

An Analysis of Synergy Effects between Closed-Loop Supply Chains and Product-Service Systems

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Abstract

Closed Loop Supply Chains (CLSC) present a mechanism for enhancing environmental sustainability and enable more efficient supply chain management. Product-Service Systems (PSS) present a possibility of increasing customer satisfaction, and firm competitiveness. We analyze the synergy effects that firms can achieve by integrating the concepts of PSS with CLSCs.

Keywords: Closed-loop supply chain (CLSC), product-service system (PSS), integrated management

Introduction

Firms are increasingly challenged by pricing pressures and competition due to new product or service providers from countries with lower wages and costs of production (Leimeister and Glauner 2008). Pure product sales make it difficult to ensure customer loyalty and competitive advantage leading to the necessity to enrich the offered portfolio. Additionally, there is higher awareness of environmental and sustainability issues driven by concerns associated with resource limitation, pollution, and waste resulting in green image considerations and governmental regulations (Mont 2000).

Product-service systems (PSS) allow firms to extend their portfolio from pure product sales to a system of products and services tightly interconnected, and individually combined to

fulfill ongoing customer needs (Tukker and Tischner 2006). This increases customer satisfaction, loyalty and firms' competitive advantage, creates new market opportunities through innovation and exploitation of new target groups (Leimeister and Glauner 2008, Tukker 2004). PSS are also considered to support environmental issues, for example, reducing resources during the products' lifecycle to fulfill customer needs or changing customer consumption behavior (Mont 2000).

With regard to sustainability of PSS, researchers suggest to offer services along the product lifecycle such as take-back or reprocessing services (Aurich et al. 2006, Mont 2000). Such suggestions for PSS indirectly refer to the management of a closed-loop supply chain (CLSC). A CLSC consists of forward flows of products and reverse flows of used products (Souza 2013). Therefore, a reverse supply chain "includes the recovery of products, which is typically achieved through processes such as repair, remanufacturing and recycling" (Cardoso et al. 2013), and reintroduces reprocessed items into the forward flow (Flapper et al. 2005). Hence, CLSCs offer opportunities to improve the environmental performance of products because resources are used more than once to meet the market demand.

Besides the motivation of firms to improve the environmental performance, there are also different external drivers that motivate firms without PSS offerings to consider a CLSC system such as governmental laws. Further, firms have also recognized the value of returned products. Returned products can be refurbished, and allow firms to generate new revenues by reselling reprocessed products or to save resources by reintroducing returns into the forward supply chain (Flapper et al. 2005). However, CLSC management leads to difficulties as firms struggle with higher complexity of planning and controlling activities as well as new arising challenges such as quantity uncertainties for returned items. Researchers in the CLSC area suggest to move from pure product sales to leasing or renting to handle complexity associated with CLSC management (Souza 2013, Guide Jr and Jayaraman 2000). This is also reflected by findings pointing out that providing PSS within a closed-loop system increases economic and environmental benefits as well as ensures competitive advantage (Mont 2000, Aurich et al. 2006).

Despite that, both research streams lack an in-depth analysis how a mutual understanding can support the relationship between PSS and CLSC. Therefore, this study aims to analyze the inter-dependencies between PSS and CLSC to identify benefits such as synergistic effects decreasing uncertainties or enhanced firm performance.

Theoretical Foundation - PSS and CLSC

According to Goedkoop (1999, 18) a "Product Service system (...) is a marketable set of products and services capable of jointly fulfilling a user's need." Physical products, services, software, and information are tightly interconnected and individually combined to a holistic customer solution in order to fulfill customer needs (Tukker and Tischner 2006, Leimeister and Glauner 2008). Researchers identified three major types of PSS: product-oriented, use-oriented and result-oriented (Mont 2000, 2002, Bartolomeo et al. 2003). With a *product-oriented PSS*, products are sold to customers with product-related services. Customers pay for the usage of products in case of *use-oriented PSS*, usually with no shift of product ownership as known with leasing or renting. *Result-oriented PSS* often include long-term contracts, no shift in product ownership and involvement of providers in the internal processes of customers, where a "provider supplies a complete solution to an on-going need for a customer" (Bartolomeo et al. 2003, 831).

