Bridging Economy and Ecology: a Circular Economy Approach to Sustainable Supply Chain Management

Completed Research Paper

Holger Schrödl
Otto-von-Guericke University Magdeburg
FIN/ITI
Universitaetsplatz 2
39106 Magdeburg/Germany
holger.schroedl@ovgu.de

Paulina Simkin
Otto-von-Guericke University Magdeburg
FIN/ITI
Universitaetsplatz 2
39106 Magdeburg/Germany
paulina.simkin@gmx.de

Abstract

The linkage between economic and environmental issues in an inter-organizational context receives significant attention from scholars and industrial practice. Emerging concepts like Green Supply Chain Management (Green SCM), extending supply chain management with ecological aspects like resource optimization and recycling, might be the first step towards an ecologically responsible economy. But, the question for an appropriate solution for sustainable economic systems remains still open. This paper proposes the integration of the Circular Economy, an economic concept with a focus on long-term sustainability, with established concepts for inter-organizational systems. The proposed framework CESC integrates the Circular Economy model with SCOR (Supply Chain Operations Reference model) to establish a sustainable SCM model beyond Green SCM. The holistic approach is demonstrated by applying CESC to a selected Green SCM concept. CESC may be used to analyze inter-organizational systems on their long-term sustainability and as a blueprint for the development of sustainable, inter-organizational eco-systems.

Keywords: Green IT/IS, Supply chain management, SCOR, Design Science, Economic modeling, Inter-organizational systems

Motivation

Meadows et.al and the Club of Rome (Meadows, 1974) sent out a warning in 1972 about the finiteness of resources. Resource scarcity is and remains a current and pressing topic. The careful use of resources, as they directly affect the environment, is necessary for preserving populations and enabling their economies. Companies can especially contribute through their own sustainable actions by using resources carefully and for a longer time, thereby maintaining national economies. In order to be able to produce and offer goods and services, supply networks started by primary product suppliers, whose products come from raw materials, is required and needs to be applied efficiently. Supply networks are a typical inter-organizational system, engaging numerous organizations, processes, and technologies. Supply Chain Management (SCM) covers the process chains in a supply network and allows for long-term cooperation between all participating vendors and service suppliers all the way to the customer (Cooper, Lambert, & Pagh, 1997). It ensures that under consideration of total efficiency, optimal solutions can be implemented for investments and costs, such as transportation and information flow. However, SCM is only a linear oriented model which describes the steps from resource extraction to its consumption. Several leading discussions emphasize that closed-loop models are much more appropriate to describe modern economics and business processes (Schumpeter, 2008). In the case of SCM, the idea of Green SCM makes use of this circular approach, while additionally dealing with aspects of environmental sustainability and resource optimization in order to address emerging environmental degradation and its effects before they occur (Sheu, Chou, & Hu, 2005). It also considers the recycling of goods (Ying & Li-jun, 2012) in making the entire supply chain process more sustainable. In this sense, Green SCM has a tremendous positive impact on environmental management (Chakraborty, 2010). But, empirical investigations on Green SCM implementations show that, in general, companies are focusing on internal descriptive activities rather than external engagement processes (Holt & Ghobadian, 2009). Teuteberg & Wittstruck (Teuteberg & Wittstruck, 2010 investigated the current state of research on sustainable supply chain management and have shown, that currently, there are more than 30 unsolved issues in supply chain management research concering environmental issues. They proposed the development of new, comprehensive and holistic supply chain management models as one of the crucial issues in future research on sustainable supply chain management. Seuring & Müller showed in their study, that the lack of existing supply chain management model with emphasis on sustainability is a main obstacle in the practical implementation and management of environmental issues in supply chain management (Seuring & Müller, 2008). In summary, Green SCM measures are not enough to accomplish long-term sustainability in inter-organizational systems like supply chain management and there is a need for comprehensive and holistic sustainable supply chain management models.

There are various approaches to integrate the concept of sustainability into economic systems. The idea of long-term sustainability is reflected in an economic model called the Circular Economy (CE) (Pearce & Turner, 1990). It represents a life cycle model that focuses on the recycling of waste in the product lifecycle beyond the classical view, distinguishes between consumable and durable products, and suggests that all the energy required to power this economy cycle should be made from renewable resources. These design principles go far beyond those concepts, which are only based on resource minimization and coordinated recycling like Green SCM (Bauer, 2008). The question is now how to integrate these principles of the Circular Economy into an economic system based on inter-organizational systems like SCM? To answer this question and to propose an appropriate concept for sustainable, inter-organizational economic systems, this paper bridges the gap between long-term sustainability and the established concepts of inter-organizational systems like SCM to unite economic and environmental benefits and provide a holistic approach.

The structure of this paper is as follows: in Section 2, we explain the research approach. In Section 3, we provide the current state of research on the relevant foundations of this research. We present a current introduction to Supply Chain Management and Green SCM as well as an overview of the concepts of Circular Economy and the SCOR model. In Section 4, we develop a new sustainable supply chain model CESC by integrating the concepts of Circular Economy along the process steps of the classic supply chain model SCOR. In Section 5, we apply the new model to the issue of Green SCM. We discuss some findings from the model's application in Section 6. The paper closes with a brief summary and an outlook of future research in Section 7.

Research Method

The main objective of this research is to develop a supply chain management model which focuses on sustainable resource management. The research uses a design science approach, which is a research method used to solve organizational problems by creating and evaluating IT artifacts (Hevner, March, Park, & Ram, 2004). These artifacts are defined as constructs, models, methods, and instantiations (March & Smith, 1995). Several methodological approaches for the conduction of design science research are proposed in the literature (see, for example, Kuechler & Vaishnavi, 2008; March & Smith, 1995; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008). For this research, we have adapted the design science research methodology from Vaishnavi & Kuechler. Based on their five-step approach, we conducted the research according to Figure 1.

