
Customers' perceived marginal value	Low	None
Forward business concept	Independent from manufacturing	Independent from forward business concepts
Established take-back channels	Municipal collection and private contractors	Municipal waste system
Regulation & policies	Recycling preferred, no incentives for remanufacturing	Negligible regulations, policies facilitate product return and collection
Customers' willingness to return	High, without a fee	High
Threat of IRCs' market entry		
Strategic costs	Low	High
Technical feasibility	Particularly hard	Easy for low quality
Technology requirements	Low	High
Specific knowledge	Required	Medium
Certifications & laws	Ineffective	Negligible
Rivalry for recoverable products		
Rivals' segmentation	Brokers, remanufacturers, recyclers	Recovery market dominated by manufacturers
Recovery alternatives	Scarce	Virtually no recovery option above recycling
Heterogeneity of rivals	High	Low
Number, size & concentration of competitors	High number of small players, low concentration	Oligopoly
Existence of intermediaries	High	Predefined as collection is publicly organized
Adverse effects on core business		
Cannibalization	No concern	No concern
Quality differential between new & recovered product	High	Marginal, adjustable
Strategic stakes	Not present	Cost reductions in primary manufacturing
Effects on brand image	Unknown	Positive
Speed of innovation	Fast efficiency gains	Negligible
Product design	Not suitable for remanufacturing	Easily recyclable
Remarketing opportunities		
Existence of secondary market	Existent, but unknown size	Congruent to primary market
Customers' willingness to pay	Relatively high for products with high brand equity, low for the rest	Slightly lower for some products
Potential and dynamics	Slow growth	Stable
Technology life-cycles	Continuous innovations	Negligible
Sinks for unwanted by-products	Existent for most parts	Existent, partly profitable

Appendix:

On the attractiveness of product recovery in the white goods sector

This case considers, from the perspective of an OEM and in the context of the application of the framework developed in this paper, the attractiveness of the reverse market for washing machines in the United Kingdom. The case is distinguished from the other case elaborated in the paper by the fact that the remanufacturing processes are still not fully consolidated. That is, the focal OEM does not engage in product remanufacturing. Notwithstanding the focus on the OEM, multiple conversations were held with two IRCs and the remanufacturing facilities of them were visited at least once by two of the researchers. Interviewing independent remanufacturers was particularly important to gain an understanding of the dynamics of forces 'Threat of IRCs' market entry' as well as 'Access to recoverable products' and 'Rivalry for recoverable products'. While the OEM is a global brand, the independent remanufacturers both located in Europe act domestically.

'Access to recoverable products' is a serious issue for the OEM. Although the **reverse market potential** is high, obtaining high quality core is a challenge. The **customer structure** mainly consists of geographically dispersed households. Regarding the **forward business concept**, liaison with these B2C customers is via retailers, which is not beneficial to OEMs seeking to collect core. A significant fraction of returned core is of bad condition as the OEM observed that consumers "use [their machines] until [...] [they] break down." **Quality of returns** thus also reduces the attractiveness of the market. **3rd party sourcing opportunities** do exist, but they hold strong positions in the market limiting the possibility of a good bargain. On a positive note, **mobility of the product** is not a major issue as the product is mostly heavy and of considerable size making it hard to transport. Moreover,

customers' perceived marginal value is low, a segment of the customer population shows a high **willingness to return** the product as long as no expense is incurred in doing so. **Established take-back channels** are in place for one of the remanufacturers and could potentially be useful should it decide to engage in remanufacturing. **Regulations & policies** are geared towards recycling, and government-provided financial incentives for remanufacturers seem to be lacking. In summary, with respect to access to recoverable products, this is not an attractive market.

'Rivalry for recoverable products' is low if only the market for remanufactured products is considered. There is, however, a group of well-established rivals in the business of product take-back. These are segmented (**rivals' segmentation**) into brokers that compete for any type of core, recyclers looking for high- and low-quality core, and remanufacturers that tend to consider only high-quality returns. This leads to a reverse market that exhibits high **heterogeneity of rivals** comprising numerous players of different size and interests (**number, size & concentration of competitors**). **Recovery alternatives** thus differ among these players. With regard to intermediaries, retailers control much of the supply chain for returned products. **Intermediaries** exist in large numbers. The intermediaries that sell returns to remanufacturers may also be engaged in product recycling. Their power in the supply chain fluctuates with, among other things, the price of metal. Obsolete products are readily obtained when metal prices are low, but the balance tips in favor of intermediates selling core when the price of metal increases.

'Threat of IRCs' market entry', works in favor of the OEM as outlined below. **Strategic cost** is not a major impediment to newcomers, not least because economies of scale are difficult to achieve and the remanufacturing process is mainly conducted manually. Therefore, the **technology requirements** are low in many cases.