The PSS research reveals specific characteristics of PSS such as the integration of an external factor when producing and delivering PSS. In this context, requirements management and the involvement of customers in this process are emphasized (Aurich et al. 2006, Mont 2000). Moreover, researchers identified other characteristics. For example, individuality of PSS refers to standardization or customization of PSS (Bonnemeier et al. 2007). With regard to individuality of products, PSS research identified modularity as an efficient way to provide individual products with standardized modules (Mont 2000). Moreover, integration from customers refers to physical or intellectual involvement in the processes necessary to develop and deliver a PSS (Mondragon et al. 2011). Further, Bonnemeier et al. (2007) mention the level of integration of the PSS provider into customers' processes of value creation. When providing PSS to customers, traditional manufacturers often need to establish value-added networks and partner with service providers (Meade and Sarkis 2002).

With regard to CLSC, Souza (2013) identified that returned items can be core products, product parts or distribution items such as pallets or bottles. These items can be recovered and reintroduced in the forward supply chain forming a closed loop (Flapper et al. 2005). For example, firms can return raw materials back to suppliers due to damages during shipment, defective products, or obsolescence (Tibben-Lembke and Rogers 2002). Customers may return items because of dissatisfaction, wrong deliveries, or simply because of using commercial or warranty return possibilities (Flapper et al. 2005, Krikke et al. 2004). CLSCs often lead to the necessity to manage three new activities (Guide Jr and Van Wassenhove 2009, 2002). First, returns acquisition management includes planning activities associated with physical item returns encompassing product core acquisition, forecasting core availability, synchronizing returns with demands, gatekeeping as well as physical collection of returns (Guide Jr and Jayaraman 2000, Meade and Sarkis 2002, Rogers et al. 2012). Second, reprocessing management refers to inspection, testing, categorization, reprocessing as well as decisions on disposition options. For example, some firms have to disassemble returns before deciding between different reprocessing operations, such as repair, refurbish, remanufacture or recycle (Guide 2000). Third, redistribution management includes market development, redistribution, and sales activities for reprocessed items (Guide Jr and Van Wassenhove 2009). Reassembled items are reintroduced into the forward flow again by deciding on different options such as resell as new or as spare parts, sell via outlet, to broker or to secondary market (Tibben-Lembke and Rogers 2002). Despite that broad understanding, researchers identified complicating characteristics when managing CLSC, such as uncertainties regarding quality, quantity and timing. This is mainly due to different usage patterns from customers resulting in uncertainties regarding the ability to remanufacture items (Guide 2000). Furthermore, firms have to balance between returns from consumers and the demand for reprocessed items in order to minimize inventory costs (Guide 2000).

While there is no clear understanding on the inter-relations between PSS and CLSC, previous research indicates the importance of an inter-connectedness of PSS and CLSC (Mont 2000, Guide Jr and Jayaraman 2000). The relationship to a reverse flow can be explained by focusing on the different PSS types. In use-oriented PSS, the relationship is simple and often automatically implicated. If firms offer leasing, renting, or sharing of items, then customers return these items respectively after the lease-, rent-, or usage-time as the items are no longer needed creating returns for the firm. However, product-oriented PSS do not imply a CLSC management, so that PSS providers do not automatically face any item returns (Azarenko et al. 2009). Returns are mentioned in the context of environmental sustainability of a PSS (Mont 2000, 6ff.). Sustainability can be ensured, for example, by providing after-sales services such as

maintenance for the sold items; PSS providers receive product returns in order to reprocess and return them to the same customer or to supply another customer with the refurbished product. Furthermore, Aras et al. (2004) and Guide Jr and Jayaraman (2000) state that firms, facing quantity and timing uncertainties as they offer product-oriented PSS, can use buy-back campaigns and lease contracts in order to influence these uncertainties. Hence, a better understanding of inter-relations between PSS and CLSC needs to be elaborated.

Research Method

As the current literature lacks an explanation of the relationship between PSS and CLSC, we conducted an industry study that aims at identifying factors that influence the adoption of both concepts, and their inter-relation. Thereby, we provide a broader understanding of how both PSS and CLSC benefit from each other.

