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On the Attractiveness of Product Recovery

The Forces that Shape Reverse Markets

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Summary

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.

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 enter new market segments with reprocessed products (reuse, remanufacturing, and 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 previous research has paid scant attention to the

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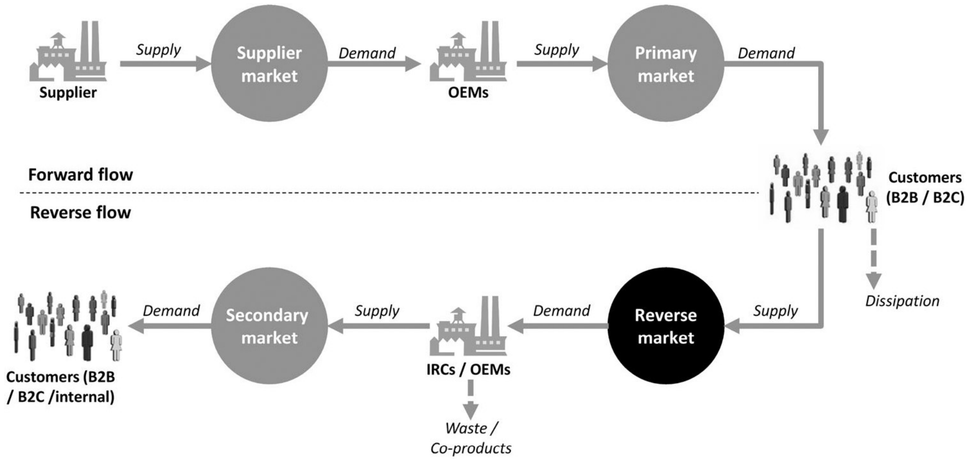

Figure 1 Markets in closed-loop networks.

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. We answer Q1 at the beginning of the section headed *Forces in Reverse Markets* and by subsequently developing the factors into the R5F model in the remainder of that section we answer Q2. 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 Q3 is answered in the section headed *Discussion*.

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, 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).

In reverse markets, both business-to-business (B2B) and business-to-consumer (B2C) customers offer recoverable goods, such as end-of-use (EoU) 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

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

Notes: OEM = original equipment manufacturer; IRC = independent recovery company.

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, "[the] 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 nonuniform, mostly unknown, and dependent on both initial product design and utilization patterns, and some obsolete products do not enter the market at all because of 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, whereas a computer OEM may consider a much smaller market focusing on its own end-of-life (EoL) products.

These differences in key characteristics between traditional and reverse markets led 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, previous 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 and colleagues (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.

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.

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 and colleagues (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. Afterward, 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 used 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 and colleagues (2002) and Boyer and Swink (2008). It is worth noting that our approach is qualitative in nature, as defined by Ketokivi and Choi (2014), that is, our intention is not to quantify each of the forces described in this article, but rather to outline the factors that affect the attractiveness of the reverse market.