Conversely, **technical feasibility** is a far greater barrier to IRCs, particularly for the high-end spectrum of machines due to the ever-increasing complexity of the electronics and software components. Independent remanufacturers find it difficult to remanufacture washing machines when problems with defective returned core are electronics-related, and OEMs can to a large extent, whether intentionally or not, lock out new independent remanufacturers by controlling the supply of key spare parts and employing proprietary software for control boards. These circumstances can make IRCs' market entry technically impossible for certain product types. Potential competition from IRCs is further impeded by lack of **specific knowledge**, there being a shortage of trained personnel. Acquisition of the required knowledge to remanufacture low-end analog washing machines is straightforward, not so for newer, more sophisticated models. **Certification & laws** are ineffective in reducing impediments to or promoting future competition. In summary, technical feasibility and specific knowledge issues pose relatively high entry barriers to IRCs and thereby enhance the attractiveness of the market for OEMs.

With respect to 'Adverse effects on core business' our conversations with the OEM did not reveal fear of **cannibalization**. With the focal OEM not having a remanufacturing operation in place, our conversations with the IRCs have shown the issue of **quality differential between new & remanufactured products** for certain models of washing machines to be quite high. **Strategic stakes** not being present unlike the case in which proper functioning of products is crucial (e.g., healthcare equipment), the OEM is less concerned with driving competitors out of the reverse market to prevent poorly remanufactured washing machines. The **product design** is largely not suited for remanufacturing. Whether potential positive or negative **effects on brand image** exist, is a question that could not be clearly answered by the OEM.

Speed of innovation is also relevant. In general, although the product can be classified as functional, efficiency gains drive machines to rapid obsolescence, which guarantees a steady flow of returns. Summing up, 'Adverse effects on core business' are marginal favoring the market attractiveness.

A new line of remanufactured products, in particular of high-end models, would have a **secondary market**, but how large is unclear. A certain segment of the population shows a high **customers' willingness to pay**, as they perceive remanufactured washing machines with high brand recognition to be of good quality, but for most other washing machines that can potentially be remanufactured willingness to pay is low and the market insufficiently large to attract OEMs' participation. It is difficult to predict market **potential and dynamics**, but the OEM stated that it continuously re-assesses the secondary market observing a slow growth. Concerning **technology life-cycles**, we believe that OEMs will continue to drive innovation in order to persuade consumers to buy new products, and that this will only change if the current business model changes.

By conducting the analysis some major insights concerning the reverse market could be revealed. First of all, it can be noted that the market is characterized by an overall sufficient potential of recoverable products and a lucrative secondary market, especially for remanufactured goods with high brand-recognition. Nevertheless, this market is widely ignored by OEMs although the analysis suggests certain levers that may help the OEMs to further increase the attractiveness of individual product recovery. In particular, OEMs may mitigate the influence of IRCs on the market as they have a monopoly for needed spare parts and have advantages on the technical and informative knowledge necessary for recovery operations. Another lever may be an alteration of the forward business concept, for example by introducing product-

service bundles, leasing contracts or old-for-new offers at retailers. The benefits for an OEM with high brand recognition are threefold: First, by entering the reverse market the OEM may tackle its low-brand competitors on their playing field with limited risk of jeopardizing its primary market. Second, it may mitigate the risk from IRCs that remanufacture their own products. Third, and probably most importantly, it may offer the opportunity for earning additional profits. Surely and as already mentioned in the article, these insights alone are not sufficient for a holistic decision-making. Based on these initial observations and the thorough market understanding, the OEM must further elaborate on the topic matching its own capabilities, assess profit and loss effects in more detail and evaluate the needed changes within the organizational structure.

On the attractiveness of product recovery in the paper and pulp sector

This case evaluates the attractiveness of waste paper recovery from the perspective of a manufacturer that uses paper and pulp as inputs to the papermaking process. Information for this case was derived from a collaborative project that re-assessed a large paper manufacturer's European sourcing strategy for secondary raw material. Executives in charge of production planning, strategic purchasing, and supply chain management were engaged in numerous conversations throughout the project. In contrast to the white goods case, the focal manufacturer is already involved in product reprocessing, and waste paper has a long tradition as an input in the industry. The R5F model was consequently used primarily to enhance understanding of the market and potential rivals as opposed to evaluate market entry, as was the case for the white goods manufacturer.