Our study is based on 30 qualitative interviews with industry experts from 27 firms, which are from different industries offering diverse types of PSS and managing different types of CLSC. Because of their holistic knowledge of the firm's strategy and core success factors, we primarily interviewed top level executives and managers in charge of operations, after sales services or logistics. To gain detailed insight into processes, in some of the firms, we additionally interviewed experts involved in process design. The data was collected from July to September 2013. Experts from these firms were confronted with open questions regarding the adoption of PSS and CLSC in their respective firms, and their assessment of interfaces and potential synergy effects between both concepts.

In order to be able to estimate the effect of an integrative management of PSS and CLSC on firm performance, we interviewed three types of firms: (1) Firms that offer PSS but do not actively and consciously manage CLSC, (2) firms that manage CLSC but do not offer PSS and (3) firms that offer PSS to their customers and additionally manage reverse flows of products or product parts. In the case of this third type of firms, we additionally analyzed to which degree PSS and CLSC were managed in an integrative way.

We used semi-structured interview guidelines to ensure comparability of our findings. Before the actual interviews, the guidelines were pre-tested by one supply chain management expert, one PSS expert and two independent researchers from adjacent areas to ensure validity of constructs (Yin 2009). Experts were asked to name (1) external factors that influence PSS offerings and/or CLSC management, (2) identify internal success factors in both areas, (3) illustrate effects of a successive integration of PSS or CLSC, (4) describe the PSS offerings, product design and supply chain partner integration in detail as well as to illustrate the group of activities in the CLSC context, and (5) estimate the effect on firm's performance. We additionally reviewed publicly available information on the firm, focusing on their products and offered services as well as return strategies and processes. The interviews were carried out via phone or face-to-face meetings with sessions lasting 55 minutes on average. Almost each interview was voice recorded, transcribed and checked for accuracy by the interviewee. In the few cases where voice recording was undesired, notes were taken manually.

For analyzing the collected data we applied qualitative content analysis (Miles and Huberman 1984, Strauss and Corbin 1990, Gläser and Laudel 2010). Building on literature about PSS and CLSC that we had reviewed beforehand, we developed a system for categorizing relevant information according to different dimensions and derived a corresponding schema of first-order codes (Pratt et al. 2006). This initial schema was iteratively adapted as data collection

and analysis proceeded and new insights were gained (Gläser and Laudel 2010). By aggregating and structuring the data chunks from interviews, publicly available information on the firms and further relevant documents that were handed over by interviewees we built a knowledge map about PSS and CLSC focusing on external and internal drivers for both concepts, success factors for an integrative management and implications on firm performance.

Results and Discussion

Our research findings support and extend the current PSS and CLSC research. First, the results provide evidence that PSS/CLSC drivers and success factors indirectly influence CLSC or PSS. This offers new insights into the inter-relationship between PSS and CLSC. Second, the results show the benefits of a successive integration of PSS and CLSC. Third, we extend the current CLSC research by illustrating the benefits of an integrated management of PSS and CLSC. Fourth, we show effects of an integrated management on firm performance, thus providing new insights for future research.

We identified that some PSS drivers motivate a firm to manage CLSCs and that some CLSC drivers motivate a firm to offer PSS. Customer requirements (81%) and pressure due to competition (54%) were mentioned as main drivers to offer PSS. Legislation (15%) was mentioned in respect to warranties or guarantees. If firms are obliged by law to take back their products, offering them as a PSS is often perceived as a logical consequence. In this context guarantees can be seen as implicit reason for offering PSS. In these cases, firms extend their service offerings such as support or maintenance resulting in the need to accurately manage returns. Besides that, firms tend to reprocess returns which are still of high value in order to cut costs and save resources. Regarding factors that drive CLSC management, experts responsible for use- and result-oriented PSS emphasized that returns are perceived as a normal process as the ownership of the product remains at the firm. Further, experts emphasized customer requirements (59%) and the aim for a high profitability of the business (31%) as major influence factors from the external side for CLSC. For example, experts mentioned reprocessing as possibility to increase profitability. Hence, reprocessing and reusing leads to cost savings for both, the firm and their customers. Figure 1 provides an overview of our findings for the external drivers.