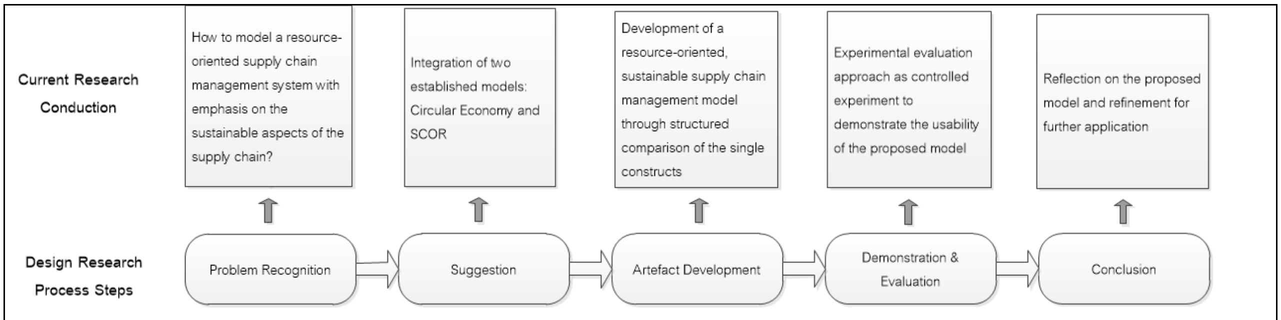

Figure 1. Research Design (adapted from Kuechler & Vaishnavi, 2008)

The first process step, problem recognition, has been addressed in the introduction. This leads to the main research question: How to design a resource-oriented supply chain management system with emphasis on the sustainable aspects of the supply chain? In the second process step, we recommend the integration of two established models: the Circular Economy Model with emphasis on the economic aspects of a sustainable production circle and the SCOR model as an industry standard for supply chain modeling. This is done by means of a model integration process in alignment with a four-dimensional model integration concept (Dolk & Kottemann, 1993). In research step 3, development, we construct a new supply chain management model for the development and enhancement of resource-oriented, sustainable supply chains. For this, we identify common constructs as well as a lack of constructs in each underlying model. For the lacking constructs, we propose an integrative concept for a holistic model. For the evaluation of the proposed supply chain management model, we follow the guidelines for design science research according to Hevner et al. (Hevner et al., 2004). In our research, we selected an experimental evaluation approach in terms of controlled experiments to demonstrate the usability of the proposed model. In the conclusion, we reflect on the proposed model and discuss refining its further applications.

Research Background

Supply Chain Management

In 1961, Forrester (Forrester, 1996) considered material flow and the reduction of total inventory before these issues were blanketed under the term "supply chain management" (SCM). SCM was purely concerned with the external logistical integration of customers and suppliers (see also Bowersox & Closs, 2005). The logistical literature essentially presumed rational co-operation between buyers, suppliers, and service providers and on this basis strived to find optimal solutions for inventory, transportation, information flow, etc. In contrast SCM also considered the behavioral and political dimensions of trust and power, as well as conflict and dependence between supplier and buyer. Logistics research focused on minimizing total cost, while SCM was concerned with long-term profitability of serving customers and their customers (Lamey, 1996). Finally, the traditional focus of logistics was often intra-organizational, while SCM became inherently inter-organizational (Larson & Rogers, 1998). Hence (Cooper et al., 1997) used the term "supply chain" to represent the alignment of firms. They defined SCM as: "The integration of business processes from original suppliers to the end-user that provides products, services, and information that add value for customers." Introducing the term "network" into the SCM arena has extended the SCM concept into more strategic areas, which covers long-term aspects of the customer-supplier relationship. One proposition was that competition occurred not only between firms but between supply chains and networks, see (Cunningham, 1990) and (Yoffie & Gomes-Casseres, 1994). Through a supply network's perspective a focal company views its whole supply network in order to compare the performance in its multiple supply chains, to identify potential competitive problems and opportunities, and to identify overall process improvements through supply chain style thinking. Current industrial supply networks are formed by the flow of materials, services, and associated information, supported by modern information and communication technology (ICT).

Green SCM

Green SCM is a combination of SCM and Environmental Management, and it forms the sub-area of Sustainable SCM (SSCM). Since the end of the 1960's, Environmental Management has been pursuing the idea of protecting the environment by managing human´s interaction and their impacts by controlling and preventing pollution and managing entire ecosystems (Nikbakhsh, 2009). In 1987, the committee World Commission on Environment and Development (WCED) defined the concept of sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (World Commission on Environment and Development, 1987) It has three main aspects: environmental, social, and economical. These dimensions made their way into many industry concepts such as SCM.

Mainly for the ecological aspects, Green SCM addresses these issues and endeavors to handle incurred environmental damage and impacts, ideally before they occur (Nikbakhsh, 2009). Green SCM deals with the command challenges of SCM and additionally with aspects of environmental sustainability and challenges of resource optimization. The classical SCM only concerns itself with the one-way point of view, the one from the supplier to the customer. Green SCM brings the circle to a close by adding recycling (Ying & Li-jun, 2012). It can be framed as "…integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life." (Srivastava, 2007). Green SCM can be divided into two blocks, Green Design and Green Operations. The first area focuses on environmentally conscious design and life-cycle assessment while the second is dedicated to manufacturing and remanufacturing, reverse logistics and network design as well as waste management. Green SCM measures give companies cost and risk advantages such as benefits in productivity, property value, and the environment. Thus, raw materials and energy costs can be lowered, low emission production can be designed, and the company's image can be improved, which can lead to higher product sales and high societal acceptance (Nikbakhsh, 2009). Therefore, consumers, environmental groups, and other organizations are motivated to Green SCM measures, but political statements also stimulate a restructuring to environmentally sustainable business processes (Wohlfahrt & Vogt). The realizations of Green SCM measures might be the first steps towards a more ecologically responsible economy, but it doesn´t cover the long-term and holistic sustainability picture.