Access to recoverable products is not a concern in reverse markets for paper. **Customer structure** typically involves a distinction between pre- and post-consumer waste paper, the former consisting largely of packing materials and other wastes concentrated at manufacturing sites, the latter of more heterogeneous materials that are highly dispersed. As both B2C and B2B customers regard used paper as waste, **customer's perceived marginal value** is negligible. **Established take-back channels** commonly organized by local authorities as part of municipal waste systems (**3rd party sourcing opportunities**) contribute to a high **customers' willingness to return** both pre- and post-consumer paper, and large amounts of pre-consumer waste may be returned directly to the reprocessing facility. The recovery rate for paper is consequently as high as 70% in Europe, and paper being used in manifold applications and sold in large quantities on the primary market. The overall **reverse market potential** is virtually infinite and continuously regenerating. Availability of recoverable paper is not restricted by **regulations**, most waste paper being free of toxic or otherwise harmful substances. Indeed, waste paper recovery is facilitated by laws like the European Directive on Packaging and Packaging Waste. As leasing and similar concepts are not common in paper trading the reverse market is totally decoupled from the **forward-business concept** of primary manufacturers. **Quality of returns** of post-consumer paper is highly heterogeneous as products include packaging, newspaper as well as graphical and office paper, and many other varieties. Although most authorities offer separate disposal channels for waste paper, returns are also often contaminated with other products (staples, plastics, organic wastes, etc.). Quality requirements in paper recovery are quite low and separation processes are well established. Although the high **mobility of the product** gives rise to numerous possibilities for dissipation (e.g., the general waste stream and the

fireplace), this concern is marginalized by the vast amounts of paper in use and continuous replenishment via the primary market. In sum, access to recoverable products registers as a positive factor with respect to the attractiveness of the reverse market.

Degree of rivalry for recoverable product is low in the reverse market for waste paper. There are fundamentally two **recovery alternatives**. Waste paper can either be used as a secondary input to the primary production process or can be energetically recovered. In practice (at least in central Europe), the latter occurs mostly in connection with such grades that cannot be used as secondary inputs due to technical restrictions (e.g., fiber length). **Rivals' segmentation** hence focuses on companies that demand waste paper to substitute primary inputs. As competition from IRCs is negligible, primarily companies active in the primary market are left as rivals. This market being characterized by a low level of **heterogeneity of rivals**, relevant competitors are easily monitored, being well known to one another. The resulting market can be best described as an oligopoly with few but large players (**number, size & concentration of competitors**) able to exploit their position as the largest consumers of waste paper collected and offered by **intermediaries**, whether local authorities or private contractors. These attributes clearly favor the OEMs and increase the attractiveness of the market.

Entry into the paper recovery business, **technical feasibility** notwithstanding (washing, re-pulping, fractionation refining, and dispersion, among other reprocessing steps, being well established and mature), is highly unattractive for IRCs. Waste paper used as a secondary raw material in the primary production process can be mixed in large quantities with primary raw material. Depending on the final product, the fraction of secondary material may vary between 30% for office paper and 100% for

newspaper grades. The need for a player seeking to enter the waste paper reprocessing business to invest in capabilities similar to those employed in primary production are consequently impeded by **strategic costs** driven mainly by high **technology requirements**. This is clearly the dominant attribute within this force. Paper manufacturing on an industrial scale is highly automated and requires special machinery costing several hundreds of million euros. **Specific knowledge** and **certification & laws** play inferior roles in paper recovery. That the threat of market entry by IRCs is consequently quite low increases the attractiveness of the market for OEMs.

Although **product design** is not explicitly considering recovery, waste paper is fully integrated into the primary manufacturing process. The **quality differential** between totally new product and products containing secondary input generally being marginal, distinct primary and secondary product does not exist, eliminating the risk of **cannibalization**. Moreover, use of waste paper resulting in reduced costs and being considered environmentally friendly contributes to positive **effects on brand image**. **Strategic stakes** (beyond these positive effects) do not factor as an impetus for entering reverse markets. Advances affecting recovery operations not being anticipated, **speed of innovation** is not a consideration. We thus perceive no adverse effects, and even some positive effects, on paper manufacturers' core business.

The **secondary market** for products made from or with secondary input is largely the same as for primary products. Only in specific niches is **customers' willingness to pay** higher for high-quality paper containing lower fractions of secondary material. At the other end, many environmentally conscious consumers prefer paper with high fractions of secondary input, up to 100%. Relative to secondary market **potential and dynamics**, demand for paper is considered to be

stable despite the print media seeming to be in enduring crisis, which is partly compensated by increased demand for packaging materials in connection with mail orders. **Technology life-cycles** likely to alter secondary market dynamics are not observed on the horizon. **Sinks for unwanted by-products** generated in the reprocessing of waste paper may in many cases be a source of additional profit (staples and cardboard, for example, can be sold to brokers).

Summing up, the reverse market for paper is highly attractive for companies already involved in the primary business mostly due to the considerable synergies that can be realized between the primary and secondary manufacturing processes. Indeed, these processes, being wholly symbiotic, are not practically distinguishable. Competition for waste paper consequently occurs exclusively between OEMs, which command a strong position vis-à-vis the intermediaries charged with waste paper collection. The foregoing analysis suggests that disruptive changes that would alter the structure of the market are not conceivable at present.