

Article

A Three Level Framework for Closed-Loop Supply Chain Management—Linking Society, Chain and Actor Level

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Abstract: Supply chain management and closed-loop supply chain management (CLSCM) have developed into established concepts in recent years. The related material cycles and product returns form an important part of all related processes with high potential for reducing environmental burden. The paper proposes a framework for (environmentally triggered) closed-loop supply chain management, spanning three different levels: the societal or governance, the chain and the actor level. Within each level, a set of activities or processes can be identified. Taken together, the levels allow a comprehensive analysis of a closed-loop supply chain system. This is illustrated building on two case studies in the textile and apparel industry, where closed-loop supply chains have been designed to take specific apparel products back. The case studies are analyzed against all three levels and allow exemplification of related challenges and interrelations among the three levels. The three levels contribute to the further comprehension of the multiple issues having to be taken into account for successfully implementing closed-loop supply chains.

Keywords: closed-loop supply chain management; sustainability; product returns; closed-loop economy; supply chain governance

1. Introduction

Approaches of inter-organizational sustainability management, sustainable supply chain management and closed-loop supply chain management received much increased attention in recent years. This has been influenced by related regulations, but also found their way into business practice and influenced individual customer behavior in their buying decisions.

A range of related concepts and frameworks have been proposed, which comprise e.g., industrial ecology and symbiosis, life-cycle assessment and management, integrated chain management, and sustainable supply chain management. One common denominator is that a single actor (*i.e.*, company) cannot solve related challenges on its own, so inter-organizational approaches are needed [1]. This has triggered the development of a wide range of individual concepts and frameworks, where it is no surprise that quite recently efforts emerged for understanding the interaction between human beings and nature. In line with this, there is a continuing discussion about sustainability science [2] and its implementation along the economic, environmental and social dimension [3,4]. The interactions between natural and human systems are to be analyzed integrating different perspectives and moving beyond the single, typically disciplinary level and more systematically analyzing respective issues [5,6].

As another conceptual development, the field of closed-loop supply chain management has appeared in recent years [7-9]. Closed-loop supply chain management deals with all kinds of product return, both from unwanted products as well as from products at the end of their life-cycle. Related end-of-life product returns might even be demanded such as in the WEEE-directive for electrical and electronic products of the [10] European Union enforced in 2003 (see also the analysis in [11,12].)

The aim of this paper is to outline an analytical framework for closed-loop supply chain management, placing it within (1) the political or societal environment, while linking it to (2) related supply chain partners and (3) single actor activities. These levels have already been proposed in so-called integrated chain management [13,14]. As is typical for theory building [15-17], such approaches have to find a balance between generalization and specialization. Generalization makes them applicable in a wider range of settings. Specialization allows being detailed enough to yield insights on the individual case level. Hence, the paper aims for a conceptual-theoretical contribution, but will use two brief case studies for illustrating related issues. This determines the subsequent structure.

We will first propose a three level framework for closed-loop supply chain management, which is subsequently explained in a stepwise manner, starting at the political level and reaching down to the individual actor level. This is illustrated through two case studies from the apparel industry.

2. A Brief Literature Review and a Three Level Framework

In much of the (mainly management driven) literature on supply chain management, society is not part of the focus and analysis. Looking at e.g., the definition and context [18] societal aspects are not taken into account (see in a similar manner [19], while there are also early critical accounts [20]). This is rather the case in sustainability related concepts, where different approaches to inter-organizational sustainability management have been developed [1]. This also holds for related analysis of other

sustainable products, such as those from organic farming. Smit *et al.* [21] use the same three levels for their analysis of the conversion to organic farming in The Netherlands.