Circular Economy

The term "Circular Economy" was first mentioned by Pearce & Turner in 1990 (Pearce & Turner, 1990). In this book, the Circular Economy is designed as a circular model for a new perspective of the linkage between resource flow and economic issues in contrast to the existing open-ended models of classic production processes. The principles, which are incorporated into the model of Circular Economy, have their foundation in the economic discipline called industrial ecology (Andersen, 2007). Industrial ecology focuses on the recycling of residual waste in the product lifecycle (Jacobsen, 2006). In general, industrial ecology can be defined as a "systems-based, multidisciplinary discourse that seeks to understand emergent behavior of complex integrated human/natural systems" (Allenby, 2006). The underlying principles in this economic concept are closely related to observations of its behavior in nature. These natural behaviors are taken as patterns to redesign industrial processes (see, for example, Pan, Yu, & Sun, 2010; Yanglei, 2011). One of these patterns is the observation that waste from one process may be a resource for another process (Frosch & Gallopoulos, 1989).

In the Circular Economy, the principles from industrial ecology have been adapted to design an economic system, which should provide economic developments in alignment with the protection of the environment and resources. It is intended to behave regeneratively by design. To achieve this, the end-of-life concept in a traditional industry is replaced by a restoration cycle which makes use of a waste-less design of materials, products, systems, and business models. The foundation of the Circular Economy consists of three design principles: First, waste is designed out. This means a tight integration of component and product life cycles and goes beyond classic concepts of disposal and recycling, where large amounts of waste and energy are lost. Second, there is a difference between consumable and durable products. Third, all energy which is used to fuel this cycle economy should be made from renewable resources. To ensure the alignment of all activities with these three principles, a shift is made from the view of a consumer of a product towards the view of the user for a product. This means that, in Circular Economy, products are not sold to a customer, but users use products on a leased, rented, or shared basis whenever possible. Pearce & Turner proposed a conceptual model for the Circular Economy as depicted in Figure 2:

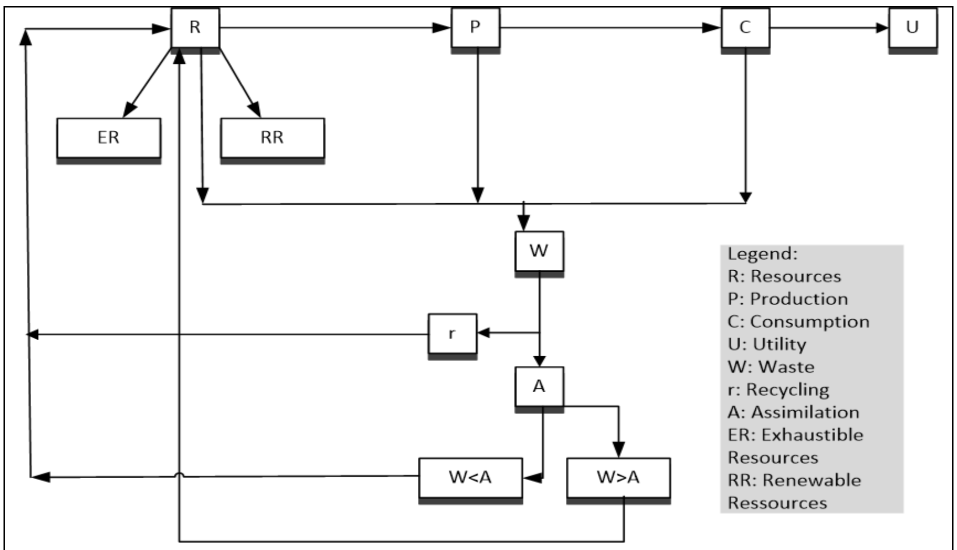

Figure 2. Circular Economy Model (according to Pearce & Turner Pearce & Turner, 1990).

Briefly described are the main constructs R (Resources), P (Production), and C (Consumption). All of these three concepts lead to W (Waste). Resources may be differentiated in ER (Exhaustible Resources) and RR (Renewable Resources). Waste is part of the design and is considered as a resource for other activities in the circle. Therefore, through a recycling process, waste returns as a resource for further production. It is assumed that not all of the waste may be recycled for reuse. The rest, which cannot be recycled, leads to the construct of A (Assimilation). This is used to indicate the backflow of waste into the biosphere. To control the impact of waste on the biosphere, the assimilation capacity is related to the amount of waste. If the assimilation capacity is larger than the amount of waste, the impact of the biosphere is positive. Otherwise, if the assimilation capacity is lower than the amount of waste, the impact of the biosphere is negative.

SCOR Model

There exist several business process frameworks to structure supply chain management processes in the literature (see, for example, Hewitt (Hewitt, 1994) or Cooper et al. (Cooper et al., 1997)). In order to obtain a holistic view of the opportunities of industrialization in supply chain management processes, we decided to use a more high-level framework. The framework chosen for such a holistic approach is the SCOR (Supply Chain Operations Reference) model (Poluha, 2005). This model was designed by the Supply Chain Council as a reference model for describing business processes in the Supply Chain (Supply-Chain Council, 2008). It can be considered as the first cross-industry framework for evaluating and improving enterprise-wide supply-chain performance and management (Stewart, 1997). The model draws on both corporate and enterprise-wide business processes and has established itself as an industry reference model, which can be seen by the fact that more than 1000 companies worldwide have joined the Supply Chain Council. Beside this practical success, SCOR is used as a core concept in academic research in the area of supply chain management (see for example Arns, Fischer, Kemper, & Tepper, 2002, Huan, Sheoran, & Wang, 2004, Lockamy & McCormack, 2004, Hwang, Lin, & Lyu, 2008). Therefore, SCOR can be considered as a comprehensive body of knowledge for research activities around supply chain management and its processes (Soffer & Wand, 2007).

The SCOR model includes five key supply chain operations: Plan, Source, Make, Deliver, and Return. It has four levels of description. Level 1 is the process level and thus represents the highest level, whose scope is the organization and the content of its supply chain. There are five processes considered: plan (the interplay of supply and demand), source (procurement of products, components and services for service provision), make (the manufacturing of products, intermediate products, and services to different manufacturing processes), deliver (the supply of products and services to the customer with the appropriate accompanying documentation) and return (to receive a faulty product or a return of primary products or raw materials to the supplier). The second level of description is the configuration level. On this level, the core processes are divided into process categories. A distinction is made between planning processes, implementation processes, and support processes. The detailing of the processes takes place in level 3. On this level, the sequence of activities and the input and output information are described. This level of consideration, referred to as a design level, completes the SCOR model. The viewing plane 4 is the implementation level, which is not included in the model. In this level, it is about company-specific considerations, not general ones concerning all types of companies.

