Beyond Waste Reduction: Creating Value with Information Systems in Closed-Loop Supply Chains

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Abstract	We study the role of information systems in enabling closed-loop supply chains. Past research in green IS and closed-loop supply chains has shown that it can result in substantial cost savings and waste reduction. We complement this research by showing that the effects are more than that: using information systems can also create business value for a firm in closed-loop supply chains. We make a novel distinction between four types of value: sourcing value, environmental value, customer value and informational value. Particularly the last two types have not been recognized in past research. We then analyze 8 cases (2 for each of the 4 value types) to highlight the role that information systems play in enabling this value creation and find three key results. First, we find that IS is an essential enabler for all four value types. Second, while sourcing value and to some extent environmental value, can be created with IS that are internal to the firm, the novel types of value (customer value and informational value) can only be created with information systems that are extraorganizational, i.e. aimed at customers and supply chain partners. Third, the value created by extraorganizational systems can only be created if the appropriate intraorganizational systems are in place. Overall, our results show that substantial value can be gained from implementing green IS in closed-loop supply chains, but that collaboration between all stakeholders in the supply chain is necessary in order to reap the full value.
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BEYOND WASTE REDUCTION: CREATING VALUE WITH INFORMATION SYSTEMS IN CLOSED-LOOP SUPPLY CHAINS

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Abstract

We study the role of information systems in enabling closed-loop supply chains. Past research in green IS and closed-loop supply chains has shown that it can result in substantial cost savings and waste reduction. We complement this research by showing that the effects are more than that: using information systems can also create business value for a firm in closed-loop supply chains. We make a novel distinction between four types of value: sourcing value, environmental value, customer value and informational value. Particularly the last two types have not been recognized in past research. We then analyze 8 cases (2 for each of the 4 value types) to highlight the role that information systems play in enabling this value creation and find three key results. First, we find that IS is an essential enabler for all four value types. Second, while sourcing value and to some extent environmental value, can be created with IS that are internal to the firm, the novel types of value (customer value and informational value) can only be created with information systems that are extraorganizational, i.e. aimed at customers and supply chain partners. Third, the value created by extraorganizational systems can only be created if the appropriate intraorganizational systems are in place. Overall, our results show that substantial value can be gained from implementing green IS in closed-loop supply chains, but that collaboration between all stakeholders in the supply chain is necessary in order to reap the full value.

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INTRODUCTION

There is no denying that sustainability has become an important consideration nowadays, as governments, organizations and people aim to make society more sustainable. For organizations, this translates into a focus on the triple bottom line of people, planet and profit. While this aim is clear, how organizations should achieve this aim is less clear, as many approaches exist. Historically, society has moved from reactive approaches, such as pollution control, to more proactive approaches, such as product stewardship and sustainable development (Hart, 1995). From a production perspective we are moving from cradle-to-grave practices, where consumption and waste management is the norm, to cradle-to-cradle practices, where all outputs should either serve as biological or technical nutrients ("waste=food", McDonough & Braungart 2002) . Consistent with the latter is the approach of closed-loop supply chains: the integration of the traditional forward supply chain with that of the reverse supply chain of recovered products. While past work has demonstrated that indeed closed-loop supply chains are able to reduce waste of products and materials, this presents only a limited view. In particular, we believe that a focus on waste reduction obscures two important aspects. First, more than just achieving the societal goal of waste reduction, closed-loop supply chains create business value for the firm that goes beyond the cost reduction from reducing waste (Guide and Wassenhove, 2009), Second, value creation does not only come from redesigning operational processes, but information systems play an integral role in this. Therefore, in this paper we aim to answer the question: how do information systems help to create value in closed-loop supply chains?

After a short literature review on closed-loop supply chains and the role of information systems, we will describe a novel typology of value in closed-loop supply chains, consisting of sourcing value, environmental value, customer value and informational value, of which particularly the last two have not been previously recognized in the literature. Then, using a re-analysis of 8 previously published cases on closed-loop supply chains, we show that information systems in all cases are an integral part of the value that is being created. We furthermore show that both intraorganizational and extraorganizational systems (which include both interorganizational systems to other supply chain partners and customer-oriented information systems) help in creating sourcing value and environmental value. Most importantly though we show that customer value and informational value can only be achieved through extraorganizational systems. Thus, in order to reap the full benefits of closed-loop supply chains, firms should invest more in extraorganizational systems. We end with a discussion on the IT capabilities that firms need to have to successfully do this.

CLOSED-LOOP SUPPLY CHAINS

Instead of focussing on sustainability goals in the forward supply chain (cleaner and less wasteful operations), a much more effective way of contributing to sustainability is to avoid the use of scarce resources and to avoid manufacturing operations altogether (Hischier et al., 2005). An effective way of doing that is to integrate recovery practices into the forward supply chain (“closing the loop”). A well-known example is recovery at the material level; discarded products are collected, sorted and reprocessed at the material level (recycled) in order to be reused as raw materials in conventional manufacturing operations. However, there are more sophisticated forms of recovery that recover not only the material value, but also the value from the resources that facilitated the production phase (energy, manpower, catalysers, fuel). Such recovery forms include reuse at the product component level (car engines, spare parts) and at the product level (mobile phones, copier machines). The management of these closed loops referred to as Closed Loop Supply Chain Management (CLSCM; Guide et al. 2003). CLSCM contributes to environmental sustainability through the reduction of emissions, non-renewable/scarce resource consumption, and energy use. Economical gains mainly come from the reduction of sourcing and processing costs. Social sustainability is enhanced through a safer and healthier living environment and more welfare.

Geyer and Jackson (2004) identify three types of processes that are key to effective CLSCM: *acquisition processes* to ensure the right volume of product returns of the right quality, *recovery processes* to ensure that product returns are reused in a meaningful way, and *integration processes* that ensure that reused products and materials find a useful outlet (Figure 1).

