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Vicious cycles that hinder value creation in closed loop supply chains: Experiences from the field

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Vicious cycles that hinder value creation in closed loop supply chains: Experiences from the field

Abstract: Closed loop supply chains can create value by product acquisition, recovery and reselling returned products and parts. Although advanced supply chain optimization models are available, the literature shows that value creation in closed loop supply chains is limited by too many constraints. Strategic success factors may relax these constraints. This study investigates business practices in the closed loop supply chain of four brand owners in capital goods. We find that strategic success factors may relax constraints but they themselves are also constrained, as multiple stakeholders are involved, each having different interests. In all four cases studies, the interaction between success factors and constraints leads to vicious cycles. Breaking these cycles proves to be difficult and requires integral thinking particularly among internal stakeholders of the brand-owners. Further research is needed to differentiate between different types of cycles, e.g. in a taxonomy, and different stakeholder viewpoints, both quantitative and qualitative.

Keywords: Closed Loop Supply Chains; stakeholders; sustainability; value creation

1. Introduction

Closed Loop Supply Chains (CLSCs) create value in various ways, e.g. expanding markets by offering recovered products to customers with limited budgets (Heese et al., 2005; Purohit, 1992, Schenkel et al., 2015a,b) or reducing a company's environmental footprint (e.g. Atasu et al., 2010; Krikke 2011; Kumar & Malegeant, 2006). Three processes are key in value creation, namely the return of used products and parts from the market, the product or part recovery, and the re-integration (sales/reuse) of recovered products and parts back into the market (Geyer & Jackson, 2004). These processes are often hampered by a variety of external and internal constraints such as costs for disassembly, uncertainty of timing, quality and quantity of returns (e.g. González-Torre et al., 2010; Inderfurth, 2005; Ravi & Shankar, 2005; White et al., 2003). In fact, recent studies show that CLSCs are far from reaching their full potential (Krikke et al., 2013;).

Today, optimization of supply chain processes across different echelons takes center stage, however most research is limited to the domain of forward supply chains, see e.g. Seyed Ashkan Hoseini Shekarabi, Abolfazl Gharaei and Mostafa Karimi (2018). In order to apply these models in closed loop supply chains, an empirical foundation is needed. This calls for explorative research into closed loop supply chains. Only then, objective functions, constraints and solution procedures can be tailored to the specific characteristics of closed loop supply chains

The aim of this paper is to map qualitatively which constraints limit value creation in closed loop supply chains, and which success factors may help to relax the constraints. Actors in different echelons make various decisions which interact, unfortunately often ending up in vicious cycles. We feel that if we understand these dynamics, we may be able to intervene effectively and optimize the closed loop supply chain.

Vicious cycles are a concatenation of unwanted or ineffective events that arise from the interaction between CLSC key processes and their constraints (González-Torre et al., 2010). Strategic factors that serve to relax constraints include product design standards, e.g. to ease disassembly (Krikke & Le Blanc, 2004), customer services, e.g. to enhance return volumes (Östlin et al., 2008), information management, which improves decision making on recovery, and business model changes to strengthen reintegration in the market (Schenkel et al., 2015a; Van Nunen & Zuidwijk, 2004). However, the implementation of these strategic factors themselves may be constrained too as multiple stakeholders are involved whose actions are also inter-related (Corbett & Klassen, 2006; Guide et al., 2003 Meixell & Luoma, 2015). For

example, product design standards involve many stakeholders whose return on investment is slow at best due to long life cycles (Ghazilla et al., 2015). Salespersons are not motivated to sell recovered products as they typically receive lower commissions for selling recovered products than for new ones (Guide et al., 2003). In sum, current literature provides sufficient evidence that stakeholders influence CLSC activities, constraints and strategic success factors that may alleviate constraints, simultaneously and in an interrelated fashion. The lagging implementation of CLSCs in business is due to the fact that this inter-relatedness leads to the emergence of vicious cycles, a phenomenon that has been under-investigated in CLSC research (Meixell & Luoma, 2015).

This study contributes to the literature by examining how constraints and strategic success factors mutually interact and how stakeholders may hamper CLSC value creation. Twenty-seven in-depth interviews and eight site visits have been conducted in four case companies, active in the business to business, high capital electronic goods industry. Better understanding of vicious cycles may transform them into virtuous cycles that lead to improved CLSC value creation. The insights gained can also be used in further developing optimization models.

2. Literature review

A CLSC comprises the original forward supply chain and extends it with key reverse supply chain processes: acquisition, recovering and reselling returned products and parts (Guide and Van Wassenhove, 2009; Özkir and Bashgil, 2012). Used, recovered and new products constitute the installed base from which used products and parts are returned. Returned products and parts are recovered and subsequently sold and re-integrated into the installed base. These three processes re-enforce each other in creating value. CLSC management is defined as the “design, control and operations (of a system) to maximize value creation over the entire life cycle of a product with dynamic recovery of value from different types of return over time” (Guide and Van Wassenhove, 2009). Clearly, value creation means more than just optimizing profits, and should be rooted in the triple bottom line. However, this proves to be difficult to achieve in business practice.

Previous work on value creation in CLSCs (Schenkel et al., 2015a,b) has shown that CLSC activities can be constrained by organization-internal factors such as company policies, product design, lack of know-how about CLSCs or financial constraints (e.g. Kapetanopoulou & Tagaras, 2011) as well as external factors such as infrastructure, governmental policies, or customers’ perception that recovered products are of poorer quality (Abdulrahman et al.,

2012; González-Torre et al., 2010; Zhu et al., 2014). Preliminary studies using surveys (González-Torre et al., 2010; Murillo-Luna et al., 2011), content analyses and case studies (Lau & Wang, 2008; Shaharudin et al., 2015) found mixed evidence with regard to the relative importance and impact of internal or external constraints. Table 1 provides an overview of the internal and external constraints as identified in the literature and following the classification from González-Torre et al. (2010).