Circular Economy Supply Chain (CESC) Model

In the following, a new sustainable supply chain model is developed by integrating the design principles of the Circular Economy to the classic design of the supply chain. For this, a four-dimensional model integration concept from Dolk & Kottemann is applied (Dolk & Kottemann, 1993). The integration concept serves as a systematic way to integrate different models by considering the four model dimensions from four perspectives: organizational, definitional, procedural, and implementational. The organizational perspective refers to the synchronization of organizational objects and organizational levels in the models. Definitional integrations refers to the integration of different description, while procedural integration refers to the synchronization of processes and process steps. The implementational level covers the technological prerequisites for model implementation. This research concentrates on the organizational, definitional and procedural integration and leaves the implementational integration to future research due to space restrictions. According to this model integration method, both concepts will be integrated by identifying common and divergent tasks and issues. The construction of the new supply chain model follows the process steps of the SCOR model. For every process step, the activities on description level 3 of the SCOR model are investigated. Since the Circular Economy is focused on all issues related to resource management, all activities which are directly related to resource issues are identified and put into context.

Planning Processes

The Plan processes cover the planning activities which are necessary to operate a supply chain. The planning process includes all process steps of the SCOR model and can be regarded as the overall planning activities for the whole supply chain. On level 3, planning consists of 20 activities (Supply Chain Council, 2010). Ten activities are directly related to resource management (see Table 1):

Table 1. Resource-related activities in the planning processes of SCOR

sP1.2: Identify, Prioritize, and Aggregate Supply Chain Resources	sP1.3: Balance Supply Chain Resources with Supply Chain Requirements	sP2.2: Identify, Assess, and Aggregate Product Resources
sP2.3: Balance Product Resources with Product Requirements	sP3.2: Identify, Assess, and Aggregate Production Resources	sP3.3: Balance Production Resources with Production Requirements
sP4.2: Identify, Assess, and Aggregate Delivery Resources	sP4.3: Balance Delivery Resources with Delivery Requirements	sP5.2: Identify, Assess, and Aggregate Return Resources
sP5.3: Balance Return Resources with Return Requirements		

In the basic Circular Economy model, provided by Pearce & Turner (Pearce & Turner, 1990), there are no explicit planning activities described. But, planning is an essential component in the Circular Economy model. Pearce & Turner describe planning as the assumption that the economy operates with free markets. This means that: production factors and the production itself are through private companies; income is only achieved through services and company profit; there is no restriction from government for production planning; and market participants have free choices for consumption, labor, saving, and investing (Halm, 1960). Reflecting this, the operationalization of these economic rules is well aligned with the resource management activities from Table 1. Therefore, the planning activities from the SCOR model may serve as an overall planning framework for the Circular Economy model.

Sourcing Processes

The Source processes describe the ordering (or scheduling) and receipt of goods and services. In SCOR, the source processes are divided into three sourcing strategies in relation to their production strategies: sourcing of a stocked product, sourcing of a make-to-order product, and sourcing of an engineer-to-order product. Due to the highest ratio of environmental issues in the activities, the activities for the engineer-to-order product are examined. In this sourcing strategy, seven activities are defined on SCOR level 3. Five of them are related to resource management (see Table 2):

Table 2. Resource-related activities in the sourcing processes of SCOR for engineer-to-order products

sS3.1: Identify Sources of Supply	sS3.2: Select Final Supplier(s) and Negotiate	sS3.4: Receive Product
sS3.5: Verify Product	sS3.6: Transfer Product	

Sourcing in the Circular Economy model is related to all concepts concerning resources. For this, the construct of a resource is available in the model. This construct of a resource is further divided into two sub-constructs: exhaustible resources and renewable resources. With these, the model is able to put a strong emphasis on the type of resources that go into the production processes. In the combination of the Circular Economy model and SCOR, the construct of resources can be linked with the sourcing activities from the SCOR model.

Production Processes

The Make processes cover all activities dealing with the conversion of materials. Material conversion is a much broader application than classic production or manufacturing. In the sense of SCOR, make covers conversions like repair, recycling, maintenance, remanufacturing, and many more. As already seen in the sourcing process, the production process is also subdivided into three different production strategies: make-to-stock, make-to-order, and engineer-to-order. In alignment with the sourcing process, the engineer-to-order activities will be examined. On SCOR level 3, there are eight activities in the make process. Four of them are directly related to resource management (see Table 3):

Table 3. Resource-related activities in the Production processes of SCOR for engineer-to-order products

sM3.1: Finalize Product Engineering	sM3.4: Produce and Test	sM3.5: Package
sM3.8: Waste Disposal		

The overlapping of the Make process of the SCOR model to the Circular Economy model comes in a natural way through the construct of production in the Circular Economy model. But due to the broad definition of Make in SCOR, also the construct of Recycling from the Circular Economy model overlaps with the Make processes. Both constructs, Production and Recycling, deal with the transformation of material in different settings.

Delivery Processes

The Delivery processes describe the activities associated with the creation, maintenance, and fulfillment of customer orders. In SCOR, the delivery processes are subdivided into four distinct delivery strategies on description level 2: delivery for stocked products, make-to-order products, engineer-to-order products, and retail products. The first three strategies overlap a great deal in their activities, while the delivery of retail products differs significantly from the others. In alignment with the sourcing and making strategies, an investigation will be done for the delivery activities for the engineer-to-order products. In this delivery strategy, 15 activities are defined on SCOR level 3. Seven among them are directly related to resource management (see Table 4):

Table 4. Resource-related activities in the Delivery processes of SCOR for engineer-to-order products

sD3.3: Enter Order, Commit Resources, and Launch Program	sD3.6: Route Shipments	sD3.7: Select Carriers and Rate Shipments
sD3.8: Receive Product from Source or Make	sD3.10: Pack Product	sD3.12: Ship Product
sD3.14: Install Product		

There is no explicit construct for delivery in the Circular Economy. From the perspective of its design principles, there are several issues like energy consumption, reuse strategies, and product collection that are essential components to its precepts (Ellen McArthur Foundation, 2011). Despite the fact that there is no general construct in the model, delivery issues are tightly integrated into the model. Therefore, a direct mapping between the Circular Economy model and the SCOR model is not possible. For a holistic approach, the resource-based activities from the delivery processes of the SCOR model are a means to demonstrate clearly the significance of the delivery options for a sustainable supply chain management model.