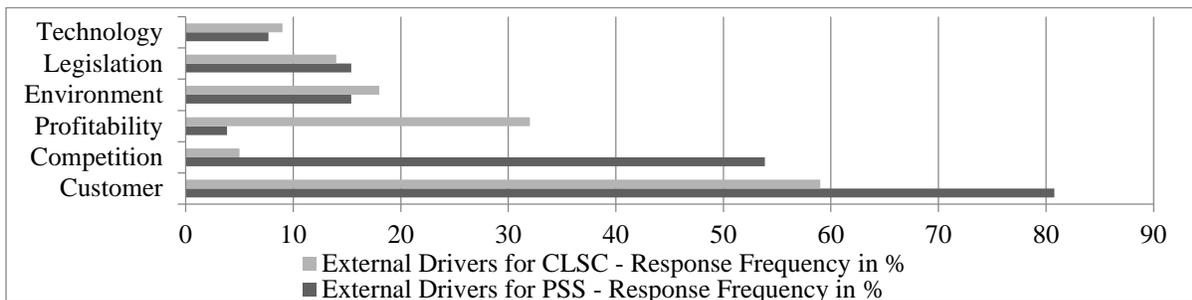


Figure 1: External Drivers

With regard to internal PSS/CLSC success factors, we also found indirect and positive effects between PSS and CLSC. Important internal factors that contribute to success of PSS are employee qualification (48%) and geographical coverage (41%). Geographical coverage in a certain market facilitates returns acquisition, collection, and cost-optimal transportation of

returns. Therefore, PSS success factors indirectly contribute to CLSC success. Furthermore, our experts identified core resources (50%) such as special tools or technologies that enable return processes as success factor. Second, employee qualification (42%) was highlighted as a major success factor for CLSCs. Table 1 summarizes the most important internal success factors for both, PSS and CLSC.

Table 1: Top 5 internal success factors for PSS / CLSC

Top 5 success factors for PSS	Response Frequency in %	Top 5 success factors for CLSC
Employee qualification	48	50
Geographical Coverage	41	42
Customer Requirements	30	21
IT Support	26	21
Internal Processes	19	17

Further, we analyzed the effects of a successive introduction of PSS or CLSC. Our results provide evidence for the importance of internal and external influence factors on PSS and CLSC, as well as the effects if both concepts are implemented successively (see Figure 2). Moreover, our analysis suggests an indirect influence of core resources on a firm’s PSS offering. For example, firms are able to provide attractive solutions at lower costs, enhance customer loyalty and to improve competitiveness. The experts (89%) explained that their firm initially offered PSS before consciously managing CLSC. They argued that existent know-how, experiences in the service area, or already established relationships with customers facilitated the introduction of CLSC. Experts reported (78%) that introducing CLSC while PSS were existent had a positive influence on the success of PSS. 75% of the experts confirmed that a PSS introduction was easier because essential internal processes were already in place. Additionally one expert confirmed that the introduction of a PSS contributed to the success of their CLSC due to availability of information regarding product usage. Furthermore, we found that firms offering PSS without CLSC management have fewer problems to include a CLSC system and vice versa. This offers new insights for PSS as well as CLSC research focusing on problems within firms to offer PSS or manage CLSC.

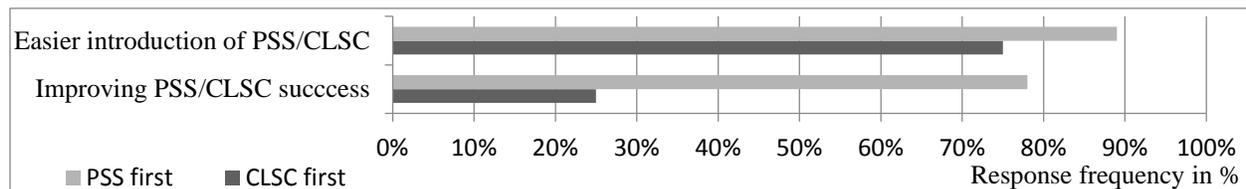


Figure 2: Effects of successive introduction

The following results provide a deeper understanding how PSS characteristics improve the management of CLSC and vice versa. In detail we analyzed 6 characteristics of PSS and CLSC: (1) requirements management, (2) PSS intensity, (3) PSS individuality, (4) PSS modularity, (5) customer and partner integration and (6) redistribution management.

Our results suggest that proper consideration of customer requirements decreases the amount of avoidable returns (83%). By fulfilling the customer’s requirements as much as possible, firms ensure higher satisfaction resulting in fewer returns due to poor performance of the products. Two experts highlighted the influence of requirements management on the product quality (11%), resulting in a higher reprocessing rate.