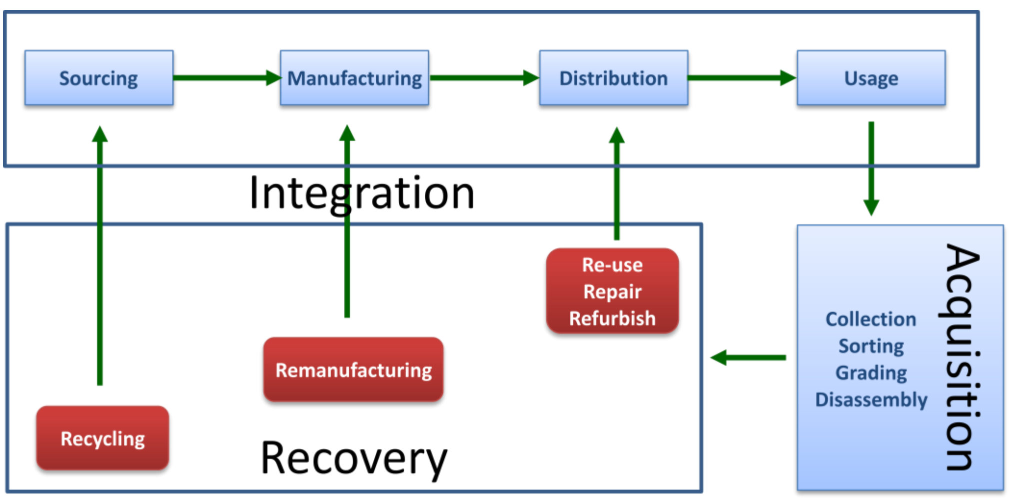

Figure 1 Key processes of closed loop supply chains

Acquisition processes provide the inputs for the recovery processes, such as collection from the end user, sorting and grading, and possibly some disassembly operations (see e.g. Quariguasi et al., 2010). Recovery may occur at the product level (direct reuse, repair, refurbishing), at the component level (remanufacturing) or at the material level (recycling), depending on the quality of the inputs and available markets for the outputs (Thierry et al., 1995). This very much depends on the type of product return (De Brito and Dekker, 2004). A customer has the legal right to return a product within a specified number of weeks after sale. Such returns, which are generally referred to as 'commercial returns' are typically of high quality and can often simply be restocked. Warranty returns occur if the customer perceives that there is a problem with the product. Repair is common for warranty returns which mostly have only minor defects. Such defects are repaired so that the product can be put back into working condition and resold in secondary markets, possibly at a lower price.. Refurbishing, on the other hand, entails more elaborate operations: disassembly of products into their modules, performing necessary inspections, component replacements and reassembly of modules to form a refurbished product (Thierry et al., 1995). Remanufacturing is regarded as recovery at the component level in which components are rigorously tested, cleaned, and reworked until they have at least the same quality as newly manufactured ones. Remanufactured components may be sold as spare parts or end up in refurbished or even newly manufactured products. 'After use returns' are products that are still in working condition but are discarded by the consumer, because they no longer meet his/her needs. Such returns may be refurbished and resold on a secondary market, or may be disassembled for components to use for aftermarket services (remanufacturing). End-of- life returns are products that have surpassed the economic or technical lifetime; recycling at the material level is often the only available option.

Given an access to the right volume of collected products and the appropriate reprocessing capabilities, it is essential that the firm has access to sufficient markets for the recovered materials/components/products and possesses the capabilities to integrate the recovery chain with the forward chain (production and capacity planning, redistribution).

As discussed earlier, closed loop supply chains potentially contribute to all three dimensions of sustainability. From the perspective of the firm, however, there is much more economical value to be leveraged than just direct financial gains from improved sourcing value. If managed well, one could also gain 1) *environmental value* from footprint reduction and , proactive compliance with legislation2) *customer value* from improved customer relations and 3) *informational value* from better access to product data. Next we examine these four value types in detail.

VALUE CREATION IN CLOSED-LOOP SUPPLY CHAINS

As shortly discussed in the previous section we classify the value types that can be generated by means of CLSC management into four categories: sourcing value, environmental vale, customer value, and informational value.

Sourcing value refers to all types of direct cost reductions and savings that can arise from CLSC practices. Through reprocessing strategies discussed in the previous section (i.e. reuse, repair, refurbishing, remanufacturing and recycling), product returns can be reutilized in some way in the same or in an alternative forward supply chain. For instance, recovery outputs can be sold in secondary markets (e.g. as repaired/refurbished products or cannibalized parts/components) and generate additional revenue for the firm or they can be used internally (e.g. as spare parts in maintenance or as input in production instead of virgin materials) and reduce supply costs. Today several companies such as IBM, Xerox, L'Oreal, HP, Ocè, Kodak, and Volkswagen realized the embedded value in product returns and already started to reutilize them in various ways. For instance, HP remanufactures the unsold printers returned by its retailers and uses the good quality components as spare parts or in remanufactured products. Defective components on the other hand, are recycled for materials (Davey et al., 2005). In CLSCs, substituting virgin materials with recovered components or materials as production inputs may also lead to substantial energy and water savings. Furthermore, by minimizing waste, CLSC processes can reduce land filling and waste treatment costs and help to avoid legal fees and taxes (e.g. emissions taxes, take-back fees paid for per unit end-of-life (EOL) product not taken-back). We consider all these and similar direct financial benefits arising from CLSC practices under sourcing value. According to Geyer and Jackson (2004) all the three CLSC process types of Section 2.1 should be geared towards maximizing these benefits.

Extra benefits which may not imply immediate financial value but may increase the competitive advantage of a manufacturer and lead to financial improvement in the long-term are classified under environmental vale, customer value, and informational value which will be discussed next.

Environmental value[1] mainly refers to two types of benefits of CLSC practices that result from improved footprints: (1) ease of compliance and (2) improved green image. In the last decades, several waste management regulations (e.g. Directive on Waste Electronic and Electrical Equipment, Directive on End-of-Life Vehicles in EU, E-waste regulations in 23 states of USA) have been enacted to hold manufacturers responsible for the take-back and proper treatment of their used or EOL products. These regulations imposed obligatory take-back and recovery targets on manufacturers, which become more stringent over time. In this respect, CLSCs can enable a manufacturer to take a proactive stance and ensure easy

[1] Here, it is important to note that both in this value type and in the customer value, we take a manufacturer perspective and refer to the value acquired by the manufacturer not by the environment or the customers.

compliance with such regulations. Manufacturers who take steps to set up a take-back system and start recovery operations ahead of legislation may also have a chance to lobby for rules and regulations in line with their practices. They get the opportunity to shape the legislation in their favor. Furthermore, by the first mover advantage they can gain expertise in recovery operations and capture a bigger market share. A good example of this is Electronic Recycling Platform which is created by four big electronics firms to take-back and recycle their products in anticipation of Waste Electrical and Electronics Equipment (WEEE) legislation in Europe. After the legislation enacted, this proactive initiative provided 55% savings to its founders compared to their competitors (Nidumolu et al., 2009).

The second benefit under the environmental value is *improved green image*. In the last decades, several organizations (e.g. Greenpeace and Newsweek) and voluntary initiatives (e.g. Global Reporting Initiative and Electronic Take Back Coalition) started to publish environmental performance rankings and reports for big manufacturers and increased attention on environmentally malignant processes. Combined with the increasing interest of the society to the environmental problems and a growing ‘environmentally conscious’ customer segment, these developments increased the pressure on manufactures. Being able to calculate, record and communicate the reductions in footprints (energy and virgin material use, emissions, waste to landfill, etc.) that result from closing the loop leverages the environmental value and becomes an important competitive weapon.