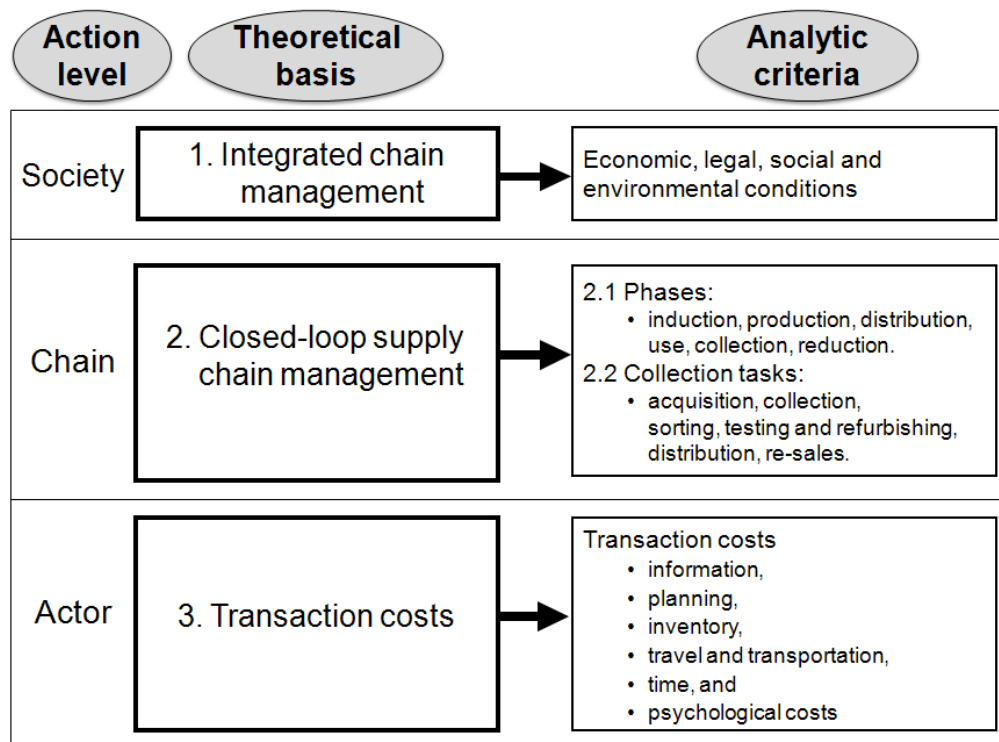
In related literature on sustainable supply chain management, related aspects of governance are rather discussed on a voluntary basis [22], which form an integral part of the discussion in sustainable supply chain management [23]. Usually, three stakeholder groups are particularly emphasized for their influence on supply chains, which are governments acting on behalf of society, as well as consumers [24] and non-governmental organizations [25], the latter ones representing so-called secondary stakeholders [26]. Yet, sustainable supply chain management (see also [8,27]), rather stays on the company and actor level.

Before describing the framework itself, it is necessary that we outline the two dimensions being used in forming it. The first one is taken up from integrated chain management [1], a concept mainly developed against national political initiatives in The Netherlands [13,28] and Germany [14]. The three levels are mentioned in related definitions, such as the one provided by the Enquete Commission of the German Bundestag on the “Protection of Humanity and the Environment” [29]: “Integrated Chain Management (Stoffstrommanagement) is the management of material flows by stakeholders [to be] the goal-orientated, responsible, integrated, and efficient manipulation of material flows. Set targets derived from the ecological and economic realm, under consideration of social aspects. Goals are set on the level of the single firm, within the supply chain of actors, or on the public policy level.”

The key point of relevance here is that three action levels are distinguished, namely the individual actor one, the supply chain (or life-cycle) one and the political or societal level. The first two are similar to what is usually present in supply chain management [18,19]. Yet, supply chains operate within certain political systems and governance structures [30]. As one major outcome, related governmental action has triggered regulation such as the WEEE-directive already mentioned [12].

In relation to this, closed-loop supply chain management [7] incorporates these aspects linking legislation to environmental improvements as in [31] using the example of the WEEE-directive. Such demands are increasingly put forward to the supply chain level, as the individual actor would not be appropriate. Staying with this example, the taking back of electrical and electronic products cannot be enforced for the single component or even brand item, but is carried out by return to retailers or central collection points.

The second dimension is now used to gain insights into the action levels. The theoretical basis incorporates related developments in inter-organizational management concepts, while the analytic criteria allow the detailed assessment of a certain closed-loop supply chain on all three action levels. Figure 1 outlines the resulting framework which is subsequently explained level by level. In this respect, we see the three levels justified as they can be distinguished as three different analytic levels.

Figure 1. An analytic framework for the management of closed-loop supply chain.

2.1. Societal Level

The societal level could also be called the political level, as it deals with both societal and stakeholder demands as well as related political decisions, which might both be triggers for companies for related action [25,30,32]. It is acknowledged that in a similar manner the societal level plays an important role in the overall sustainability debate and has even been instrumental in starting the related research on integrated chain management [33]. This is also a current debate as it leads to the adoption of related environmental and social standards [23].