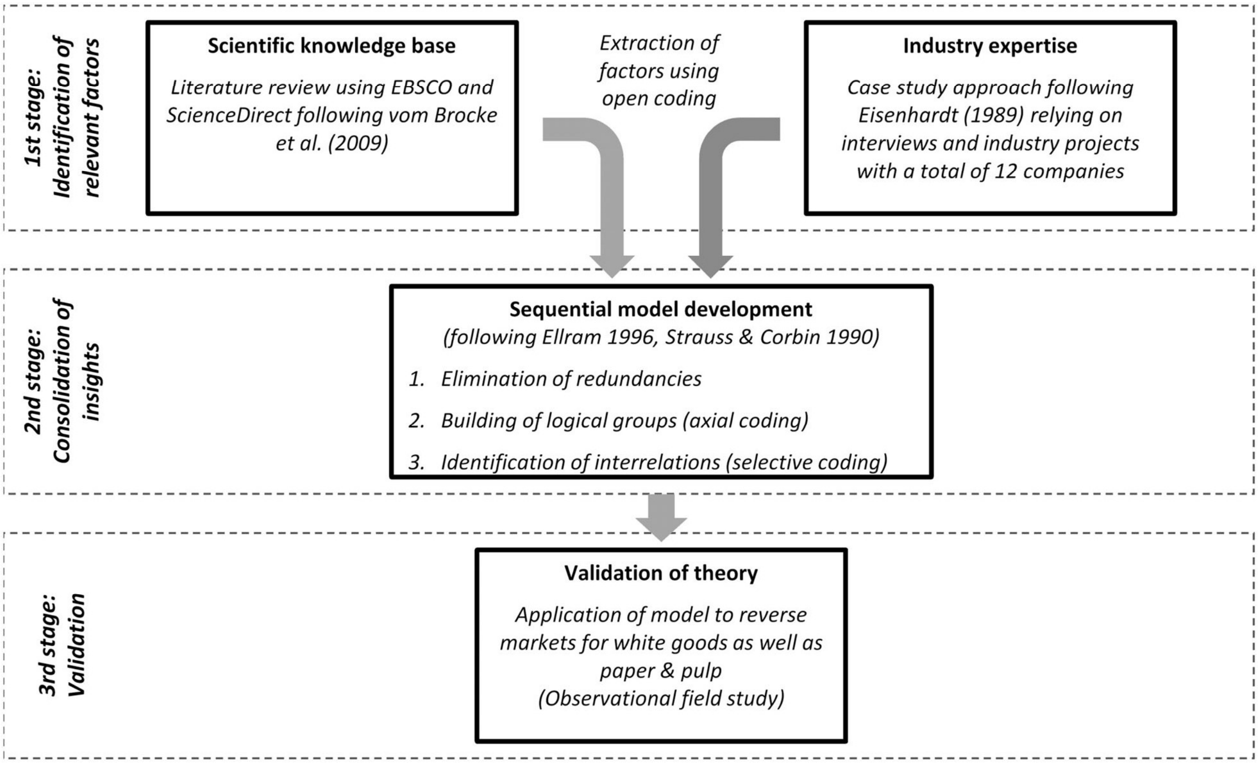

Figure 2 Methodological approach for development of a theoretical model.

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 semistructured 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 (eight) and IRCs (four), 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.

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 inter-relations between these factors (selective coding): the top level, the forces that shape the market, and 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 used an international and interdisciplinary research team in order to account for common patterns across industry sectors, business models, and regional peculiarities.

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 previous 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).

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

Table 2 List of companies studied within this article

Company ID	*Industry sector*	*Type of company*	*Revenues (in USD)*	*No. 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	Semistructured interview
C5	Plastics & Polymer	OEM	N/A	N/A	Head of Department Plastics and Environment	Semistructured interview
C6	Mechanical Engineering	OEM	10–20 bn	20,000–50,000	Head of Production	Semistructured interview
C7	Aerospace	OEM	10–20 bn	50,000–150,000	Head of Strategic Capability; Defense Aerospace Project Manager	Semistructured interview
C8	Healthcare	OEM	>50 bn	50,000–150,000	Vice President Environment, Health and Safety (EH&S); Director Global EH&S, Director Refurbished Programs	Semistructured 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	Semistructured interview
C11	White goods	IRC	N/A	<10,000	Company Director; Sales Manager; Technician	Semistructured interview
C12	IT-Equipment/NGO	IRC	10–20 bn	10,000–20,000	Director International Partners Compliance; Sales and Customer Service Specialist; Technician	Semistructured interview

Note: IT = information technology; NGO = nongovernmental organization; OEM = original equipment manufacturer; IRC = independent recovery company; USD = U.S. dollars; bn = billion; N/A = not applicable.

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.

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 EoL and EoU goods in a market. This number represents the upper bound of products that is theoretically collectable and can be approximated from a product's life cycle and average length of use (Geyer et al. 2007). Long life cycle 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

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		X
Quality of returns					X									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
Customers' willingness to return		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					
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	
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						
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
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							

Note: IRCs = independent recovery companies.