Our third value type is *customer value* which refers to increased customer loyalty, better customer satisfaction, and superior brand and know-how protection provided by CLSC activities. First of all, a well organized product take-back system, which is a sine qua non for an efficient CLSC, can offer customers hassle free service for warranty or commercial returns and this can increase the willingness of consumers to purchase the firm’s products again to a great extent (Ramanathan, 2011). Similarly, reprocessing activities such as remanufacturing can increase the availability of spare parts especially for the old models whose parts are no longer produced or very infrequently produced. Improved spare parts management can also enable the company to provide extended warranty and service agreements to its customers. All these opportunities provided by CLSCs substantially contribute to customer satisfaction and customer loyalty. CLSCs may lay the ground for leasing and installed base contracts as well. Manufacturers who have started reprocessing activities and established remarketing channels are more willing to offer lease or installed base contracts. Under such contracts, customers purchase only the right of use and get regular maintenance, and at the end of a certain period turn back and replace the old products with new models. Lease or installed base contracts are generally used for large-size equipment such as copiers, press equipment, etc. To illustrate, major digital press equipment manufacturers such as Oce, Xerox, Kodak, and Canon explicitly include returns in the sales contracts and offer special service agreements which provide leasing, trade-in upgrade, replacement and parts exchange (Chapman, 2009; Krikke, 2004). This enables the firms to increase customer retention and prevent third parties to collect, recover, and resell their products. Finally, product take-back also helps manufacturers prevent third party intervention (which may either reveal know-how or hurt brand name due to poor reprocessing) and protect know-how and brand credibility.

Finally, *informational value* refers to the valuable data on common production or supply (input) defects/problems, failure rates, useful life-time of the product, consumer complaints, and consumer usage patterns, which can be acquired more easily through the acquisition processes of CLSC practices. For instance, common production defects or consumer usage patterns can be revealed by simply recording the defect types and problems observed during grading/sorting and disassembly processes. Similarly, consumer complaints can be easily learned by applying a simple survey to consumers when they turn back their products. Such kind of information can then be used to improve different processes (e.g. product design, production, etc.) in the value chain.

Sourcing Value -Cheaper sourcing -Market extension	**Environmental value** -Market leader through proactive compliance -Green image
Customer value -Customer loyalty -Customer satisfaction	**Informational value** -Product design improvement -Supply chain process optimization

Table 1 CLSC Value Matrix

THE ROLE OF INFORMATION SYSTEMS IN CLOSED-LOOP SUPPLY CHAINS

The previous section described the four types of value that can be gained from CLSCs. Past research (e.g. van Hillegersberg et al., 2001; van Nunen & Zuidwijk, 2004) has shown that closed-loop supply chains has quite different informational requirements than forward supply chains, and that information systems are an important enabler for closed-loop supply chains. However, the focus of the literature thus far has been primarily on how information systems enable the overall environmental benefits. To what extent, if at all, information systems creat value for the firm remains an open question. We ground our empirical analysis in the following sections in the integrative model of IT business value put forward by Melville et al. (2004), since that is one of the few IT business value that takes into account the role of external business partners, which is essential to CLSCs.

In the model of Melville et al. (2004), "IT business value is generated by the deployment of IT and complementary resources within business processes" (p.293). IT resources are subdivided into technological IT resources (IT infrastructure and business applications) and human IT resources (technical and managerial expertise). Complementary resources are comprised of non-IT physical resources, non-IT human capital resources, and organizational capital. While these are the resources owned by the focal firm, its ability to create value from these resources is shaped also by the IT and non-IT resources of its business partners. As firms start to increasingly compete as network against network instead of firm against firm (Van Heck and Vervest, 2007; Lee, 2010), the role of these business partners is crucial for understanding the IT value in a CLSC setting.

This importance of external partners is also highlighted in an alternative classification of IT resources that distinguishes between inside-out, outside-in, and spanning resources (Day, 1994; Wade and Hulland, 2004). Inside-out resources are the internally focused IT resources such as infrastructure, technical skills, and development skills. Outside-in resources are those resources related to external business partners and markets, such as the management of external relations and responsiveness. Spanning resources are those resources needed to integrate inside-out and outside-in resources, such as aligning business and IT as well as change management. We use these frameworks as our initial starting point for an inductive analysis of 8 cases of IT initiatives in closed-loop supply chains, which will be described in the next section.

METHODOLOGY

We study the role of information systems in closed-loop supply chains by conducting a re-analysis of 8 published cases (2 for each value type) in the literature on closed-loop supply chains. Just like meta-analysis helps to synthesize findings across series of experiments or surveys, re-analyzing published cases through a common lens can help to uncover patterns that would be hard to derive from single studies. Although less common than collecting primary (case) data, the method has seen applications in the information systems literature (Lee, 1991; Gengatharen & Standing, 2005), as well as other fields such as marketing (Lim et al., 2006), leadership (Shrivastava & Nachman, 1989), and strategy (Miller & Friesen, 1977; Larsson, 1993). Such a method is deemed to be suitable particularly "…when case studies dominate an area of research (Yin & Heald, 1975), when the unit of analysis is the organization, when a broad range of conditions is of interest (Jauch et al., 1980)" (Larsson, 1993, p. 1516), because it "…overcomes the problem of generalizing from a single case study and at the same time provides more in-depth analysis of complex organizational phenomena than questionnaire surveys." (Larsson, 1993, p. 1516). Since primary fieldwork is very intensive, there are resource and practical constraints that may prevent individual researchers from doing cross-case analyses that can improve theory-building, and using published cases can help to overcome such limitations (Bowman & Ambrosini, 2010),

We selected our cases through a number of steps: we started with identifying cases on closed-loop supply chain initiatives from two key published volumes of closed-loop supply chain practices (Guide & Van Wassenhove, 2003; Flapper et al., 2005). Since these two volumes contain some of the pioneering publications in closed-loop supply chains, we used these as starting points for cases, as well as subsequent articles that referred to these volumes. We used a previous article on e-enabled closed-loop supply chains for a similar purpose (van Nunen & Zuidwijk, 2004) and we consulted some experts for additional cases. This resulted in 30 cases at the first step. In the second step, with the help of a research assistant, we classified each case according to the value type (or types) that was/were being created in the case, based on the descriptions of the business benefits in each article. In virtually all cases, some form of sourcing value was created; the other three value types were less common. Disagreements were infrequent and when they occurred, they revolved around a minor value type, i.e. a value type that had only a small overall importance compared to the other value types. No disagreements occurred around the major value types in each case.

In the third step, we then selected 2 cases from each value category for our final analysis based on the extent of information about value creation that was available for that type and whether or not some form of information systems was mentioned in the article. No other criteria regarding IS types/IS usage/IS quality/IS success or similar concepts were used during case selection, only if mention was made or not. Where necessary, we augmented the original source with additional secondary data from other sources (usually company websites and sustainability reports of companies) and in some cases contacted the authors of the original case for more details. The final case selection with value types and corresponding literature sources can be found in Table 2.