<<<Table 1. Literature review on constraints for product recovery >>>

In additional studies, cause and effect relationships between constraints and success factors in CLSC processes were investigated using Interpretative Structural Modelling (Govindan et al., 2016; Mukherjee & Mondal, 2009; Ravi & Shankar 2005) and the Grey Decision Making Trial and Evaluation Laboratory (DEMATEL) approach (Xia et al., 2015; Zhu et al., 2014). For example, the absence of top-management commitment causes deficient strategic planning of CLSC processes which in turn reduces the financial resources dedicated to CLSC processes (Ravi & Shankar 2005). Other studies focused on the optimization of strategies and control regarding business models (Bocken et al., 2016), remanufacturing (Gaur et al., 2017; Zhang et al., 2014) and hybrid manufacturing (Zanoni et al., 2006). Geyer and Jackson (2004) suggest that constraints, which pose specific challenges at each stage of the recovery process, can create inefficiencies for the entire CLSC. Given the interdependencies between CLSC processes, feedback loops can occur that influence the entire CLSC performance (Lehr et al., 2013). Research is needed that addresses the interaction and complexity of constraints in CLSC processes. This can be done by using dynamic models that include feedback loops (Huang et al., 2009; Lehr et al., 2013).

Finally, constraints to CLSC processes can originate from stakeholders and a company's response to the interests of stakeholder groups (Abdulrahman et al., 2012; Govindan et al., 2016; Hillary, 2004). Managing CLSCs involves the interaction and integration of, both forward and reverse, supply chain stakeholders and stakeholders beyond organizational borders and the traditional value chain (Corbett & Klassen, 2006). Freeman (1984) defines a stakeholder as "any group of individuals that can affect or is affected by the achievement of an organization's objective" (Freeman, 1984, p. 46). To stay competitive in today's markets, companies not only have to respond to stakeholder requests, but also prioritize them based on their relevance for the company (Matos & Hall 2007; Mitchell et al., 1997; Olugu et al., 2010; Sarkis et al., 2010). Stakeholders can be distinguished into different groups such as primary

versus secondary stakeholders (e.g. Álvarez-Gil et al., 2007; Chapter 3), or, as followed in this study, internal versus external stakeholders (e.g. Abdulrahman et al., 2012). Internal stakeholders are for example employees, departments, or top-management and external stakeholders can be customers, suppliers, governmental and non-governmental organizations, or even the natural environment. Both stakeholder groups can “promote or constrain the development of more effective (reverse logistics) processes” (Corbett & Klassen, 2006, p. 14).

Constraints for CLSC processes can be overcome by adapting and changing the design of processes and products in the forward and/or in the reverse supply chain (Geyer & Jackson, 2004). Schenkel et al. (2015a) identifies product design, customer services and business models for recovery as strategic factors. Intra-and inter organizational information sharing and stakeholder relationships also strengthen value creation, provided that the first strategic three factors are already present. Product design principles include design for disassembly, design for the environment, modularity, and upgradability facilitate disassembly, low-level recovery and upgradability of parts (Khor & Udin, 2013; Niinimäki and Hassi, 2011; Rashid et al., 2013, Mollenkopf et al., 2011, Jayraman, 2007). From a general perspective, implementing sustainability in design principles is influenced by different human factors, such as resistance against change and communication (Verhulst & Boks, 2012). Customer services, such as service contracts, after-sale-services, pay-per-use or leasing, enable manufacturers to keep track of their products and make targeted service or trade-in offers to customers with used products (Mont et al., 2006; Östlin et al., 2008). Business model aspects include trade-in activities, choice of recovery activities or decisions on recovering in-house or with a third party (Oezkir & Bashgil, 2012; Subramoniam et al., 2013; Toffel, 2004; Wells & Seitz, 2005). Thereby, CLSC business models should aim at integral value creation that is taking into account multiple stakeholders and the entire process instead of separate business functions (Guide et al., 2003). Information management and IT systems (e.g. product data management systems, installed base monitoring) are also used to obtain information from the installed base. This information can be used for forecasting product returns and timing or choosing recovery options for returned products (e.g. Huscroft et al., 2013; Van Nunen & Zuidwijk, 2004; Zhou et al., 2017). Information sharing is an important factor when dealing with resistance to change (Verhulst & Boks, 2012), hence it is an important enabler for alignment of interests and relationships between stakeholders (Gan, 2017, Östlin et al., 2008). Abolfazl Gharaei and Seyed Hamid Reza Pasandideh (2017a,b) model a four level integrated supply chain. The aim of both papers is to optimize lot-sizing in each level such that the total

cost of the chain is minimized while (stochastic) constraints such as limited procurement cost, limited space, and limited ordering cost are satisfied. Note that these types of optimization models presume perfect information availability.

In conclusion, current literature provides mixed evidence about the relative impact of internal or external constraints to CLSC activities as well as strategic success factors that may alleviate constraints. We argue that in practice vicious cycles emerge from the inter-relatedness between constraints and strategic success factors. Our study will investigate this phenomenon that hitherto has only been scarcely addressed in CLSC research (Meixell & Luoma, 2015). Understanding vicious cycles, and how to turn them around, is crucial for further advancement of the field, both in qualitative and quantitative research as well as business practice.

3. Methodology

3.1 Data collection approach

This study conducts explanatory multiple case study research (Eisenhardt, 1989; Miles & Huberman, 1994) focused on the CLSC of a product group of brand owners, as they are best equipped to take decisions in CLSCs.

The sample consists of four European brand owners of high capital goods who operate in global electronics and baggage handling equipment industries. These cases are suitable for studying constraints to CLSC for several reasons. First, companies in this industry are actively involved in CLSC processes (Talbot et al., 2007) and hence, probably encounter several constraints. Second, high-end capital goods are suitable for our study, because they entail complex, closed loop systems that incorporate many relevant aspects like high financial value, a long life cycle or service level agreements. Third, electric and electronic goods are subject to environmental regulations such as Waste Electrical and Electronic Equipment (WEEE), Restriction of Hazardous Substances (RoHS), or Registration, Evaluation, Authorization and restriction of Chemicals (REACH), which both trigger and constrain recovery processes. Fourth, brand owners of high-capital goods tend to have close relationships with external stakeholders, for example, by offering service level agreements to their customers. These are common characteristics of all four cases.