Return Processes

The Return processes describe the activities associated with the reverse flow of goods back from the customer. In SCOR, return is more about the coordination and documenting of the return of products. Activities like repairing, recycling, and remanufacturing take place in the Make section of SCOR. Return in SCOR is subdivided into six different return strategies, depending on the type of return reason. There are three different reasons considered: returning a defective product, returning an MRO (maintenance, repair and operations) product, and returning an excess product. All of them strongly overlap in their activities. For a holistic view on the return process, all of the return strategies are investigated. On SCOR level 3, there are 27 activities in the return processes. 9 of them are directly related to resource management (see Table 5):

Table 5. Resource-related activities in the return processes of SCOR

sSR1.1: Identify Defective Product Condition	sSR1.5: Return Defective Product	sSR2.1: Identify MRO Product Condition
sSR2.5: Return MRO Product	sSR3.1: Identify Excess Product Condition	sSR3.5: Return Excess Product
sDR1.4: Transfer Defective Product	sDR2.4: Transfer MRO Product	sDR1.4: Transfer Excess Product

In the Circular Economy again, there is no explicit construct for the return processes. But on the other hand, in the Circular Economy, the construct of consumer goods has a very broad meaning. All activities related to the product usage and handling are covered by the construct of consumer goods. Therefore, it is possible to link the resource-related activities in the return processes, which mainly deal with the return of a defective or excessive product with the construct of consumer goods from the Circular Economy.

The combined CESC model

From the previous sections, we have identified common constructs, different interpretations, and differences between the SCOR model and the Circular Economy model. These findings are now combined into a resource-oriented, circular supply chain management model for a holistic approach.

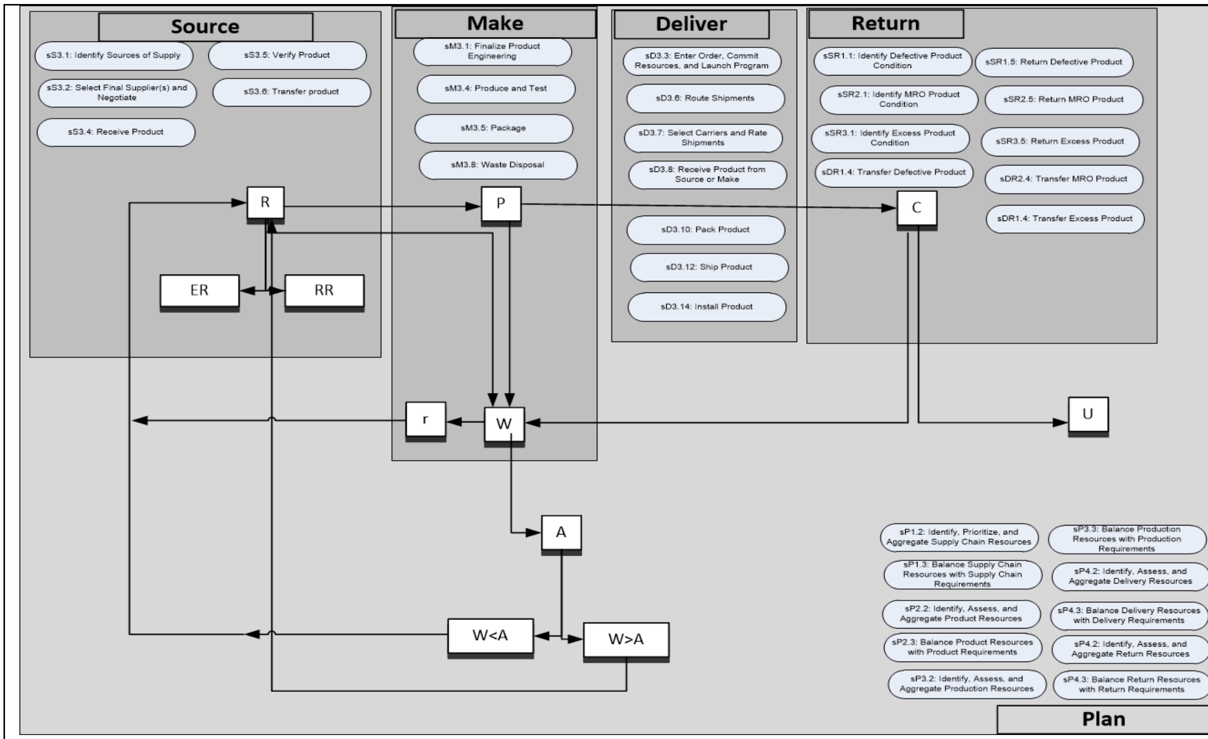

Figure 3. Circular Economy Supply Chain Model

From the SCOR model, the resource-relevant activities from all process steps lay the foundation of the CESC model. The constructs from the Circular Economy model are integrated in the corresponding process steps from the SCOR model. We see that for the Deliver processes, no corresponding construct from the Circular Economy model is available. From the other side we see that for the constructs of utility and assimilation, there are no corresponding processes in the SCOR model. The CESC model integrates these gaps and provides a holistic approach for a circular, resource-based supply chain model. There is a more detailed discussion of these differences in section 6.

Green SCM through the Lens of the CESC Model

There exist several applications of the CESC model, some of which will be discussed in the next section. One natural application is the investigation of resource-oriented inter-organizational ecosystems. One prominent example, which is widely discussed in scientific as well as industrial practice is the concept of Green Supply Chain Management (Green SCM) (for some examples of the current discussion, see Dao, Langella, & Carbo, 2011; Green, Morton, & New, 1998; Nikbakhsh, 2009; Sheu et al., 2005).