Value type	Case	Source
Sourcing	Hewlett-Packard	(Davey et al., 2005)
Sourcing	Heineken	(Van Dalen et al., 2005)
Environmental	Schering	(Teunter et al., 2005)
Environmental	Xerox	(Maslennikova& Foley, 2000)
Customer	Wehkamp	(De Koster et al., 2005)
Customer	OMRON	(Kuik et al., 2005)
Informational	NEC	(Geyer et al., 2005)
Informational	Retread	(Debo & Wassenhove, 2005)

Table 2: Selected cases and sources

CASE DESCRIPTIONS[2]

[2] Unless noted otherwise, all descriptions in this section are taken from the corresponding source in Table 2.

Sourcing value: Hewlett-Packard (Imaging and printing solutions group)

Imaging and Printing Solutions (IPS) group specialized in printers such as Liquid Inkjets, Laserjets, and other imaging equipment such as cameras and scanners was a large business unit in Hewlett Packard.

Returns were a major problem in IPS. Only in the U.S., 6.6% of sales dollars and 5.7% of all shipments were returned on average. The three main return categories were overstock returns from resellers, customer returns (due to unfulfilled expectations), and defective product returns. In the current closed loop supply chain, returns picked up from resellers were delivered to two returns depots. After the visual inspection at return depots, depending on their condition the returns were either sent to recycling (obsolete products), to Testing & Refurbishment (T&R) facility (returns in opened boxes) or Shipping Depot (SD) (returns in closed boxes). The operations both at T&R facility and the returns depot as well as the recycling were outsourced to third parties. At T&R facility, all returns were rigorously tested and those with no defect were sent to Shipping Depot while the defective ones were disassembled, their modules were checked and after necessary repairs reassembled again (refurbishing). In case refurbishing was not possible, remanufacturing was preferred: individual parts were tested and repaired to be used as spare parts. Irreparable parts, on the other hand, were sent to recycling. From SD, after necessary repackaging products were sent to the secondary markets to be sold with a 15-25% price discount.

The primary value type HP sought to generate from this CLSC was sourcing value. Realizing the substantial costs and value loss associated with returns, the company started to regard all the activities associated with returns as a separate business in itself and initiated a new strategy with two main goals: reducing the returns volume and as a result the total cost of return business and increasing the revenue from the sale of returns. Main problems led to losses in this CLSC were inefficiencies in the acquisition stage (i.e. long lead times, high return stocks at return depots and T&R). HP sought to alleviate these problems by collaborating with its value chain partners to eliminate the causes of returns and by improving the returns handling process by some optimization tools. To maximize the value obtained from returns, on the other hand, the reprocessing stage was improved. The company developed decision models to determine the best reprocessing alternative and also encouraged common design platforms among different products to boost component reuse. Design engineers were encouraged to 'steal' the design of previous products instead of inventing their own designs. The decision models employed product life cycle analysis and info about the product value/condition. Improvements in the integration process were also made. To sell the recovered products, new markets such as online auctions were examined. To assess the returns on all these investments in CLSC practices, HP conducted an Economic Value Added (EVA) analysis. This showed that HP generated positive returns on its CLSC investments for returns handling.

Sourcing value: Heineken (Chip in Returnable Packaging Materials)

Heineken, the third biggest brewery of the world, operates all over the world with headquarters in the Netherlands. The company has two corporate brands (Heineken and Amstel) and several national and regional ones.

Heineken uses returnable packaging materials (RPM) (i.e. returnable bottles, crates, and kegs) for most of its products. In 2001, 47% of total beer sold was packaged in RPM which requires substantial investments (replacement cost of RPM is around 550 million EUR for Heineken Europe). RPM necessitate a reverse logistics chain as well. Used containers should be collected, stored, and cleaned before reuse. Determining the right number of RPM to be launched in the supply chain is an important but difficult decision. Expected sales amount and the circulation time (the time between two entries of a crate at the production belt) of crates in the chain which is uncertain are used to determine this number. Traditionally, Heineken has adopted a risk-averse policy and kept large amounts of RSM in use so that there was almost no risk of stocking out and disrupting other activities (i.e. production and bottling). However, large amounts of RPM also implied redundantly tying up large amounts money in RPM and incurring substantial operating costs (i.e. for storage).

In 2000, the company started a pilot project at the Brand brewery (a local brand of Heineken) which involves baking chips into a certain portion of the crates used by the company. The objective was to measure the circulation time of the crates through the reverse chain. Using the scanners located at the entrance of the production belts and the unique codes attached to the chips the two consecutive entrances of the crates into the production were recorded. The project provided valuable information about the return patterns and the circulation times of crates, which can be used to reduce the investment costs in RPM. The contribution of the project if implemented for all crates was not measured by Heineken, but by a rough calculation chip technology reduces crate stocks by 1 million and saves €3.5 million for the company. These figures do not even include the additional benefits such as improvements in the reverse chain of the RPM.

Environmental Value: Schering AG

Schering AG was a German pharmaceutical company founded in 1871 and taken over by Bayer in 2006. After the takeover the company was renamed as Bayer Schering Pharma AG.

There were two types of recovery activities in Schering: (1) recycling of byproducts and (2) recycling and reuse of solvents. Byproducts were generated in various stages of production, wheras solvents were needed in the production of most active ingredients. Thus, profit was an important driver for both recovery activities. Besides, complying with the legislation (e.g. the EU Directive on Registration, Evaluation and Authorization of Chemicals (REACH), The German Recycling and Waste Control Act, etc.) and reducing environmental impact of their business (e.g. membership to the German Chemical Industry Federation's voluntary initiative "Responsible Care") were also key drivers. Recovery rate was high in solvents (some portion was distilled for pure solvents and some low quality portion was used as fuel), however a small portion which could not be recovered in any way was disposed of as waste.

Integration of byproduct recycling and solvent reuse made the production planning complicated in Schering, existing materials requirement planning (MRP) system was not sufficient to handle this complication. To solve this problem the logistics department of the company developed a Mixed Integer Programming (MIP) model and embedded this in the existing MRP system. This system allowed the planning employees to follow the procedure they were used to. The only input to be entered by the employees was the Bill of Materials data and this data was automatically converted into MIP formulation by a Decision Support System (DSS) again developed by the company. The IT infrastructure helped to easily integrate the recovery activities in the existing SC.

The main motive for starting recovery activities was profit, however, recovery activities helped the company comply with several existing regulations and ensure a leading position in environmental issues as well. As Bayer Schering AG, the company now publishes annual sustainability reports which are subject to external audit and available to all stakeholders (e.g. customers, suppliers, shareholders, investors, etc.). As being listed in the Carbon Disclosure Leadership Index and the Dow Jones Sustainability World Index, and with its A+ rating reporting under the framework of Global Reporting Initiative (GRI) (a widely accepted sustainability reporting system), the company has gained public recognition in environmental issues (Bayer, 2009).