The four companies differ in size and maturity of recovery activities, their business model, recovery activities, type of industry, and service activities (Table 2 and 3). This variety

allows us to study the impact of CLSC-, organizational- and product characteristics on the value creation process, success factors and their constraints (Eisenhardt, 1989). Data were collected via interviews, participative observation in workshops and site visits (Table 4). Secondary data was obtained from corporate internal research projects, environmental reports and internal documents and presentations obtained from interview respondents. Twenty-seven semi-structured interviews were held with managers in service, reverse logistics, sustainability, sales, R&D and product management. The interview questions were related to product characteristics, reverse supply chain processes, service offers, product recovery options, value creation and constraints to CLSC processes.

<<<Table 2. Sample criteria and CLSC characteristics>>>

<<<Table 3. Sample characteristics and strategic success factors>>>

<<<Table 4. Data used in this study>>>

3.2 Data analysis approach

For each case, data was coded using NVivo 10 to identify relationships between different constructs. While coding, memos were written to capture emerging ideas (Miles & Huberman, 1994). Next, the effect of constraining factors on the three key processes was examined. Codes were constantly reviewed, and constraints to CLSC processes identified, as well as constraints to implementing the strategic success factors (internal and external). Subsequently, findings on the constraints with four strategic success factors for various stakeholders were derived (Table 5).

Causal loop diagrams were developed to capture interactions between CLSC constraints, strategic success factors and stakeholder interests (Figures 1 and 2). Vicious cycles can be described as a sequence of reciprocal causes and effects leading to a worsening of the situation. Causal loop diagrams generate deeper insights about complex issues by investigating causes and effects in feedback processes (Kim, 1992; Moorecroft, 2007). Due to the explanatory power of interactions among actors and processes, this method is often used by researchers investigating complex issues (e.g. Georgiadis & Besiou, 2008; Lehr et al., 2013; Spengler & Schröter, 2003).

The relationships between the variables in a causal loop diagram can have a positive or negative polarity and encompass delays (Miles & Huberman, 1994; Moorecroft, 2007). A “+”

means that if the cause increases, the effect increases too, while “-” means that if the cause increases, the effect decreases below what it would have been otherwise. A “delay” means that a given cause leads to effects after a time delay (Moorecroft, 2007, 39-40). A “-” in the centre of the loop indicates a balancing feedback loop. In a balancing loop, a change in one variable is counteracted in the course of the loop. In a re-enforcing loop, indicated by a “+”, a change in one variable is re-enforced in the course of the loop (Moorecroft, 2007). Please note that the purpose of causal loop diagrams is to show interdependencies rather than inflows or outflows in a process.

4. Results

This section overviews the results regarding constraints in the case companies on the level of key processes (section 4.1) and the success factors (section 4.2).

4.1. Constraints to key processes

Constraints to the return process and trade-in of used products and parts

The return process is influenced by several factors. A major internal factor is a company's trade-in rate. Cases 1 and 2 have dedicated business units, recovery facilities, and capacity for recovery. Their product portfolios consist of both new and recovered products, which requires continuous availability of returns inventory and, hence, trade-in of used products and parts. One manager explained (case 1, company specific information was replaced by neutral terms between square brackets [...], editorial amendments for readability are indicated by parentheses ()):

“(For) the main runners we have a constant flow of [products] coming in, mhh, we would have some (used products) in the warehouse and we have constant (refurbishment) production running in the [x products] so, mhh, and also that is not a stable thing, which might fluctuate over time, (...) yeah, you have seen we have quite some square meters for storage.”

In cases 3 and 4 trade-ins were occasionally used for offering customers discounts on new products when returning old ones. Hence, dedicated capacity, and inventory were lower in cases 3 and 4 than in cases 1 and 2. One operations manager (case 3) indicated that product and part recovery required a high inventory of used parts, and hence, high working capital

costs. Cases 1 and 3 also faced limited capacity and utilization issues due to the uncertainty of timing, quantity and quality of product returns.

Manufacturers offered trade-in prices for returning their used products and parts. They calculated the trade-in price based on information about a product's residual (book) value, maintenance status and life cycle position. Many manufacturers struggled to determine a realistic residual value. They often calculated the residual value of used products and parts based on linear value depreciation after years of use and estimated recovery costs (cases 1, 4). However, the market value of the product was sometimes higher (cases 1, 2). As manufacturers were not able to pay the same trade-in or acquisition prices as competitors or brokers, some products were sold elsewhere and not returned (cases 1, 2, 3). Furthermore, case 4 showed a high level of customization that inhibited a proper calculation of the residual value of used products. All four brand owners faced constraints to obtaining information about the maintenance status, the life cycle position and the rest value due to a low field traceability of products and parts. For example, low field traceability occurred in the case of products without service contracts. In case 3 products and customers were also not traceable anymore due to fusions and acquisitions of companies.

Complex CLSC design added to this problem. For example, case 2 outsourced the sales and service of products and parts to third parties, i.e. a broker or service company. As a result, the company had little direct contact with customers and therefore less control over the installed base. One manager (case 2, translated):

“Yes, but if you do a lot of sales via dealers [...] as we do, then the barrier for the return flow is simply higher.”

Having a complex global CLSC design in addition to worldwide installed bases resulted in high reverse logistic costs. Cases 3 and 4 had a worldwide - although much smaller - installed base with low return rates. Here, reverse logistics costs increased due to small economies of scales.

With regard to external constraints, some customers refused to return used products (cases 1, 2). They were hesitant to return parts and products because these contained confidential information.