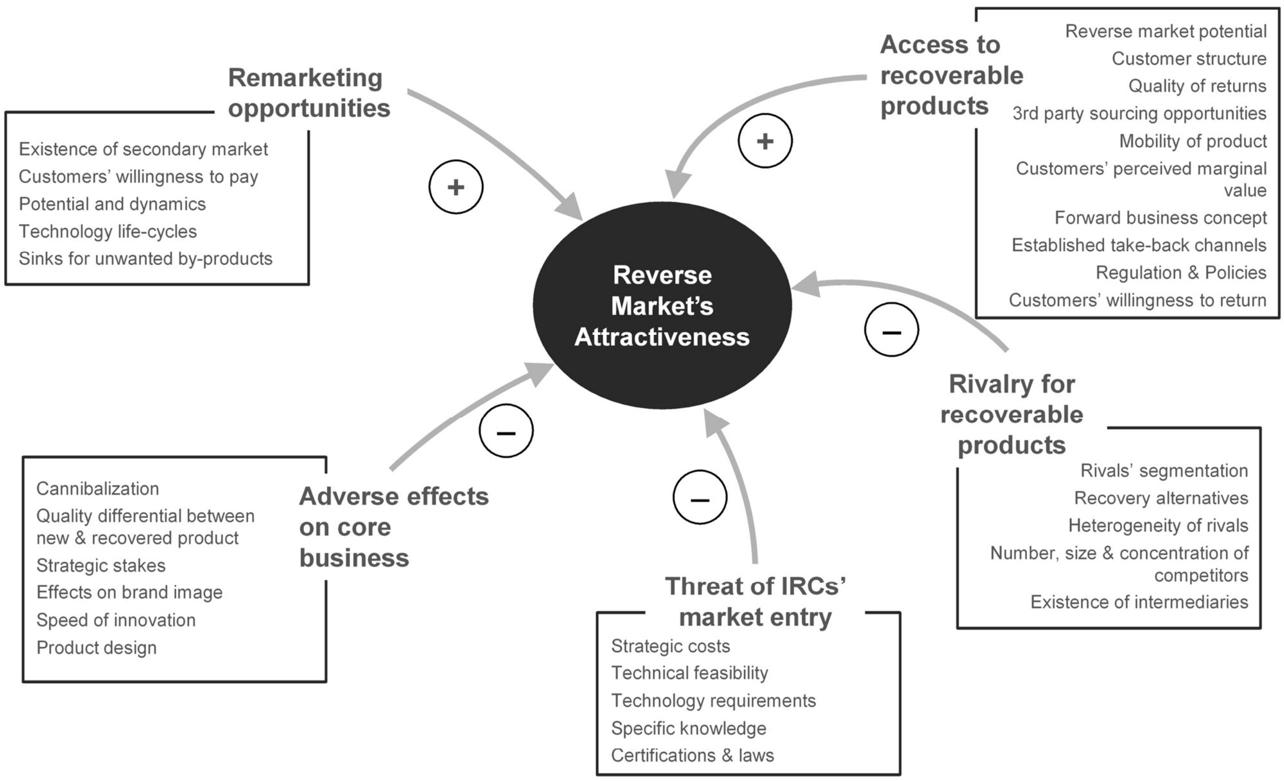

Figure 3 Reverse five forces model (R5F).

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 information technology (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 *third-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 third 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 EoL 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, and C7) or public collection of goods like waste electrical and electronic equipment 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 and 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 mind sets 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).

Threat of Independent Recovery Companies' 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. Given that "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, and 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 because of 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, and 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 skill set for inspection and reprocessing (Hammond et al. 1998). Lack of the requisite skill set 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 and laws*. Disposal of products containing noxious substances is often subject to tight control and reprocessing limited to certified actors (C1, C7, and 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).

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, nongovernmental 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 use 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 nonprofit 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 nonstructured 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, and 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, and concentration of competitors* within each segment (C2, C3, and C9).

Competitive structure may also be influenced significantly by the *existence of intermediaries* that may accumulate large quantities of recoverable items (C2, C3, and 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.

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 influences 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 and 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, given that 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 health care 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, and 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.

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 and colleagues (2016) and Pang and colleagues (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 and colleagues (2015a, 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, and C8). Short technology life cycles, 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 back-flow, also warrant examination. Unwanted products include nonfocal 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 cathode ray tubes; C1) or generating revenues (e.g., from the sale of cardboard; C2).

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 is 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 given that a complete set of primary manufacturing machinery is necessary to use secondary input material.

Whereas table 4 gives a brief overview of the assessment of the according forces, detailed descriptions of the cases are provided in the Supporting Information available on the Journal's website.

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.

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 reshape 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

Table 4 Application of the "reverse five forces" (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
Third-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, and 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 and 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

Note: IRCs = independent recovery companies.

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 and colleagues (2015).

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, previous 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 previous 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 used 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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Supporting Information

Supporting information is linked to this article on the *JIE* website:

Supporting Information S1: This supporting information presents a detailed description of the two case studies that investigate the attractiveness of product recovery in the white goods sector and in the paper and pulp sector. The case studies revealed the developed 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.