Environmental value: Xerox

In contrast to the traditional business definitions, Xerox defines itself as 'a provider of document services across all aspects of document life-cycle management, from creation to distribution, printing, and storage' (Maslennikova and Foley, 2000, p. 226). Xerox Europe is a part of Xerox Corporation with headquarters in UK and with an average 25% of the total business (Guide and Wassenhove, 2003). In this case description we will mainly focus on Xerox Europe's activities.

A product stewardship program and waste-free business policy implemented by Xerox Europe led to a closed loop supply chain (CLSC) for the company's products. The first step in this CLSC is the take-back of products from customer locations and their transfer to return centers where they are inspected, tested and classified under four grade categories. For inspection products are dismantled to the base-unit level and each component is carefully inspected and its remaining life is determined. Grades depend on the physical conditions and the age of product as well as the demand for the recovery output. Grades determine the reprocessing alternative for each product (Guide and Wassenhove, 2003).

Proactive leadership in environmental sustainability has been one of the most important objectives of Xerox Europe. The company's internal environmental standards most of the time have been stricter than the legislation and industry standards (Guide and Wassenhove, 2003). For instance, the company started recovering its products and its waste free policy ahead of WEEE Directive legislated in Europe in 2003. In 1997 Xerox Europe collected 160000 products and recovered about 3.8 million components from these products. To avoid products ending up in landfills, recycling symbols and reprocessing codes, which show the recovery potential of products were placed on products. Similarly, bar-coded labels were used in tracking packaging materials. To ease recovery, a completely modular and advanced technology product, Document Center, with open architecture that allows for any type of technological upgrades and component replacements, was developed. This product is compliant with Energy Star (USA EPA label for energy efficient machines) and European eco-labels (e.g. Blue Angel (Germany) and Nordic Swan (Scandinavia)) and allowed the technicians to use 'SiXth Sense' Diagnostic systems and diagnose the product remotely and immediately solve the problems. The company also used Total Quality Management tools to develop an environmental management system (EMS) and to bring a systematic approach to decrease the environmental impact of the company. As a result of all these activities, the company got European Environmental Award for Industry from the European Commission and the United Nations Environment Programme, UK Packaging Industry Award, Eco management and Audit Scheme certification for all of its products and manufacturing sites, and ISO 14001 certification for its waste free approach. Xerox is aware of the importance of external recognition for its environmental achievements. Hence, the company uses its environmental credentials in its marketing campaigns to build a green image and attract environmentally conscious customers.

Customer value: Wehkamp

Wehkamp is a catalogue order/online retailer company operating in the Netherlands. It receives orders from its customers via catalogue or online for a broad range of products such as clothing, electrical appliances, and furniture, household products and leisure goods. It offers around 100,000 product types and completes about five million orders every year

(Mostard et al., 2011). With a turnover of 441 million Euros (excl. VAT) the company is the market leader in online shopping in Netherlands.

Product returns are an important part of the Wehkamp's business. On average 28% of all sales are returned and this percentage may rise to 40% for fashion sales. For convenience, Wehkamp offers three options to its customers for returns: pick up from home in the afternoon, pick up from home in the evening and service point drop-off. When the products are picked up from home, customers do not pay for transportation costs. Pickup and transportation of returns are partly integrated with forward flows (delivery of new orders to customer locations). Same trucks are used for both the collection of returns and the delivery of new orders. Upon arrival to the warehouses in Dedemsvaart and Maurik (in NL), returns are unpacked, checked for any problems (e.g. steins in garments), reconditioned (e.g. cleaned, ironed if necessary), repacked and relabeled.

Both the acquisition stage (i.e. pickup, identification, and grading) and the integration stage (remarketing) are quite fast and efficient so that after repacking returns can be immediately be put on market same as original before any value loss and hassle-free return service can be offered to customers. Indeed, the company regards an easy return policy as a business strategy. This policy increases the service levels for their customers and generates competitive advantage for the company. Returns pickup and handling are costly, however Wehkamp achieved to ensure efficiency in these processes thanks to its IT infrastructure. A standard truck routing software is employed to schedule delivery and pickup routes and a tailor made software is used to identify and grade returns, and refund the customers when needed. Integration of this software into a standard warehouse management system (Locus) enabled to gather immediate information about whether the client should be refunded or not (based on whether or not this product category may be returned), the condition of the product, payments made, and date of original purchase. Return tickets given to customers at the time of purchase further facilitated tracing the number and frequency of returns in each product category.

Wehkamp achieved to generate customer value through its CLSC practices for returns. The company's return policy has increased customer satisfaction and enabled to establish sustainable customer relations. Supporting this conclusion, the company has one of the largest customer base in Netherlands and in a survey conducted to reveal customer satisfaction, outperformed all of its competitors in all dimensions.

Returns also serve as a key supply source for the company. Wehkamp receives its orders from suppliers only twice a season. However, for seasonal products, which constitute a major portion in Wehkamp sales, demand estimation in far advance is difficult. Returns, which arrive throughout the season and are immediately reprocessed, are used as reserves to stabilize any fluctuations in demand within the season.

Customer value: OMRON

Omron is an international manufacturer and service provider in the industries of industrial automation, medical health care, automating services, and information processing with products such as card readers, connectors, and sensors. Omron is a B2B business and sells its products to companies such as system builders and Original Equipment Manufacturers (OEM) who use Omron products to build larger technical systems. Omron Electronics Europe (OEE) operates in Europe, former Soviet Union, the Middle East, and Africa markets. This case description will mainly focus on the activities of OEE. OEE has National Sales Companies (NSCs) managing the sales in each European country and a European Logistic Center (ELC) and a European Repair Center (ERC).

Since Omron products are used by other companies as a part of the larger technical systems, the failure of these products hamper the important processes of product users and create serious problems for them, thus such failures should be solved in short time. The initial closed loop supply chain for product repairs in OEE operated as follows: the user of the technical system including the Omron product informed its supplier (mostly an OEM) about the failures and the supplier investigated which component caused the failure in the technical system. If an Omron product caused the failure, NSC was contacted and depending on the nature of the problem and warranty conditions NSC proposed a solution. Sometimes the supplier itself dealt with simple problems. If a defective component or product should be changed, NSC did the replacement and the defective product was sent to ERC for repair with a Repair Material Authorization (RMA) issued by NSC via the channel of NSC and ELC. After repair the product was transported to the user through the same channel (via ELC, NSC, and then the supplier). Each step in this flow took approximately one week and in total getting back a repaired product from ERC took about 6 weeks of the user. This was a substantial delay for users which inhibit their operations. Due to such a big delay NSCs sometimes prefer to use an unofficial local repair center which did not have quality assurance and provided low quality repairs that hurt the brand name of Omron.