Constraints to the recovery of used products and parts

Internal constraints to product and part recovery were mostly related to product characteristics. Managers from all cases admitted to face high costs, as end of life issues had

not been considered during product development, especially for older products (cases 1, 2, 3). Harvesting and recovering parts is only possible when products are easy to disassemble, modularly designed, and recovered parts can be used across product groups. This requires inter-release and inter-product compatibility, which is reduced by customization and limited standardization (case 4). All brand owners produced products with long life cycles, implying that products and parts that were returned from the market could not always be upgraded and were not always compatible with new releases (cases 1, 2, 4). Hence, recovered products may have become unattractive for customers.

On the external side, environmental directives such as RoHS and REACH restricted the use of certain substances and materials (cases 1, 2). The brand owners in this study sold products with long life cycles that could contain restricted materials. This resulted in higher recovery costs, because non-compliant components had to be replaced. An asset recovery manager (case 2) mentioned that when the latest RoHS regulation was launched, the company had to dispose of valuable inventories of recovered parts because they contained non-compliant components.

When selling recovered products or parts, brand owners strive for high quality and warranty leading to high recovery costs. One service manager explains that their customers expect this (case 3, translated):

“So, let’s say, a broker’s customer accept that, ok, this [part] does not work, so, (the broker says) I send a new one. But they do not accept that from us, we have to go there (to the customer), we have to make costs. “

Part recovery decreased the procurement of new and recovered parts from the supplier and, hence, affected supplier relationships. In case 3, suppliers reacted by increasing prices for new parts and refusing to collaborate. Additionally, third tier suppliers lowered new material prices when manufacturers recovered old materials and lowered their demand. These market price mechanisms increased recovery costs and made it economically unattractive to undertake recovery activities.

Constraints to the sales of recovered products and parts

The sales of recovered products and parts was hampered by internal constraints related to the original and secondary markets. For example, companies were careful with promoting recovered products and parts on the original market in order to reduce the risk of cannibalization of new sales (cases 1, 2). As a result, they focused on cascaded secondary

markets. Another concern was that secondary markets might be too small to make recovery beneficial for the brand owner (cases 3, 4). One manager (case 2) explained how his company manages recovery and sales of used products and parts (translated):

“Depending on which point in the development of the population we start [with the second life cycle], we can say something about when we expect products to come back. And that depends on the product, but also on the competition and if there is still enough money in the market for a [recovered] product.”

Moreover, bonus systems for sales people also promoted sales of new products and parts rather than recovered ones (cases 1, 4).

Externally, brand owners mainly faced competition by third parties, i.e., competitors or brokers. Parts that are harvested and resold by brokers destroyed the demand for the brand owner's spare parts (case 1). Brokers could also offer cheaper recovered products due to low quality standards and no provision of warranty and, hence, lower recovery costs (cases 1, 3, 4). However, customers expected warranty and service contracts when they bought a recovered machine from the brand owner. Depending on a product's age, manufacturers feared that they could not provide service parts and warranty (case 3):

“If it is already end of sales, we will be reluctant in reselling it. Because then again, you re-enter commitments. The customer to whom you sell the machine, expects certain warranty times. So if you do that, one year before the end of service, then in the warranty he gets limited service. That is not what he wants. So we look at the age of the equipment, if it is already 15 years old the trade in deal we take into account is that we will probably scrap it.”

Sometimes, customers preferred new machines with new functionalities over recovered ones (cases 1, 3, 4). From recovered products, they demanded a product's environmental performance that is equal to new products (2, 3, 4). One manager (case 2) questioned (translated):

“But if it is about green, then in the new products there are also quite some developments, let's say, a new car drives in general also greener than a second hand car which is 10 years and this one drives less economical than the new one. So what is green?”

Additionally, as products have to be returned from the market, inspected and recovered, lead times for recovered product were longer than for newly built products (case 1). Furthermore, some countries (e.g. China) impose import and export regulations which, for

example, inhibited the import of recovered products and, hence, reduced the size of the secondary market (cases 1, 2).

<<<Table 5. Constraints to CLSC key processes>>>

Figure 1 provides a modelled view of the dynamics of the factors presented in Table 5. For example, the more products and parts are produced, sold and placed in the installed base, the higher is the (potential) trade-in rate and return rate after customers' use (delay). As often old products are traded-in for new ones, a high trade-in rate in turn increases the sales of new products and parts. The trade-in rate is influenced by the installed base visibility, which refers to knowledge about the location, maintenance status, and life cycle of products. For example, a good installed base visibility indicates that trade-in offers can be made to customers with products that become end of life. As a result, the trade-in rate increases. These dynamics re-enforce each other negatively, and a vicious circle arises, impeding the three key CLSC processes on an operational level.

<<<Figure 1. Re-enforcing CLSC key processes>>>

Based on prior literature (Östlin et al., 2008, Van Nunen & Zuidwijk, 2004), one may assume that strategic success factors (i.e. customer services, information management, product design and business models) relax operational constraints and ideally, break the vicious circle. For example, customer services affect the return rate and the sales of recovered machines. Services such as leasing increase sales and oblige customers to return the used product after the leasing period. Information management may increase field traceability, which enables higher trade-in prices. The product design, such as design for disassembly, influences the recovery rate by facilitating the recovery of used products and parts. The business model focuses on internal constraints related to trade-in offer and constraints related to the re-integration. Figure 2 shows the relationships between the operational constraints and strategic success factors.

<<<Figure 2. The impact of strategic success factors>>>

4.2. Constraints to the strategic success factors

The implementation of success factors is constrained itself in several ways (Table 6). These constraints concern corporate strategic choices on, for example, product design or customer service offerings, and are often rooted in conflicts of interest between stakeholders. First, service models, such as leasing, are constrained by limited customer demand. A manager (case 4) stated (translated):

“These (service models) are not yet common, at this moment there are no customers who ask for this (leasing or pay per use). We are talking to some customers about this, yet there are no concrete examples, yet”.