Supply chains have tremendous impact on societies which can be seen with the example of raw materials and products shipped around the world for the next step of production to allow the use of cheaper labor or other resources [34]. On the political level, which can be national as well as supra-national, economic, legal, social and environmental conditions are set. A typical example is the German Life-Cycle Resource Management Act, which was enforced in 1996 and aims to advance a closed-loop economy. Sticking with the same example, the WEEE-directive is a similar case on a supra-national level. Both acts were enforced to account for environmental problems, in particular regarding used products. In this respect, they have triggered the development of respective closed-loop supply chains [35]. Sinding [32] summarizes this by pointing to the fact that legal and market demands might trigger companies to engage in respective activities, while a more recent study [25] also points at these two issues as most important starting points for sustainable supply chain management. Hence, closed-loop supply chains for used products might also be created, based on voluntary initiatives of companies aiming for improved performance [36]. Morana and Seuring [37] present a case study in the textile industry, where a voluntary take-back initiative was implemented by a producer of outdoor and sportswear. This was seen as a response to the high volumes of used apparel available for re-use or

recycling in developed countries. An analysis on this level would take a look at the legal requirements and economic conditions for product take-backs as well as related environmental and social challenges and benefits [30].

2.2. The Chain Level

Within the chain level, two sub-levels are distinguished. First, this is the material or product cycle, which is broken down into several phases describing the overall flow of material in an industrial ecology life cycle [38]. This is then complemented by a more detailed analysis of the closed-loop supply chain activities. It is emphasized that the focus here is on end of life return, while closed-loop supply chain management might also cover return of unwanted products or defective products for repair [7]. As just mentioned, there are two parts of the analysis on this level. The overall product cycle captures the product life cycle from cradle to grave or even from cradle to cradle [39] and is thereby closely linked to the typical analysis within life-cycle assessment. Yet, this is too general for analyzing the processes of closing the loop for a certain product. Hence, the typical processes of a closed-loop supply chain are added.

- The overall product cycle

For analysis the overall product life-cycle six phases are used [40] (see 2.1 in Figure 1):

(a) Induction of material from nature represents all processes related to the extraction of raw material, may it be from mining of ore, coal or oil as well as agriculture, forestry and fishing.

(b) Production represents the activities that transform the raw material into final products. This may take place across different tiers of the supply chain and therefore even in different countries or parts of the world.

(c) Distribution is the transactional activity, which represents the logistical processes both within different production stages as well as towards reaching the final customer.

(d) Consumption is usually labeled the use phase in life-cycle management. For long-lived products which are used more than once (*i.e.*, that are not eaten up or else disappear while being used), this can range from several years to even decades.

(e) Collection forms the process that opposes distribution. Again, it is rather transactional as goods move from the user to any kind of collection or recycling facility.

(f) Reduction is seen as complementary to production, where products be disassembled and parts or material become available for re-use, therefore resembling the idea of industrial ecology that industrial activities mimic natural cycles. Ideally, materials would be re-used and the cycle would start again.

This product cycle is supplemented by a more detailed analysis of the closed-loop supply chain processes in the second sub-level.

- The closed-loop supply chain activities

The second sub-level is embedded into the first one, and might be referred to as closed-loop supply chain management in a narrower sense. It takes a look at the business processes required for product collections and returns. Guide and co-authors [41] summarize the required business processes into the following steps (see 2.2 in Figure 1):

- (a) product acquisition to obtain the products from the end-users,
- (b) reverse logistics to move the products from the points of use to point(s) of disposition,
- (c) testing, sorting, and disposition to determine the product's condition and the most economically attractive re-use option,
- (d) refurbishing to enable the most economically attractive possibility of the options. Direct re-use, repair, remanufacture, recycle, or disposal, and
- (e) remarketing to create and exploit markets for refurbished goods and distribute these goods.

The individual processes are based on the assumption that technical fulfillment is possible, where it is assumed that actors would behave accordingly. This leads to the third level.

2.3. The Actor Level

While the second level describes the overall product life-phases and related return processes, the third level assesses the single actor's transaction costs for product returns. This has to be emphasized, as it limits the framework to a single actor and process in the overall closed-loop supply chain. This is justified, as without this important step of returns, the overall idea of closing the material cycle would disappear. Related cost on the single actor level can be summarized based on transaction cost economics; a concept explaining why companies exist at all which is frequently taken up in supply chain management [42]. Transactions are the single units of analysis, where economic exchange of goods takes place among different actors. Based on this, an approach has been developed for the selection of retailer locations [43] into a total of six cost components [37]:

- (a) Information costs: The customer has to search for information on how and where to dispose of a certain product.
- (b) Planning costs: The disposal of old products, other than just putting them into municipal waste, has to be planned for.
- (c) Inventory costs: Usually, old products are stored for some time before they are disposed of. Inventory costs are closely related to travel and transportation costs.
- (d) Travel and transportation costs: This covers costs incurred for having to go to a disposal site (e.g., costs for using a car). In the case of returning products by mail, packaging and postage costs might have to be paid.
- (e) Time costs: This refers to the time needed to access any disposal site.
- (f) Psychological costs: The more bothersome disposal is seen, the more the customer suffers from psychological costs ("disposal agony"). This also relates to the good or bad feeling consumers have by choosing a certain disposal method, *i.e.*, putting old electronic products into household waste although it is not allowed (in the European Union).

Much of the related costs would be opportunity costs, so they do not relate to a direct payment. However, the customer has to accept them, while for many products the alternative would be as simple as dumping them into the waste bin.

The contribution of this framework links the societal level of an industrial ecology or closed-loop economy to the supply chain, the single actors and their respective activities. Hence, it allows analysis

of a certain case or application toward these levels, which would yield insight on the overall feasibility of operating a related closed-loop supply chain.

3. An Illustration of the Framework in Two Case Studies

3.1. A Brief Summary of the Research Methodology

Two cases in the textile industry were studied. Case study research is justified, as the main aim was to explore related issues in real world settings. The basic information on the case study research process is summarized in Table 1. In the two subsequent paragraphs, the two focal companies of the case studies and the respective supply chains are introduced. After this, a cross case analysis is presented building on the above framework.

Table 1. A summary of case study research applied.

Dimensions	Case 1: ECOLOG	Case 2: GETEX
Theoretical aim	Stage 1: Research Question Exploration	
Cases	Stage 2: Instrument Development	
Case selection	ECOLOG is an ideally set up closed-loop supply chain, operated by the German outdoor products produced by VAUDE Embedded units of analysis where all stages of the CLSC.	GETEX is a return network for used apparel, which is still of considerable value and might therefore be sold on a secondary market. It focuses on collection phase.
	Two case research design	
	Revelatory case	Revelatory case
Data gathering techniques	Stage 3: Data gathering	
	Four embedded units of the supply chain were studied covering all phases of the product life-cycle from production to collection. Data collection was mainly based on semi-structured interviews (58 in total), with staff at ECOLOG (5), including the manager responsible for the CLSC, retailers (23), and consumers (17). Additionally company documents were accessed.	A total of 47 actors involved into the network were interviewed, covering franchisees (2 out of 17 in Germany interviewed, representative ones chosen), acquisition companies (mainly cleaning services; 18 interviewed) and 15 acceptance companies (all different kinds of companies, 26 interviewed in total) 1 interview with the chief executive officer of GETEX
Data analysis	Stage 4: Data analysis Interviews were transcribed; cross case analysis among the two cases.	
Case quality	Stage 5: Dissemination/Overall process Construct validity: Multiple sources of evidence during data collection; case findings were discussed with key informants for review. Internal validity: The logic of the explanations was tested for consistency, mainly a means of triangulating data sources coming from different informants. External validity: Describing the case according to closed-loop supply chain management. Comparing findings in the two cases as well as to other published cases. Reliability: For all interviews, protocols were kept and information obtained was transcribed. This way, a case study database was developed to inform the later analysis.	

3.2. Background on the ECOLOG Case

The ECOLOG Recycling Network GmbH is a textile recycling network in Tett nang at Lake Constance, Germany. The network was founded in 1994 by two German clothing manufacturers for sportswear and outdoor wear, where VAUDE (<http://www.vaude.com>, accessed on 3 April 2011) is the better known partner. Today, it remains a very small company and a subsidiary of VAUDE. The ECOLOG network spans all related actors: producers, retailers, consumers, and recycling companies of polyester textiles. The objective is market introduction of apparel manufactured from one kind of uniform polyester which can be fully recycled. The ECOLOG concept is planned for two different target groups. On the one hand it is designed for industrial customers, usually ordering a large amount of new apparel products in one lot. This also implies that they would usually have a lot of used apparel products at the end-of-life at the same point in time. On the other hand the concept is designed for private customers, who normally buy a minor number of pieces, usually a one off purchase of an outdoor jacket. In both cases the ECOLOG customers have the option of returning their used apparel product. This can either be done directly via a mail service or indirectly by returning it to the point of sale. The retailers then would send the used apparel products back to the producer.