OEE has undertaken a series of structural changes in its CLSC design to reduce this delay and provide a better repair service to its customers. First creating a partnership with DHL, the customer was enabled to contact directly with DHL for the pick-up and the transfer of the defective product to ERC. In this process After Sales Application (a database running in the Omron intranet and accessible by NSCs) was used to create RMAs by NSCs. This IT system allowed NSCs to track the status of repair instantaneously. These changes reduced the delays substantially (up to 5 days) but still there were discrepancies between NSCs repair requests to ERC and actual products sent by customers to ERC for repair due to the last minute changes in the decisions of customers about sending the product for repair. To solve these, in the second phase of the structural design change, European Repair Database (ERDB) and European EDI gateway of DHL were used to generate automatic pick-up requests to the local DHL office, a confirmation to NSC and an airway bill to the customer simultaneously. The EDI gateway also informed the customers electronically about the pick-up in advance. These information systems improved the repair chain to a great extent. Long delays causing interruptions in customers' operations were substantially reduced, unofficial repairs which hurt the brand name were minimized, and economies of scale in ERC was ensured and this helped to make new investments which can further speed up and improve the repair service (e.g. specialized diagnostic equipment). As a result customer satisfaction was improved which led to an increase in repair demand to ERC (repairs generate revenue to Omron).

Informational value: NEC Computers

NEC Computers International (NEC-CI) founded in France as a subsidiary by NEC Corporation of Japan to unite PC and server business outside the US and Japan, manufactures desktops, notebooks, and servers and distributes them throughout Europe, Africa, and the Middle East.

The company experienced lots of inefficiencies in handling customer and production returns. Due to shortening life cycle of computer equipment and risk of obsolescence the company should process its returns faster and in the best possible way, and minimize the returns stock. However, this was not possible with the existing reverse chain. To solve these problems, the company created Notebook Server Recovery (NSR) as an independent unit. NSR started to handle customer and production returns separately. After checked whether they were turned back in sealed boxes or not (returns in unsealed boxes were immediately sent to serviceable inventory), customer returns in sealed boxes went through a testing/grading process which determines the best possible reprocessing option for the return. After testing/grading stage depending on whether they were still in the sales catalogue, customer returns were either refurbished to be sold as refurbished product or disassembled for components (to be used in regular production) or spare parts inventory (to be used in refurbished products). Production returns, on the other hand, were directly disassembled, components were diagnosed and the components under warranty were sent back to their suppliers while the others were repaired for spare parts inventory and if not repairable directly disposed of.

The main contribution of these two processes was the information collected in the acquisition processes (i.e. collection, testing, grading and disassembly). NSR asked each customer turned back a product under warranty to fill out a questionnaire about the problems s/he experienced in the product. This enabled the company to collect valuable information about the type and frequency of problems in customer returns and convey this information to the concerned parties to improve the related processes (e.g. production). Similarly, data was collected for production returns as well. NSR built up a database on common production failures and defects in supplied components. The company used the database to closely monitor the quality of production processes and supplies. The database made the company and NSR an important information hub in the supply chain. Based on the information obtained from the database, the company contacted and coordinated with the other parties in the supply chain (e.g. component suppliers and buyers) to solve the inefficiencies and problems in the whole supply chain.

Informational Value: RetreadCo Case

RetreadCo is a subsidiary of NewTireCo which is a large European-based tire manufacturer. Retreading involves replacing the worn rubber outer part (tread) of a tire with a new tread. The worn tread is taken away (through a procedure called buffing) and by the application of heat and pressure a new tread is affixed to the tire body which is called casing. Retreaded tires offer approximately 30-50% price reductions to tire users. RetreadCo is a large-scale tire retreader (4500 tires/day) and processes used tires of almost all brands in addition to NewTireCo's.

RetreadCo has an extensive network including tire dealers and fleet operators. RetreadCo acquires the used tires through two types of reverse channels: (1) the Nominative system and (2) the Customer system. In the nominative system tire dealers that conduct the tire management of big fleets, collect used tires from each fleet, mark them with the fleet code, and send the batch from each fleet separately to RetreadCo. By this means after the retreading process each fleet gets back its own tires. The customer system, on the other hand, involves collection from small fleets or individual vehicle owners. Such tire users leave their old tires at the dealers and pay a disposal fee. These used tires are then collected by a tire collector in turn for a fee paid by the dealer. Tire collectors separate and dispose of the non-retreadable tires and sell the retreadable ones to RetreadCo.

Retreading consists of inspection of casing, buffing, molding or procure and final inspection stages. First the casing of the used tire is inspected. By using a special technology steel cords in the casing are tested without destroying the tire. This procedure which is called non-destructive testing provides crucial information about the eligibility of the tire for retreading. The second stage, buffing, involves peeling off the old tread by means of computer controlled machines for precision. After buffing, the new tread is affixed to the casing by two alternative procedures: molding and precure. Buffing and molding/procure stages correspond to the disassembly and reprocessing processes mentioned in Section 2.1, respectively. To make ready for sale, the tires undergo one final inspection.

Especially for commercial vehicle owners tires constitute a substantial cost item (on average 11% of all operating costs). Hence, good tire management is very important for such businesses. Different factors such as pressure, temperature, driving behavior, tire rotation, tread depth and pattern, and geographic conditions determine the cost performance of a tire. Retreading, which uses high technology especially in inspection stage, can provide useful information to vehicle owners in this respect. Based on this information, sometimes tire consulting service is provided by retreaders to fleet operators. Being aware of common problems that reduce the life-time of their tires and increase the associated costs (e.g. maintenance, retread, and downtime costs), fleet operators can cut their operating costs substantially.

CASE ANALYSIS

Case analysis resulted in three main findings that will be described further down below. Cases were initially analyzed by classifying the information systems in each case according to the frameworks of Melville et al. (2004) and Wade & Hulland (2004) described in the theory section, to see if a pattern emerged, and where necessary re-reading the case for additional details. The original case descriptions focused primarily on the technical functionalities of the system and its result, much less was said about the development of the system, the implementation process itself or the technical and managerial expertise needed; hence an assessment of human IT resources is difficult to make. We therefore focus our results primarily on the technological IT resources in the findings that follow. Although a strict interpretation along the inside-out/outside-in/spanning classification of Wade & Hulland

(2004) was difficult to similar reasons as with the human IT resources, we found that we could draw on their inside/outside distinction to usefully sub-classify the technological IT resources in the cases. Specifically for our second and third finding, we distinguish between intraorganizational IS (information systems that support processes that are purely internal to the firm) and extraorganizational IS (information systems that support processes that are external to firm, i.e. processes where customers or supply chain partners are involved),

The first finding from the cases described above related to the role of IS in general: while the cases were simply selected based on the mentioning of information systems in the case, the role of information systems in creating value for the companies was substantial in all the cases. While strictly speaking the value comes from the improved acquisition, reprocessing, and integration processes, the process improvements in all cases would have been very difficult, if not impossible to achieve without extensive investment in information systems.