Many customers have sufficient budget to directly purchase products and parts instead of leasing them and they have preferred ownership over rental solutions. Customers also aim for keeping control over, for example, maintenance and repair activities. Some managers stated that leasing does not by definition reduce the customers’ total cost of ownership. Some brand owners did not perceive leasing as creating immediate economic benefits such as increased sales. Leasing requires a long-term focus as pre-investments have to be made. One manager (case 3) explained:

“You have to pre-finance the full equipment and after three months, you get it back and then it is your risk to sell it again pre-owned. And if you are not careful, you have a number of rental deals outstanding and then the crisis come and you suddenly have 20 machines back.”

Second, integrated data and information management remained challenging, because organizational departments source from different channels and process information in different databases. Complex information systems resulted, involving different databases to which, for example, the recovery department did not have access to.

Third, in our sample, the implementation of product design principles that support recovery was impeded by limited R&D budgets or short times to market that favour design requirements for new products. If part design and manufacturing was outsourced to suppliers, brand owners only specified the required functions of a part or product. Hence, they also had limited influence on low level design that would facilitate recovery activities.

Fourth, organizational inertia constrained an increased recovery business and activities as changes in the business model towards more recovery were regarded as ‘too big’. Several departments could dedicate limited resources and time to implementing a new business model that included recovery causing resistance to change. In the absence of explicitly developed guidelines, recovery activities are rather occasional than structurally included into corporate processes. Two brand owners stated that they do not engage in recovery on a regular basis because their business’ major focus is to sell new products and parts. A service manager (case 3) (translated):

“Look, the supply chain managers get the returned products back, he gets the inventory (...) and he does not want that, so he immediately tries to push (the returns) forward and sells it to a broker (...) The sales manager would say (..) as long as I can, I will sell the more expensive (new) proposition.”

Finally, the corporate accounting system was seen as linear rather than circular, aiming at short-term profitability. Every department had to be profitable by itself, which impeded integral thinking among departments. Hence, the value that investments, e.g. in new service models or improved product design, can bring for several departments in the long term were not considered. For example, leasing models could benefit the sales department by increased sales and better customer services and the recovery department by a higher recovery rate. Sustainable and circular business models are difficult to develop, and some managers demanded more top-management commitment to change the business model, as well as stimulations from external parties such as the European Union.

<<<Table 6. Constraints for the implementation of the strategic success factors>>>

5. Discussion and conclusion

5.1 Theoretical contribution

This paper analysed constraints to value creation in CLSCs at four brand owners in capital goods. Through modelling we mapped (internal and external) operational constraints in a causal loop diagram (Figure 1), which enabled us to identify vicious cycles that hamper value creation in CLSCs. Several insights could be distilled from the causal loop diagrams.

First, based on our results, it can be concluded that internal and not external constraints are most important in CLSCs. The implementation of strategic success factors mostly depends on

internal rather than external stakeholders' interests. For example, projects for changing product design towards improved recovery opportunities require close contact between the R&D, recovery and financial department. External constraints affect manufacturers' CLSC processes by reducing the return rate and increasing costs. For example, a high market value of products and a global installed base cause high trade-in and reverse logistics costs. Environmental regulations and customers' quality standards increase recovery costs as a smaller share of returned products can be reused. Hence, external constraints, which arise from demands of external stakeholders, will affect the internal stakeholders, and are internalized as costs and lower return rates in CLSCs.

In the literature there is no consensus about the relative importance of internal and external constraints to CLSC activities. Hillary (2004) and Post and Altman (1994) find that internal issues need to be solved first, while González-Torre et al. (2010), Govindan et al. (2016) and Shaharudin et al. (2015) find that external constraints are of major importance. Shaharudin et al. (2015) suggests that inconsistencies in findings may relate to the fact that studies differ with respect to the size of the firms that are in the data set of each study. Our dataset contains both large and small firms, and by taking into account the emergence of vicious cycles, we can conclude that brand-owners should integrate internal departments first. Nevertheless, the effects of the firm size or business specific aspects on the relative importance of internal and external constraints could be further investigated in future research.

Second, the constraints themselves are inter-related. The three key processes discussed in section 4.1 (return, recovery, and re-integration of used products and parts) are interdependent and form a re-enforcing loop with the installed base and rate of products that are traded-in for recovery in a negative way. Constraints that affect one key process indirectly affect others. For example, due to market uncertainty or customers' demand for service and warranty for older generations of products, manufacturers were hesitant to recover and re-sell used products and parts. Moreover, some products are not easy to disassemble or recover, which results in lower recovery rates and higher unit recovery costs. Manufacturers anticipate and weigh these costs against the benefits that they can yield from recovery. Depending on the expected benefits, they will offer a high or low trade-in value, which steers the return rate. The constraints found in the four case studies and how they influence other factors (Table 6) confirm some of the model variables and related interactions recognized and modelled in earlier research, e.g. phenomena such as uncontrollable disposal, product return rate, new product demand, new product sales (Georgiadis & Besiou, 2008; Lehr et al., 2013).

Third, constraints can be relaxed by strategic success factors, but in turn conflicting interests - especially among internal stakeholders - limit their implementation. Relaxing constraints requires integral thinking among internal stakeholders, otherwise less value is created than is potentially possible.

Contrary to past research, we did not find lack of awareness (Ravi & Shankar, 2005), lack of know-how, or lack of training to be relevant for internal constraints (Abdulrahman et al., 2012; González-Torre et al., 2010; Kapetanoupoulo & Tagaras, 2011; Post & Altman, 1994). This may be due to the fact that our sample companies were already actively involved in CLSC activities. Constraints to the business model as proposed in this study are in line with Kapetanoupoulo and Tagaras' (2011) proposed factor of inconsistency with the company's operations. Moreover, past studies proposed driving forces or enablers (e.g. remarketing, lack of strong financial support; lack of technological research) that initiate cause- and effect chains among CLSC constraints (Mukherjee & Mondal, 2009; Xia et al., 2015; Zhu et al., 2014). The causal loop diagram used in this study shows that CLSC key processes and constraints re-enforce each other in a feedback loop and create a vicious cycle that hamper brand owners to scale up and optimize CLSC processes.