Thereby, ECOLOG organizes all stages of a closed-loop supply chain [37] and forms an ideal case for the analysis. Data collection took place mainly between April 2001 and December 2003, while the case has been followed up in subsequent analyses again in 2007 and 2008. The solution is still in operation (see http://www.vaude.com/de_DE/end-of-product-line.asp, accessed on 3 April 2011). Very few customers have returned their old used apparel. As a consequence, the ECOLOG network decided to work together with the inter-trade organization European Outdoor Group. Available online: <http://www.europeanoutdoorgroup.com/> (accessed on 3 April 2011). The aim offers customers an “end-of-life solution” for the entire outdoor sector.

3.3. Background on the GETEX Case

GETEX is a franchise system for collection and re-distribution of used apparel products (see <http://www.getex.de>, accessed on 3 April 2011). GETEX itself employs 10 members of staff in the corporate headquarters. It has dealt since 2003 with about 24,000 Mg (1 mega gram equaling 1 ton) of textile per year. So called acquisition companies (a total of 800 in Germany) are used to buy the apparel pieces from private customers. Customers take pre-sorted and washed clothing to these acceptance companies, which themselves are mainly cleaning facilities. Staff working at cleaning companies has a good level of skill in evaluating the quality and value of apparel pieces. Instead of money, the customers are given a voucher, which they can use when buying goods and services at so called acceptance companies (about 2000). The voucher is usually only allowed to account for 10% of the product or service purchased. The apparel products are then collected by GETEX and resold, either to second-hand shops in Germany or on international markets. The advantage for the single customer, in comparison to selling via a second-hand-shop is that they get the voucher immediately and do not have to wait for the respective piece of apparel being sold.

Data collection for the GETEX case took place in 2003. The company has stayed in operation to date. As at 2011 there are 1,370 acceptance companies.

4. Findings on the Three Levels

4.1. Societal Level

Apparel waste constitutes an important fraction of household or post-consumer waste [44] which as a single issue already raises concerns on the societal level. In Germany alone, estimates are that more than 1.1 Mio. Mg of used textile and apparel products become waste from private households each year [45]. This makes textile recycling an important requirement, as such waste cannot just be land filled, which is indeed forbidden in Germany. About 750,000 Mg (roughly 70%) are collected per year and are therefore accessible for re-use. This imposes a societal challenge in itself, but has not triggered related legislation so far. Most of the collection is done using containers (80%) and street collection (20%). One major challenge is that such unspecific collection yields unsorted products, where the mix of materials and qualities collected requires sorting and grading activities. In both case studies, ECOLOG and GETEX, this problem is to be avoided by collecting apparel products of a certain quality. The ECOLOG Network only collects own products made from one kind of polyester, including zippers and buttons as used in the products. GETEX collects suitable apparel. In this respect, both cases operate against the same societal background, but have developed quite different solutions. One point distinguishes this setting from the apparel industry that there is no related regulation so far, such as the already mentioned WEEE-directive [31], or for used cars the end-of-life vehicle ordinance [40].

4.2. The Chain Level

A) ECOLOG

On the chain level, ECOLOG, as already mentioned, was “invented” as an ideal closed-loop supply chain system. Hence, all six phases of the product life-cycle were taken into account. Induction was limited to a single material, *i.e.*, polyester. Production took place at related facilities only. For distribution conventional apparel channels were used and consumption takes place in the “normal” sphere of customers be in a private (outdoor wear) or corporate (heavy duty work wear, safety jackets) environment. For these purposes, each piece of apparel carries a specific label explaining that it can be returned for recycling.

For the collection of the respective products, the same channels were also to be used, so customers could return their used jackets to retailers or send them directly to the ECOLOG headquarters. Over the years, it has become apparent that the material acquisitions step inside the collection phase posed to be the biggest challenge for making the ECOLOG recycling network a success. Reverse logistics was rather easy, as products could use any kind of logistical system, *i.e.*, even a normal parcel service. Grading, sorting, and disposing the material was not required as only a single raw material was used and (technically feasible) material recycling was intended. Yet, despite the implementation of the ECOLOG system and its technical feasibility, return rates stayed at a marginal level for more than 10 years. This could only be comprehended by taking a look at the each single actor level.

B) GETEX

The GETEX system is not concerned with how apparel products are produced and sold. It only cares about the collection and reduction/induction phase, as products are purchased from customers and then graded and sorted for resale. In this respect, it provides a unique business model operating a specific closed-loop supply chain independent of the producers of the original products. The business process is started by the customer returning a product; hence no joint coordination is required. Subsequent processes use standardized logistics processes and facilities within the involved companies of the GETEX system.