Our second finding relates to the differential role that IS plays in creating the different value types. If we classify the information systems in each case as being intraorganizational ad/or extraorganizational (some cases had both), an interesting pattern emerges, which can be found in Table 3. It shows that sourcing value and environmental value can be created by both intraorganizational and extraorganizational IS. In the HP case, part of the value came from better decision support for reprocessing decisions once the returned products arrived (an intraorganizational application) and part of the value came from optimization software applications joint with supply chain partners. Similarly for environmental value in the Schering and Xerox cases, a substantial part of the value came from environmental reporting systems that made the environmental costs of activities measurable. Once this was in place, this value could then be further leveraged into better compliance, for which both companies received awards and helped them to build an environmentally-conscious reputation in the marketplace.

However, the previously unrecognized value types customer value and informational value can only be created by extraorganizational IS. For instance in the NEC case, the value comes from collecting the information from customers and supply chain partners and also sharing this information back with them. Similarly in the Wehkamp case, the customer value comes from deploying information systems that on one hand make the return process very easy for the customer and on the other hand from information systems that enable better coordination with warehousing and logistics partners, such that the customer not only experiences a hassle-free return process, but also a fast one. Put differently, the sources of these newer value types lie external to the firm in better connections with customers, more information about their usage patterns and product wear-and-tear, better integration and coordination with supply chain partners and so on, and this value cannot be tapped into if the focus of the information systems remains internal to the firm.

	Sourcing Value	**Environmental Value**	**Customer Value**	**Informational Value**
Intraorganizational IS	HP Heineken	Schering Xerox	-	-
Extraorganizational IS	HP Heineken	Xerox	Wehkamp OMRON	NEC ReTread

Table 3: Value types and IS

Our third finding revolves around the relation between the intraorganizational and extraorganizational IS. The companies that had effective extraorganizational IS in their closed-loop supply chain initiatives also had effective intraorganizational IS. The Wehkamp case illustrates this best: while it is the extraorganizational information system that creates the customer value, fully obtaining this value would have been impossible if the internal IT platform had not been advanced enough to enable the successful development and deployment of the extraorganizational system. This suggests that while intraorganizational IS do not directly create customer or informational value, they are a necessary condition for the extraorganizational IS to be able to create these value types.

DISCUSSION: IT CAPABILITIES NECESSARY FOR VALUE CREATION

Although due to our methodological approach of relying on published cases, we are somewhat limited in the information that we can draw from the cases in relation to the human IT resources, the results from the case analysis suggest an interesting insight as to what IT capabilities in general are needed for value creation in a closed-loop supply chain setting. Past work on IT capabilities from the resource-based perspective proposed that the IT capabilities that are particularly valuable, are the capabilities that involve external stakeholders (Melville et al., 2004) or capabilities that are outside-in (Wade & Hulland, 2004). Our results validate this proposition by showing that it is precisely those types of capabilities that are needed to develop and successfully deploy the extraorganizational IT systems that are essential to creating the most value. Effectively developing systems that involve external stakeholders, whether it is tracking and tracing systems that span multiple parties in the supply chain or collection systems that are able to handle a wide variety of customer returns, requires a different set of capabilities than ‘classical’ internal IT capabilities.

This is not to say that those ‘classical’ internal IT capabilities are not valuable anymore, they certainly are. Especially for sourcing value, it would be quite difficult to do good reprocessing without effective IT behind it, or achieve seamless integration between the forward and the reverse processes if the firm does not have the capability to effectively align business and IT.

In combination with our third finding on the relation between the intraorganizational and extraorganizational IS, our results suggests that the role of green IS in closed-loop supply chains can fruitfully be seen through the lens of digital options (Sambamurthy et al., 2003). As can be seen in the cases, the information systems that were deployed, substantially increased the process reach (the extent to which business processes are common, integrated and connected) and process richness (the quality and transparency of the information collected about the processes). The internal IT systems created a digital platform that gave the firms valuable options for developing extraorganizational IT systems that could create value that would be difficult to obtain otherwise. In that sense, the combination of the closed-loop supply chain processes and the information systems that support them, can also be seen as a dynamic capability. Besides creating one or more of the value types in our value matrix (Table 1), it enables strategic renewal for firms by developing entirely new business areas.

CONCLUSION

The goal of this paper was to analyze the role that information systems play in creating value in closed-loop supply chains. We showed that there exist four different types of value, namely sourcing value, environmental value, customer value, and informational value, of which the last two have not been recognized previously in either the green IS literature or the closed-loop supply chain literature. Our analysis of 8 different cases shows that IT is an essential enabler for the creation of each value type, but that customer value and informational value can only be created through systems that involve external stakeholders such as customers and supply chain partners. At the same time, effectively developing and deploying these extraorganizational systems is not possibly without the necessary internal IT systems being in place.

Overall, these results carry a positive message for companies: deploying information systems in closed-loop supply chains does not have to be only for cost reduction and waste reduction (although those are of course useful benefits), it can also create new value and thus possibly lead to competitive advantage in the future. At the same time, they place companies in a quandary: the value types that are the most novel (customer value and informational value) and therefore offer the most possibility for competitive advantage, are also the value types that are the most difficult to obtain, since they require that a firm has their intraorganizational IT systems in order before moving on to extraorganizational IT. As many firms are still struggling for instance with business-IT alignment issues internal to the firm, this may prevent them from even thinking about extraorganizational systems. However, it does not have to be an all-or-nothing situation: not all extraorganizational information systems are equally advanced and hence do not require similarly advanced intraorganizational information systems. For instance, while tracking-and-tracing systems based on barcodes or GPS may not offer the same amount of detailed information as an RFID-based system, barcodes and GPS are established proven technologies that should be comparatively easy to deploy for most firms. And while a fully transparent supply chain may not be feasible for all firms, just integrating forecasts and inventory systems across supply chain partners can already yield substantial benefits. Such first steps in turn will help to develop the necessary human IT capabilities for firms to further expand in this direction, and also help to build a digital platform that enables them to do so. In a nutshell: the opportunities for value creation are available, and taking it step-by-step will get you there.

REFERENCES

Ambrosini, V., Bowman, C. and Collier, N. 2010. “Using teaching case studies for management research”. *Strategic Organization*, 8(3), pp. 206-229.

Bayer. 2009. “Sustainable development report,” Retrieved from http://www.sustainability2009.bayer.com/en/sustainable-development-report-2009.pdfx.

Chapman, A. 2009. “A study of the remanufacturing of offset and digital printing equipment in the UK,” *Center for Remanufacturing and Reuse*, Retrieved from http://www.remanufacturing.org.uk/pdf/story/1p300.pdf.

Davey, S., V.D.R. Guide Jr., K. Neeraj and Van Wassenhove, L. N. 2005. “Commercial returns of printers: the HP case,” in *Managing Closed-Loop Supply Chains*, S.D.P. Flapper, J.A.E.E. van Nunen and L.N. Van Wassenhove (*eds.*), Berlin, Germany: Springer, pp. 33-39.