As mentioned in the introduction, this is an explorative, qualitative research. The research team has followed up this project by a quantitative study applying ILP modelling in Health care industry. It includes dual sourcing options and the possibility of shortages or oversupply of returns with limited warehouse space. It involves trade-offs between selling new or refurbished parts competing in the same market and hence lot sizing both. Last but not least we should consider optimizing total supply chain cost integrally along multiple (closed loop) supply chain echelons and actors. Given the inherent complexity and uncertainty, it is important to model problems some form of stochastic modelling may be in order building on work of e.g. Abolfazl Gharaei & Seyed Hamid Reza Pasandideh (2017a,b). They model four-level integrated supply chain network problem consisting of a supplier, a producer, a wholesaler, and multiple retailers. Adding returns processes to this will further increase complexity. Other modelling elements may have to be included such as imperfect quality products and a bi-objective function, with conflicting goals (Abolfazl Gharaei, Seyed Hamid Reza Pasandideh & Seyed Taghi Akhavan Niaki, 2018).

5.2 Limitations and further research

Limitations of this study give rise to recommendations for further research. We studied constraints to CLSC key processes and strategic success factors from the perspective of brand

owners, while incorporating other stakeholders' views. A multi-perspective view of CLSC actors may lead to a supply chain view on adjusting CLSC processes. Moreover, it would be worthwhile to compare the results of this study with results from studies in other industries, outside the business to business context and electronic industry. The variables in our causal loop diagram are based on constraints deduced from all case studies. The focus of the analysis was not specifically to differentiate between constraints that were mentioned only once, or were mentioned several times. Hence, the diagrams do not provide information on the relative importance of each CLSC constraint on each CLSC key process. More research is needed on ways for breaking the vicious cycle and implementing the strategic success factors. This could be done by studying incentive management and functional integration between stakeholder groups in CLSCs (Guide et al., 2003). Thereby, the benefits could be investigated of a business model that focuses on integral value creation among departments versus individual value creation per department.

Furthermore, this study confirms the framing of ecological benefits and values within an economic perspective, in which long term profits are predominant, both in CLSC context (Schenkel et al., 2015a, b) as well as in broader sustainable supply chain context (Carter & Rogers, 2008). Further research on integrated value creation according to the triple bottom line (Elkington, 2018), specifically in CLSC context is recommended. When discussing investments for implementing the strategic success factors, the question of revenue sharing among CLSC stakeholder groups calls for more attention. For example, the party that recovers returned products and, hence, benefits from product design improvements might not be the one investing in it (Schenkel et al., 2015b). Quantitative studies using system dynamics or other simulation and optimization methods to simulate the causal loop diagrams developed in this study are encouraged. As different types of value apply, i.e. economic, environmental, social or customer value, different complementary paths may be needed. The resulting models will be nonlinear and are likely to apply advanced methods such as sequential quadratic programming (SQP), as for example Abolfazl Gharaei, Seyed Hamid Reza Pasandideh, Alireza Arshadi Khamseh, (2017b). Closed loop supply chains have typical characteristics such as multicriteria objective functions and uncertainty. Given the strict assumptions of these mathematical models, a perfect fit and perfect data are needed.

Many of these complex models have only been validated by numerical examples and not in real life cases. Yet, they can help to gain new insights on interventions which might eventually enable managers to turn vicious cycles into virtues cycles.

5.3 Managerial implications

Our study provides several managerial recommendations for organizations and managers involved in CLSC processes.

Our study illustrates that companies may be locked in into a vicious cycle in which the strategic success factors for relaxing constraints on closed loop supply chains are constrained themselves, as multiple stakeholders are involved, each having different interests. Practically, companies can set out a path to proactively manage the vicious cycles. Starting with low hanging fruit, some value created at relatively short notice may provide the resources for relaxing constraints hampering ‘the next level’ success factors. For example, by implementing incentive management and organising functional integration between CLSC stakeholder groups a first step can be taken into breaking out of the vicious cycle. Furthermore, adopting a holistic, long term view and designing internal policies and incentives that stimulate integral value creation *among* departments (as opposed to value optimization *within* isolated departments) will also mean progress towards implementing strategic success factors for managing CLSCs.

Relatedly, our study suggests that managers who are able to frame ecological values within an economic perspective, are heading for success. The challenge is to achieve the same with customer -, social and information value. Based on the four cases studied, we suspect that the optimal path varies per case. For example, where one business may start with implementing proper IT systems before implementing a new business model, others may start with product development. As already mentioned in the previous paragraph, companies need to find complementary and perhaps partly concurrent paths with carefully designed interventions.

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Table 1. Literature review on constraints for product recovery