Most discussions about Green SCM result in the proposition of initiatives which should be undertaken to achieve the potential goals on a broad Green SCM approach. The question remains, whether the proposition of the initiatives is really a holistic approach or whether they put the focus on specific issues of the supply chain based on different reasons. To demonstrate this, we selected a published study on Green SCM from Bearingpoint (Wohlfahrt & Vogt). This study is based on a survey of 450 companies on the European level. Based on this survey, the study proposes 22 initiatives developing towards a Green Supply Chain. These 22 initiatives are divided into 15 intra-organizational and 7 inter-organizational initiatives.

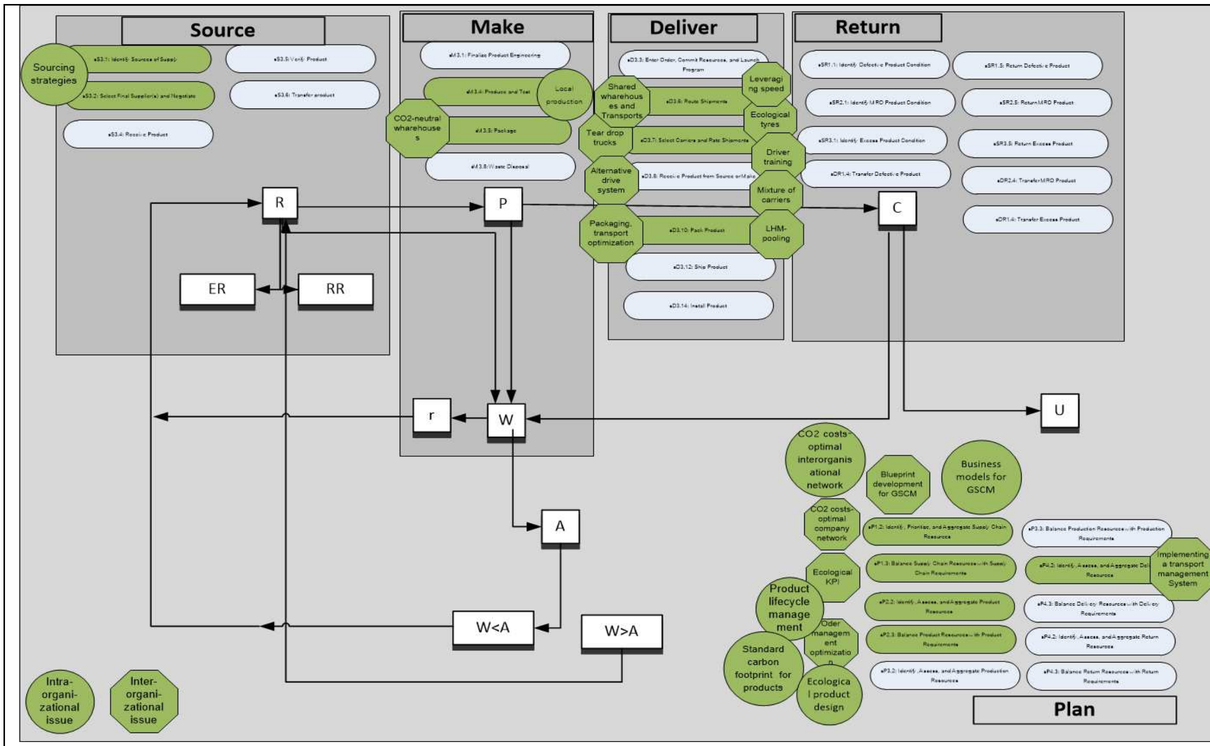

Figure 4. Circular Economy Supply Chain Model applied in the context of Green SCM

With this assessment, it is easy to see that the proposed Green SCM concept has several focus points in the CESC model, whereas other areas are not considered at all. One area, which is very broadly covered, is the area of delivery. Eight initiatives from the complete concept can be identified as relevant tasks for the area of delivery. This is remarkable from two viewpoints. First, delivery is not explicitly considered in the Circular Economy model. From this approach, these initiatives would not have been developed because of the missing focus. Second, all eight initiatives are intra-company issues. But, delivery is a global issue and therefore an inter-company topic. The discussion on this is missing in the Green SCM concept. The area of Return is not covered at all. This is also quite remarkable since the return processes are responsible for transferring material back into the economic cycle. At this point, the difference between the traditional linear consumption and the consumption cycle becomes obvious.

Discussion

The previous section has shown that the proposed CESC model provides a holistic view of a resource-oriented, sustainable supply chain. In a given Green SCM scenario, the model was able to identify weaknesses and missing topics. This is just one example of a possible application area of the proposed model. In general, the model may act as a tool for investigating resource-oriented concepts in an inter-organizational context for their sustainability. Therefore, the proposed model can be regarded as a first step towards a reference model for a resource-oriented sustainable supply chain model, which may act as a blueprint for the development and extension of classical supply chains to a sustainable one.

Due to its resource-oriented focus, the emphasis of the proposed model lies in the management of tangible goods and classic production processes. In several industries, there is a broad discussion about the substitution of tangible goods through service-based solutions. One outstanding example of this development is in the area of cloud computing. The IT infrastructure for a company, composed of hardware and software, was mainly provided by an internal IT department, which was responsible for creating, running, and maintaining servers, communication networks, databases, and applications. Cloud computing has made it so the IT department is no longer running its own infrastructure, but is rather sourcing IT services from external providers and orchestrating them to run complex business applications. This has a tremendous impact on sourcing, developing, and maintaining processes and a completely new perspective on resources in this area (see for example Bensch & Schrödl, 2012). The question is how this development may be reflected in the proposed CESC model? In an initial approach, we assume that the distinction between make and delivery has to be redesigned. In the service industry, we see a principle called uno actu, which means that, in the service industry, the making of a service and the consumption of a service may occur simultaneously. This principle changes the meaning of delivery and might create a much closer relationship between make and delivery in a revised model.