Day, G. 1994. "The Capabilities of Market-Driven Organizations," *Journal of Marketing* (58:4), pp. 37-52.

de Koster M.B.R. and Zuidema J.P. 2005. “Commercial returns in a mail order company: the Wehkamp case,” in *Managing Closed-Loop Supply Chains*, S.D.P. Flapper, J.A.E.E. van Nunen and L.N. Van Wassenhove (*eds.*), Berlin, Germany: Springer, pp. 97-106.

Debo, L.G. and Van Wassenhove, L. N. 2005. “Tire recovery: the RetreadCo case,” in *Managing Closed-Loop Supply Chains*, S.D.P. Flapper, J.A.E.E. van Nunen and L.N. Van Wassenhove (*eds.*), Berlin, Germany: Springer, pp. 119-128.

Gengatharen, D.E. and Standing, C. 2005. “A framework to assess the factors affecting success or failure of the implementation of government-supported regional e-marketplaces for SMEs”. *European Journal of Information Systems*, 14, pp. 417-433.

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

Geyer, R., Neeraj, K. and Van Wassenhove, L. N. 2005. “Reverse logistics in an electronics company: the NEC-CI case,” in *Managing Closed-Loop Supply Chains*, S.D.P. Flapper, van Nunen, J.A.E.E. and Van Wassenhove, L.N. (*eds.*), Berlin, Germany: Springer, pp. 33-39.

Guide, V.D.R., Jr. and Van Wassenhove, L.N. 2009. The Evolution of Closed-Loop Supply Chain Research. *Operations Research* 57(1): 10–18.

Guide, V. D. R., Jr. and Van Wassenhove, L. N.. 2003. “Business Aspects of Closed-Loop Supply Chains,” in *Business Aspects of Closed-Loop Supply Chains: Exploring the Issues*, V. D. R. Guide and L. N. van Wassenhove (eds.), Pittsburgh, Pennsylvania: Carnegie Mellon University Press, pp. 17-42.

Hart, S. (1995). A natural-resource-based view of the firm. *Academy of Management Review*, 20(4):986-1014.

Hischier, R., Wager, P., Gauglhofer, J. 2005. “Does WEEE recycling make sense from an environmental perspective? The environmental impacts of the Swiss take-back and recycling systems for waste electrical and electronic equipment (WEEE)”. *Environmental Impact Assessment Review* 25(5), 525-539.

Jauch, L. R., Osborn, R. N., & Martin, T. N. 1980. Structured content analysis of cases: A complementary method for organizational research. *Academy of Management Review*, 5(4), pp. 517-525.

Krikke, H., Blanc I. L. and van de Velde, S. 2004. “Product Modularity and the design of closed-loop supply chains,” *California Management Reiiew* (46:2), pp. 23-39.

Kuik, R., van Nunen, J.A.E.E., Gerrits, J. and Hogenboom, M.H.P. 2005. “The repair of electronic equipment: the OMRON case,” in *Managing Closed-Loop Supply Chains*, S.D.P. Flapper, J.A.E.E. van Nunen and L.N. Van Wassenhove (*eds.*), Berlin, Germany: Springer, pp. 109-118.

Larsson, R. 1993. “Case survey methodology: Quantitative analysis of patterns across case studies”. *Academy of Management Journal*, 36(6), pp. 1515-1546.

Lee, A. S. 1991. Integrating positivist and interpretive approaches to organizational research. *Organization Science*, 2, pp. 342-365.

Lee, H.L. 2010. “Don’t tweak your supply chain – Rethink it end to end”, *Harvard Business Review* (88:10), pp. 62-69.

Lim, L.K.S., Acita, F. and Rusetski, A. 2006. “Development of archetypes of international marketing strategy”. *Journal of International Business Studies*, 37, pp. 499-524.

Maslennikova, I. and Foley, D. 2000. “Xerox’s Approach to Sustainability,” *Interfaces* (30:3), pp. 226-233.

McDonough W. and Braungart M. 2002. *Cradle to Cradle: Remaking the Way We Make Things*. North Point Press.

Melville, N., Kraemer, K., and Gurbaxani, V. 2004. “Review: Information Technology and Organizational Performance: An Integrative Model of IT Business Value,” *MIS Quarterly* (28:2),pp. 283-322.

Mostard, J., Teunter, R. and de Koster, M.B.R. 2011. “Forecasting demand for single-period products: A case study in the apparel industry,” *European Journal of Operational Research* (211), pp. 139-147.

Nidumolu, R., Prahalad, C.K. and Rangaswami, M.R.. 2009. “Why sustainability is now the key driver of innovation?,” *Harvard Business Review*, pp. 57-64.

Quariguasi Frota Neto, J. , Walther, G. , Bloemhof, J. , van Nunen, J. A. E. E. and Spengler, T. 2010. “From closed-loop to sustainable supply chains: the WEEE case”, *International Journal of Production Research*, 48: 15, 4463-4481.

Sambamurthy, V., Bharadwaj A., & Grover V. 2003. “Shaping Agility Through Digital Options: Reconceptualizing the Role of Information Technology in Contemporary Firms”, *MIS Quarterly*, 27(2), pp. 237-263

Shrivastava, P. and Nachman, S.A. 1989. “Strategic leadership patterns”. *Strategic Management Journal*, 10, pp. 51-66.

Teunter, R. H., Inderfurth, K., Minner, S. and Kleber, R. 2005. “Reverse logistics in a pharmaceutical company: the Schering case” in *Managing Closed-Loop Supply Chains*, S.D.P. Flapper, J.A.E.E. van Nunen and L.N. Van Wassenhove (*eds.*), Berlin, Germany: Springer, pp. 21-32.

Thierry, M., Salomon, M., van Nunen, J. Van Wassenhove, L. 1995. Strategic issues in product recovery management, *California Management Review* 37(2), 114–135.

Van Dalen, J. V., van Nunen, J.A.E.E. and Wilens, C. M. 2005. “The chip in crate: the Heineken case,” in *Managing Closed-Loop Supply Chains*, S.D.P. Flapper, J.A.E.E. van Nunen and L.N. Van Wassenhove (*eds.*), Berlin, Germany: Springer, pp. 43-55.

Van Heck, E., & Vervest, P. 2007. Smart business networks: How the network wins. *Communications of the ACM*, 50(6): 29-+.

Van Hillegersberg, J., Zuidwijk, R.A., Nunen, J.A.E.E. van & Eijk, D. van. 2001. Supporting Return Flows in the Supply Chain. *Communications of the ACM*, 44(6), 74-79.

Van Nunen, J.A.E.E. & Zuidwijk, R.A. 2004. E-Enabled Closed-Loop Supply Chains. *California Management Review*, 46(2), 40-54.

Wade, M., and Hulland, J. 2004. "Review: The Resource-Based View and Information Systems Research: Review, Extension, and Suggestions for Future Research," *MIS Quarterly* (28:1), pp. 107-142.

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