With regard to intensity of PSS, experts explained how their products enable the access and collection of information such as product usage data; which can be seen as relevant and valuable data for managing CLSCs. These products are equipped with special components. These components provide features such as remote services that automatically send product-related information such as error, incident, usage or performance messages. Experts illustrated that this data is used to plan specific activities for reprocessing (69%), and for upfront maintenance services, automatized deliveries of consumables or planning for component replacements. In consequence, PSS intensity is positively correlated with the availability of data relevant for the proper CLSC management. This information is used to plan reprocessing services at customer's sites or to prepare for returns.

With reference to the individuality of PSS, two third of the experts explained that the offered PSS can be customized using standard modules that can be combined allowing a high degree of individualization. These customized solutions avoid returns due to dissatisfaction of customers (53%). Therefore, individuality can be seen as a possibility for firms to increase customer satisfaction and reduce return rates. However, individuality of products has also negative effects on CLSC management. Lead times of the reprocessing steps tend to be longer (37%) because standardization of processes and availability of product parts are limited.

With regard to product design, firms with modular products benefit mostly from shorter lead times for reprocessing (48%). Modularity of PSS shortens lead times by enabling easy replacement of components, even without requiring special technical skills. This offer the chance for firms to optimize inventories (36%). Further, product modularity improves the ability to resell or redistribute to other customers (16%). In addition, the experts emphasized that modular product design fosters higher reusability opportunities.

In case of closed-loop supply chains that are not part of a PSS, the responsibility for operating and maintaining the products lies with the customer. Our experts reported (33%) that in this case, the quality of returned products is lower on average, and more volatile. This is also true for the willingness to implement and manage closed-loop supply chains due to the lack of profitability (33%). Therefore, our findings suggest that product operation and maintenance by the customer complicates the management of CLSCs. This is further complicated by a high involvement of customers in the design phase, resulting in highly individualized solutions vs. modular products. In case of PSS, the conditions of (returned) products are better, either through proper use and maintenance or by returning items timely to firms resulting in profitability of reprocessing (80%). Therefore, we can state, that the higher the involvement into the internal processes of the customers, the more consistent is the quality of returned items. Further, if firms are responsible for the operation of their items or for maintenance and repair, then firms have the opportunity to forecast the quality of the items. This helps to plan and schedule the optimal time to return and reprocess items. This results in profitable reprocessing activities (Aras et al. 2004).

Regarding the question of partner integration, the experts confirmed that usually the same network partners are involved in forward and reverse supply chains. Some experts explained that their partners not only deliver new components, but also reprocess them. Further, as the supply chain partners are the same for upstream and downstream flows implies that firms have less difficulties to establish reverse flow networks in case only forward flows are existing; because partners are known. Our findings also illustrate how a CLSC management benefits a PSS offering of firm, especially from a sustainability and environmental perspective. Our results show the importance of reprocessing operations management. Reprocessing mostly contributes to resource savings (94%) as well as cost savings (18%), while two experts stated a cost increase

for their PSS in case of CLSC (13%). Further, most of the experts associated resource and cost savings with CLSC management, while other experts stated opportunities to increase customer loyalty, due to lower prices of refurbished products.

With regard to redistribution management, experts (81%) stated that returned and refurbished items are used either for the same market or customer. Other firms consider disposal options such as reselling as used product to a secondary market, reselling as used but certified spare parts to original or secondary market. For these experts, reusing products or product parts mostly results in resource savings (83%) of their PSS offering. Further, reselling to a secondary market generates additional revenues (83%) and opportunities to gain new (PSS) customers.

The fact that firms acquire, reprocess and reuse returned items results in resource savings and environmental sustainability of the PSS. Further, on product level, firms often reprocess to serve a completely different market, while the production of new items is unchanged for the main market. This may happen if retailers have the goal to sell as much as possible contradicting some sustainability goals such as changing consumption behavior (Mont 2002). Therefore, CLSCs can only improve the sustainability of PSS, if firms are reusing items as much and as long as possible. If firms reprocess to serve the traditional market and not secondary markets, the economic benefits due to resource savings are even higher.