The proposed CESC model may be scientifically embedded in the area of closed-loop supply chain management. The research on closed-loop supply chains has its foundations in the life cycle management (Krikke, Le Blanc, & van de Velde, 2004, Matos, S., & Hall, J. (2007)). Closed-loop supply chain management puts an emphasis on the return process of products, which might go through the recycling process to serve as new material for upcoming production processes. In the scientific discussion on closed-loop supply chains, there is a lot of attention on the development of streamlined production processes which are designed to serve as an input for adequate return and recycling processes (Zhu, Sarkis, & Lai, 2008). Another emphasis is drawn on the product remanufacturing processes (Chung, Wee, & Yang, 2008, Östlin, Sundin, & Björkman, 2008) to include the return and recycling processes in the resource-optimized product manufacturing. While all these issues help to include environmental thinking into the supply chain processes, it is just an excerpt of a holistic vision for sustainability in supply chain management. Two fundamental aspects are missing: First, it is necessary to include economic constructs into the supply chain management to address the economic barriers in global, distributed markets. Second, besides the return and recycling constructs, we need to take a closer look at the assimilation construct in the holistic approach. The aspect of assimilation helps to understand that there is already a given capacity for waste in the production and usage of products, related to the considered environment. This should be taken in account when designing and manufacturing products, that should behave "green" in their entire product lifecycle. The assimilation concept may serve as a buffering capacity to achieve an optimal distribution of waste and recycling processes for a true closed-loop supply chain. Both concepts – the economic constructs and the assimilation construct – are incorporated in the proposed CESC model. Therefore, this model goes beyond the current discussion of closed-loop supply chains for sustainability and will lead to new insights on a broader perspective.

Information technology plays a crucial role in the practical implementation of supply chain management models in general and the proposed CESC model in particular. Since this research has left out the implementational integration due to space restriction, there is no in-depth discussion of aspects arising from the need to realize the model with information technology. There is a broad scientific discussion on the implementing of SCOR with information technology (see for example Huang, Sheoran, & Keskar, 2005 on the configuration of supply chains using SCOR or Millet, Schmitt, & Botta-Genoulaz, 2009 of the usage of SCOR for the alignment of business processes and information technology. This discussion has to be investigated to identify existing IT solutions concepts which may be applicable to implement the proposed CESC model in a practical setting. For the missing IT concepts, which are very likely to appear, the research stream of information technology in supply chain management has to be extend for the specific requirements of the CESC model.

The discussed application area of supply chain management is a specific type of inter-organizational system. Its key drivers are material and information flows, and there is a hierarchical organization within the supply chain with a leading customer and a chain of subsequent suppliers in different tiers. Inter-organizational systems cover a broader area of economic infrastructure between different organizations. There are different types of relationships between the participating companies; material flows do not always exist; and issues like information security and governance gain more importance. Here again, the question arises, whether the proposed CESC model has to be adapted for the application in the general environment of inter-organizational systems.

Summary

The aim of this paper was the development of a sustainable supply chain management model which emphasis sustainable resource management in the supply chain in a holistic approach. To achieve this, the concept of Circular Economy has been selected as an economic model with an emphasis on considering resources in a closed-loop cycle to minimize unwanted output like waste in the supply chain. This economic model has been integrated with the SCOR model as an established concept for complex supply chains. It could be shown that the integration of these two models leads to a holistic view of resource-oriented sustainable supply chains. Besides the overlapping areas of both models, the proposed model combines different areas which are not considered in the underlying models. Therefore, it provides a new framework for the development and establishment of sustainable supply chain management structure. The proposed model has been applied to a selected case for Green SCM. It could be shown that the proposed approach for Green SCM lacks generality and covers only parts of the relevant aspects. Core issues like return processes are not covered at all. A discussion of the proposed model shows that it has the potential for extending into either a more service-based industry or other types of inter-organizational systems. In this sense, the proposed model acts as a blueprint for current issues in sustainable supply chain management and as a foundation for the future development of a generic approach toward product-independent, generic inter-organizational system development.

Several additional steps are an option for future research. One core development for the future would be to take a closer look at the product type. As already discussed, the proposed model has its foundation in the production industry for tangible goods. The question remains how to design a model for service products or other intangible goods. A second step further would be a study of the proposed model in an applied industrial context. This discussion in different industrial cases would lead to a deeper understanding of the mechanism within the model and would be a relevant task towards an instantiation of the model in a particular industrial context.

References

Allenby, B. (2006). The ontologies of industrial ecology? *Progress in Industrial Ecology, An International Journal*, *3*(1/2), 28. doi:10.1504/PIE.2006.010039

Andersen, M. S. (2007). An introductory note on the environmental economics of the circular economy. *Sustainability Science*, *2*(1), 133–140. doi:10.1007/s11625-006-0013-6

Arns, M., Fischer, M., Kemper, P., & Tepper, C. (2002). Supply chain modelling and its analytical evaluation1. *Journal of the Operational Research Society*, 53(8), 885–894. doi:10.1057/palgrave.jors.2601381

Bauer, J. (2008). *Industrielle Ökologie. Theoretische Annäherung an ein Konzept nachhaltiger Produktionsweisen*. Universität Stuttgart, Holzgartenstr. 16, 70174 Stuttgart.

Bensch, S., & Schrödl, H. (2012). Purchasing Cloud-Based Product-Service Bundles in Value Networks - The Role of Manageable Workloads. In *Proceedings of the European Conference on Information Systems (ECIS2012)* (pp. Paper 204).

Bowersox, D. J., & Closs, D. J. (2005). *Logistical management: The integrated supply chain process* (4th ed.). *McGraw-Hill series in marketing*. New York: McGraw-Hill.

Chakraborty, S. (2010). Concise Chronological Road Map of Evolving Green Supply Chain Management Concepts: A Review. *The IUP Journal of Supply Chain Management*, 7(4), 7–25.