	Constraints	References
Internal	Lack of information, efficient information and technology systems	Govindan et al., (2016); Murillo –Luna et al., (2011); Ravi & Shankar (2005); Rogers & Tibben-Lemke (1998); White et al., (2003); Xia et al.,(2015); Zhu et al., (2014)
	Problems with product quality; perception of poorer quality product	González-Torre et al., (2010); Krikke et al., (2003b); Kumar & Malegeant (2006); Ravi & Shankar (2005) ; Tibben-Lemke & Rogers (2002)
	Problems with product design	Geyer & Jackson (2004); Govindan et al., (2016); Mukherjee & Mondal, (2009); Thierry et al., (1995); White et al., (2003); Zhu et al., (2014)
	Problems with upstream choices	White et al., (2003)
	Resistance to change; Lack of shared understanding and incentives	Abdulrahman et al., (2012); Govindan et al, (2016); Murillo-Luna et al., (2011); Ravi & Shankar (2005); Shaharudin et al, (2015)
	Inconsistency with the company's operations; Lack of company policies	Abdulrahman et al., (2012); Govindan et al, (2016); Kapetanopoulo & Tagaras (2011); Kumar & Malegeant (2006); Ravi & Shankar (2005); Rogers & Tibben-Lemke (1998); White et al., (2003)
	Complexity of implementation	Guide et al., (2000); Kapetanopoulo & Tagaras (2011); Kumar & Malegeant (2006); Murillo-Luna et al., (2011); Van Wassenhove & Geyer (2002); Xia et al., (2015)
	Lack of appropriate performance metrics	Govindan et al., (2016); Ravi & Shankar (2005)
	Financial constraints and uncertainty (e.g. investment costs and uncertainty, economic feasibility, feasibility of recovery, human resources)	Abdulrahman et al., (2012); Del Brio & Junquera (2003); Geyer & Jackson (2004); Guide et al., (2000); Kapetanopoulo & Tagaras (2011); Kumar & Malegeant (2006); Murillo-Luna et al., (2011); Ravi & Shankar (2005); Richey et al., (2005); Rogers & Tibben-Lemke (1998); Shaharudin et al., (2015); Xia et al., (2015)
	Increased inventory costs, poor inventory management	van der Laan & Salomon (1997); White et al., (2003); Zhu et al., (2014)
	Lack of facilities for reverse logistics and recovery	Abdulrahman et al., (2012); Xia et al. (2015)
	Lack of top-management commitment, leadership and communication	Abdulrahman et al., (2012); González-Torre et al., (2010); Murillo-Luna et al., (2011); Ravi & Shankar (2005)
	Organizational inertia	Defee et al., (2009); Murillo-Luna et al., (2011)
	Lack of awareness	Kumar & Malegeant (2006); Ravi & Shankar (2005); Rogers & Tibben-Lemke (1998)
	Lack of strategic/long-term planning	Murillo-Luna et al.,(2011); Ravi & Shankar (2005)
	Lack of know-how and training	Abdulrahman et al., (2012); Autry et al., (2001); Govindan et al., (2016); Kapetanopoulo & Tagaras (2011); Mukherjee & Mondal, 2009; Murillo-Luna

		et al., (2011); Ravi & Shankar (2005); Rogers & Tibben-Lemke (1998); White et al., (2003); Xia et al., (2015)
	Uncertainty of timing, quantity and quality	Guide et al., (2000); Kumar & Malegeant (2006); Shaharudin et al., (2015); Srivastava (2008); White et al., (2003); Zhu et al., (2014)
	Problems with balancing demands with returns Long lead time	Guide et al., (2000) Govindan et al., (2016)
External	Limited market demand for recovered products and parts; Demand uncertainty or fluctuations	Geyer & Jackson (2004); Govindan et al., (2016); Mukherjee & Mondal, (2009); Shaharudin et al., (2015); Zhu et al., (2014)
	Coordination requirements of two markets (new and used); Market uncertainty	Fleischmann et al., (2000); Govindan et al., (2016); Srivastava (2008); Zhu et al. (2014)
	Conflicts with (environmental) regulations/ conflicting regulations in different countries Lack of enforceable laws and directives on take back of end-of-life Lack of industry standards	Govindan et al., (2016); González-Torre et al., (2010); Hillary (2004); Murillo- Luna et al., (2011); Shaharudin et al., (2015); Thierry et al., (1995); Xia et al. (2015); Zhu et al., (2014); Zilahy (2004) Abdulrahman et al., (2012) Zhu et al., (2014)
	Customer reluctance	Govindan et al., (2016); González-Torre et al., (2010); Krikke et al., (2003b); Zhu et al., (2014)
	Reluctance on the part of social actor (e.g. NGO or community)	González-Torre et al., (2010); Hillary (2004)
	Reluctance to support of supplier	González-Torre et al., (2010); Ravi & Shankar (2005)
	Reluctance to support of/Lack of collaboration with dealers, distributors and retailers or other third parties (including research institutes)	Abdulrahman et al., (2012); Govindan et al., (2016); Murillo-Luna et al., (2011); Ravi & Shankar (2005); Xia et al., (2015)
	Limited access to products leaving the use phase	Geyer & Jackson (2004); Murillo-Luna et al., (2011); Shaharudin et al., (2015); Xia et al., (2015); Zhu et al., (2014)
	Lack of information about the market and market value of returned goods	Srivastava (2008); White et al., (2003)
	Market cannibalization	Atasu et al., (2010); White et al., (2003)
	Deficient industrial infrastructure	Abdulrahman et al., (2012); Del Brio & Junquera (2003); González-Torre et al., (2010); Govindan et al., (2016); Murillo-Luna et al., (2011); Shaharudin et al., (2015); Zhu et al., (2014)

Table 2. Sample criteria and CLSC characteristics

	Company size in number of employees	Maturity based on estimated return rate*	Industry	Re-use	Re-furbish	Re-manufacture	Re-pair	Harvest	Re-cycle	Market for recovered products
Case 1	<35,000	High (10-12%)	Medical	+	++			+	+	Original & new
Case 2	<30,000	High (10-15%)	Document Management		+	++			+	Original & new
Case 3	<300	Low (0-2%)	ICT			+	++		+	Original
Case 4	<3000	Low (0-1%)	Material- & Baggage Handling		+		++	+	++	Original

*The return rate is estimated by corporate representatives and describes the share of returned products in comparison to new ones sold. The