Finally, our findings express the effect of an integrated management approach offering PSS within a CLSC system on firm performance (see Figure 3). Experts were asked whether an integrated management of PSS within a closed-loop system has an effect on revenues or costs. Two-third of our experts (65%) confirmed a positive effect on revenues due to an integrated management in their firm. Some experts explicitly stated that only their PSS offering contributes to higher revenues (35%). For two firms, only the CLSC management led to higher revenues as they reprocess their products and sell them as used products on secondary markets. Further, our experts stated, that the effect on cost savings or optimization is mostly due to CLSCs (61%). Experts explained that reusing product parts or extending a product’s life by reprocessing operations results in resource and cost savings. Around one-third of our experts (28%) confirmed that PSS and CLSC jointly contribute to cost reductions. However, two firms identified negative cost effects caused by closing their material’s loop. For one expert, taking back the products causes higher costs in comparison to the past where customers were responsible for the products and their disposal. In contrast, two experts illustrated that mostly their PSS offering contributes to cost savings.

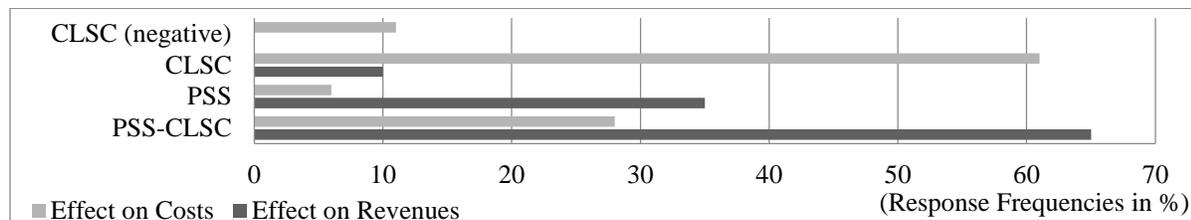


Figure 3: Effects on Firm Performance

Implications, Limitations and Future Research

The contribution of this paper is three-fold: First, it reviews the PSS and CLSC literature to (1) identify specific PSS characteristics diversifying PSS offering from traditional sales models and to (2) identify CLSC characteristics for understanding the complexity and difficulties associated with CLSC. Second, this study states and explains the relationship between PSS and CLSCs.

Third, our approach is one of the first efforts to analyze the synergy effects of specific PSS characteristics on CLSC activities and vice versa.

The results provide evidence that benefits can be achieved when offering PSS within a CLSC system. Further, the study provides implications for practitioners and managers of firms which only offer PSS, and plan to close their material's loop in the future or vice versa. Firms struggling with sustainability of their PSS offering can introduce a CLSC to achieve a more sustainable business model by reprocessing and redistribution management. However, it is important to adapt the firm's strategy towards environmental aspects, and to have network partners with the similar goals. Firms struggling with challenges in the area of CLSC management, such as uncertainties, can handle these by moving towards a PSS offering.

Further, this study validates that PSS provided within CLSC systems enable firms to cope with specific challenges existing in the CLSC context. The integration of the PSS provider into the processes of the customer leads to returns of constant quality and significantly reduces the amount of returns. In addition, the intensity of a PSS offering plays an important role for the availability of relevant data which can be used within CLSC management. Therefore, firms should strive to provide their items/products only with additional services such as consulting or maintenance in order to ensure the access to relevant information.

Actively acquiring returns from customers in order to supply the same market can reduce the amount of items which are available in the economic cycle. Therefore, firms offering PSS with reprocessed items have the opportunity to reach new target groups which are indifferent between new and reprocessed items. Redistributing to the same market, but for different customers can ensure economic benefits as resources for new products.

The expert interviews provided an opportunity to gain insights into different industries supporting the generalization of the findings. Nevertheless, the results of this study should be interpreted with caution as there are some limitations associated. Our suggestions were tested with expert interviews representing a qualitative method. The generalizability of these findings can be supported by conducting a multiple case-study or in more quantitative setting such as surveys. Future research could analyze how CLSCs with other types of products and consumers as target groups can be optimized using PSS characteristics. Finally, reprocessing and reusing were assumed to be the best options for environmental sustainability of PSS solutions. Future research should analyze how long or how often components that are part of a PSS can be reprocessed and reused in order to achieve higher environmental sustainability.

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