4.3. The Actor Level

For the single actor level, different actors could be analyzed. The focus we take is the private customer returning an apparel product after the use phase. This needs to be emphasized, as the analysis on the chain level rather centers on the focal company and its perception of the closed-loop supply chain. Table 2 summarizes this for both cases as well as three alternatives applied for used apparel products.

Table 2. Comparison of customer related transaction costs of different disposal options for apparel at end-of-life (amended from [37]).

Transaction cost element	Municipal waste disposal	Street and container collection	Second-hand sales	ECOLOG	GETEX
Information costs	Low	Medium	High	Very High	High
Planning costs	Low	Low	High	High	High
Inventory costs	Low	Medium	High	High	High
Travel and transportation costs	Low	Medium	High	High	High
Time costs	Low	Medium	High	High	High
Psychological costs	High	Medium	Low	Low	Medium

The simplest alternative is municipal waste disposal, which will be the option for any minor item with no further use. As mentioned, street and container collection account for almost 70% of all used household and apparel textile products. Second hand sales would only be an option, if the products still contain a considerable marginal value of time, so that transaction costs would be lower than the product value remaining [37,46]. As Table 2 highlights, for both ECOLOG and GETEX the customer incurs considerable transaction costs, which limit his or her will to take part in such systems. In the cities where GETEX operates, they have a higher number of return and acceptance places making it easier returning old clothing, thereby relatively reducing information costs as compared to the ECOLOG case. Another difference can be observed for the psychological costs. While ECOLOG guarantees a sound recycling of the outdated apparel, one would not know what happens to the pieces

of clothing in the GETEX case. If sold again, the next user might still dump them into municipal waste collection.

On a practical basis, this is only the case in the GETEX system, which can be explained by the simple fact that the voucher given to the customer when returning related apparel products constitutes an incentive [47].

4.4. Implications on Integrating the Three Levels

As mentioned, the case studies serve illustrative purposes. Nevertheless, they have been instrumental in developing the framework and can be used to gain insights into how the levels interact and interrelate. Even without legislation being enforced for textile recycling or take back, the overall impact of textile waste derives from its sheer amounts. Hence, on the societal or political level there is the need for related action, which can, of course, be fulfilled by business initiatives. This challenge is taken up by ECOLOG and GETEX. In both cases, companies are set up to operate closed-loop supply chains. Still, their success depends on integrating private customers into their chain of activities. The insights gained at the actor level impact both the activities within the chain as well as related political (legal) action. While it is not too much of a surprise that the end-user has to be taken into account when designing a take-back or recycling system, in particular the ECOLOG case points out problems if related transaction costs are simply too high for the individual customer. This has to be obeyed both by companies operating such systems as well as on the societal level.

5. Discussion and Conclusion

The major contribution of this paper is the three level framework linking societal, chain and actor level. While the three levels are presented in related publications, in particular on integrated chain management [13,14,23], previous frameworks have rather stayed on the company level and usually told (success) stories about how companies implemented related actions. Seuring and Müller [33] points to the need for inter-organizational arrangements and related costs, but also stays on an in-between company analysis. It should also be mentioned again that a similar framework was put forward by Smit and co-authors [21] within a quite different setting. While the three levels have now been elaborated, their integration and interactions would require further analysis, both within the particular setting of recycling networks and closed-loop supply chains, but also beyond such issues.

The framework therefore integrated closed-loop supply chain management and related business processes with their implications on the societal as well as the single actor level. Future research would have to analyze more cases, where this framework is used. This would allow (1) assessing the suitability of the framework itself, and (2) allow gaining more insights into the interrelation of the three different levels. This is in line with research demands in sustainable supply chain management [6,8,48] and recent efforts of assessing the performance of respective closed-loop supply chain solutions [36].

Closed-loop supply chain management is conceptualized in a three level framework which spans the societal, chain and actor level. This framework has been developed and illustrated by two case studies from the apparel industry, ECOLOG and GETEX. In a connected world, it seems obvious that no business process is fulfilled on its own, but is closely related to other actors in the chain as well as in society. The study portrays that a successful operation of a closed-loop supply chain system depends

on the integration among the three levels. The analysis provides some first insights into the interrelatedness of the three levels. Yet, this might be a hard lesson to learn for many managers and politicians, where such frameworks might inform them on the inter-connectedness of their action.

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