“+” indicate the degree of activity and importance within the company

Table 3. Sample characteristics and strategic success factors

	Business model	Customer services	Product design	Information management
Case 1	Integral; Recovery at the OEM by the recovery department/unit	Service level agreements; Upgrades/modifications on & off customer site; Leasing; Trade-in business standardized	Inter-release compatibility; Standardization on product & part level; Design for environment & disassembly; High level modular design	Information collection about the installed base, age, technical status and location of products, spare part consumption
Case 2	Integral; Recovery at the OEM by the recovery department/unit	Service level agreements; Upgrades/modifications on & off customer site; Leasing; Trade-in business standardized	Inter-release compatibility; Standardization & high level modular design on product and part level; Robust, design for disassembly; Customized software solutions	Information collection about installed base, age, technical status and location of products, spare part consumption; Remote diagnostics
Case 3	Business case driven; Recovery by supplier and OEM by the customer service department	Service level agreements, repair services; Upgrades/modification on customer site; Capacity on demand; No standard trade-in business	Inter-release and inter-product compatibility; Standardization on part level; Customization of software and hardware configuration; Design for environment; Modular design and design for disassembly	Information about age, technical status and location of products, spare part consumption; Remote diagnostics; Maintenance, service and recovery processes
Case 4	Business case driven model; Recovery by supplier and OEM by the customer service department	Service level agreements, local service teams; Upgrades/modification on customer site; Repair services; No standard trade-in business	No inter-release or inter-product compatibility; Standardization on part and module level; Customization of entire product; Modular design and design for disassembly on part level	Information about age, technical status and location of products, spare part consumption; Performance analysis system

Table 4. Data used in this study

Case study	1	2	3	4
Interviews	6	4	8	9
Site visits	2	1	2	3
Observation	3	-	1	2
<i>Secondary data</i>				
Presentations	-	-	2	3
Internal documents	-	-	-	3
Research projects	2	2	3	2
Brochures	2	4	-	-

Table 5. Constraints to CLSC key processes

Constraints	Return process and trade-in of used products and parts	Influences on and modelled in category...	Recovery of used products and parts	Influences on and modelled in category...	Sales and re-integration into forward supply chain	Influences on and modelled in category...
Internal	Limited capacity and inventory dedicated for product or part recovery as trade-in as an occasional business (3,4); Working capital costs (3); Uncertainty about quality, quantity and timing influences utilization (1,3)	Capacity and utilization Uncertainty of timing quality & quantity	Limited inclusion of end of life/ end of use factors into product development (1,2,3,4), e.g. Disassembly, modularity and upgradability possibilities (1,2, ,4); Limited standardization due to customization (4)	Ease of disassembly and recovery	Risk of demand cannibalization (1,2) uncertainty secondary market (3,4)	Market uncertainty
	High trade-in price(1,2,3,4), High market value (1,2) Limited information due to customization (4); Limited information status quo of products (1,2,3) and rest value (1,4)	Trade-in price	Limited inter-product compatibility (1,3) Long life cycle (1,2,3, 4) time-based value (low compatibility) of products (1,2,4)	Compatibility	Corporate bonus systems (1,4)	Bonus system
	Low field traceability (1,2) Outsourced sales to thirds (2) Low visibility due to fusions and acquisitions (3)	Installed base visibility				
	Complex CLSC design (2) and high reverse logistic costs (1,2,3,4); Small installed base (3,4)	Reverse logistics costs				
External	Customer keeps product (1,2) or sells systems otherwise (1,2,3); Customer refuses to return due to confidential information on machines (3)	Uncontrolled disposal	Environmental regulations (1,2); Customer expects high quality (1,2,3,4); Reduced business for supplier (3); Market price mechanisms for raw materials(3);	Recovery costs	Third party influence (e.g. brokers) as competitors, reducing demand for used parts (1) and products (1,3,4)	Third party influence
					Lack of service contracts	Customer demand

					and warranty; lack of demand for recovered machines (1,3,4);focus on life cycle performance (2,3,4);Longer lead time than new built (1)	for new products
					Import and export regulations (1,2)	Regulation
Stakeholders involved	<i>Internal:</i> Recovery department, sales and service department, installed base team, business units; <i>External:</i> Customer		<i>Internal:</i> R&D department, recovery department, project business <i>External:</i> Governmental organizations, customers, suppliers		<i>Internal:</i> Sales department <i>External:</i> Customer, brokers	

Table 6. Constraints for the implementation of the strategic success factors

Strategic success factor	Constraints to the implementation	Stakeholders involved
Customer service	<ul style="list-style-type: none"> ▪ Limited customer demand for leasing due to <ul style="list-style-type: none"> - Sufficient budget for purchase (1,3,4) - Customers' wish to keep control over products (1,3,4) - No reduced total cost of ownership (3,4) ▪ No perceived economic benefits of leasing for the brand owner (3,4) ▪ Pre-investment and risk that customer might go bankrupt during leasing period (3,4) ▪ Preference for traditional ownership (1,3, 4) 	<p><i>External:</i> Customers</p> <p><i>Internal:</i> Sales department, top-management; financial department</p>
Information management	<ul style="list-style-type: none"> ▪ Complex information systems due to multiple databases (1,4) 	<i>Internal:</i> IT department
Product design	<ul style="list-style-type: none"> ▪ R&D budget (1,2,3) ▪ Time to market (1,3) ▪ Supplier integration into the design process (1,4) 	<p><i>External:</i> Supplier</p> <p><i>Internal:</i> R&D department, top-management</p>
Business model	<ul style="list-style-type: none"> ▪ Organizational inertia (1,2, 4) ▪ Limited time and resources (2,3,4) ▪ No explicitly developed guidelines (1,3,4) ▪ Linear accounting system (1,4) ▪ Focus on short-term profitability (1) ▪ Focus on selling new equipment (3,4) ▪ Uncertainty about quality of recovery (1,4) ▪ Lacking top-management commitment (1,2) 	<i>Internal:</i> Top-management, recovery department, financial department, sales department, shareholders

Figure 1. Re-enforcing CLSC key processes.

Figure 2. The impact of strategic success factors

Highlights

- Closed loop supply chain value creation is limited by constraints
- External constraints affect manufacturers' closed loop supply chain processes
- Internal strategic success factors are also constrained and hinder value creation
- Internal constraints are considered most important in closed loop supply chains
- The interaction between success factors and constraints leads to vicious cycles