Chung, S.-L., Wee, H.-M., & Yang, P.-C. (2008). Optimal policy for a closed-loop supply chain inventory system with remanufacturing. *Mathematical and Computer Modelling*, 48(5-6), 867–881. doi:10.1016/j.mcm.2007.11.014

Cooper, M. C., Lambert, D. M., & Pagh, J. D. (1997). Supply Chain Management: More Than a New Name for Logistics. *The International Journal of Logistics Management*, *8*(1), 1–14. doi:10.1108/09574099710805556

Cunningham, M. T. (1990). Survival and growth strategies in new technology markets. In *Proceedings of the 6th IMP Conference* (pp. 346-372). Milan.

Dao, V., Langella, I., & Carbo, J. (2011). From green to sustainability: Information Technology and an integrated sustainability framework. *The Journal of Strategic Information Systems*, *20*(1), 63–79. doi:10.1016/j.jsis.2011.01.002

Dolk, D. R., & Kottemann, J. E. (1993). Model integration and a theory of models. *Decision Support Systems*, 9(1), 51–63. doi:10.1016/0167-9236(93)90022-U

Ellen McArthur Foundation. (2011). *Towards The Circular Economy: Economic and business rationale for an accelerated transition.*

Forrester, J. W. (1996). *Industrial dynamics*. Portland, Oregon: Productivity.

Frosch, R. A., & Gallopoulos, N. E. (1989). Strategies for Manufacturing. *Scientific American*, *261*(3), 144–152. doi:10.1038/scientificamerican0989-144

Green, K., Morton, B., & New, S. (1998). Green purchasing and supply policies: do they improve companies' environmental performance? *Supply Chain Management: An International Journal*, *3*(2), 89–95. doi:10.1108/13598549810215405

Halm, G. N. (1960). *Economic systems: a comparative analysis*. *Fletcher School studies in international affairs*: Holt, Rinehard and Winston.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly*, *28*(1), 75–105.

Hewitt, F. (1994). Supply Chain Redesign. *The International Journal of Logistics Management*, *5*(2), 1–10. doi:10.1108/09574099410805162

Holt, D., & Ghobadian, A. (2009). An empirical study of green supply chain management practices amongst UK manufacturers. *Journal of Manufacturing Technology Management*, 20(7), 933–956. doi:10.1108/17410380910984212

Huan, S. H., Sheoran, S. K., & Wang, G. (2004). A review and analysis of supply chain operations reference (SCOR) model. *Supply Chain Management: An International Journal*, 9(1), 23–29.

Huang, S. H., Sheoran, S. K., & Keskar, H. (2005). Computer-assisted supply chain configuration based on supply chain operations reference (SCOR) model. *Computers & Industrial Engineering*, 48(2), 377–394. doi:10.1016/j.cie.2005.01.001

Hwang, Y.-D., Lin, Y.-C., & Lyu, J. (2008). The performance evaluation of SCOR sourcing process—The case study of Taiwan's TFT-LCD industry. *International Journal of Production Economics*, 115(2), 411–423. doi:10.1016/j.ijpe.2007.09.014

Jacobsen, N. B. (2006). Industrial Symbiosis in Kalundborg, Denmark: A Quantitative Assessment of Economic and Environmental Aspects. *Journal of Industrial Ecology*, *10*(1-2), 239–255. doi:10.1162/108819806775545411

Krikke, H., Le Blanc, H., & van de Velde, S. (2004). Product Modularity and the Design of Closed-Loop Supply Chains. *California Management Review*, 23–39.

Kuechler, B., & Vaishnavi, V. (2008). On theory development in design science research: anatomy of a research project. *European Journal of Information Systems*, *17*(5), 489–504. doi:10.1057/ejis.2008.40

Lamey, J. (1996). *Supply chain management: Best practice and the impact of new partnerships. Financial Times management reports*. London: Financial Times.

Larson, P. D., & Rogers, D. S. (1998). Supply chain management: definition, growth and approaches. *Journal of Marketing Theory and Practice*, *6*(4), 1–5.

Lockamy III, A., & McCormack, K. (2004). Linking SCOR planning practices to supply chain performance: An exploratory study. *International Journal of Operations & Production Management*, 24(12), 1192–1218.

March, S. T., & Smith, G. F. (1995). Design and natural science research on information technology.

Decision Support Systems, *15*(4), 251–266. doi:10.1016/0167-9236(94)00041-2

Matos, S., & Hall, J. (2007). Integrating sustainable development in the supply chain: The case of life cycle assessment in oil and gas and agricultural biotechnology. Journal of Operations Management, 25(6), 1083–1102. doi:10.1016/j.jom.2007.01.013

Meadows, D. H. (1974). *The limits to growth: A report for the Club of Rome's Project on the Predicament of Mankind* (2nd ed.). New York: Universe Books.

Millet, P.-A., Schmitt, P., & Botta-Genoulaz, V. (2009). The SCOR model for the alignment of business processes and information systems. *Enterprise Information Systems*, 3(4), 393–407. doi:10.1080/17517570903030833

Nikbakhsh, E. (2009). Green Supply Chain Management. In R. Zanjirani Farahani, N. Asgari, & H. Davarzani (Eds.), *Contributions to Management Science. Supply Chain and Logistics in National, International and Governmental Environment* (pp. 195–220). Heidelberg: Physica-Verlag HD.

Östlin, J., Sundin, E., & Björkman, M. (2008). Importance of closed-loop supply chain relationships for product remanufacturing. *International Journal of Production Economics*, 115(2), 336–348. doi:10.1016/j.ijpe.2008.02.020

Pan, F., Yu, Y., & Sun, H. (2010). : A research on the structure model of automobile recycling system based on circular economy. In Y. Zhang (Ed.), *Proceedings of the 6th Euro-Asia Conference on Environment and CSR: Technological Innovation and Management Science Session. March 18 - 19, 2010 Istanbul, Turkey* (pp. 62–67). Berlin: wvb Wiss. Verl.

Pearce, D. W., & Turner, R. K. (1990). *Economics of natural resources and the environment*. Baltimore: The Johns Hopkins Univ. Press.

Peffers, K. E., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2008). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, *24*(3), 45–77.

Poluha, R. G. (2005). *Anwendung des SCOR-Modells zur Analyse der Supply Chain: Explorative empirische Untersuchung von Unternehmen aus Europa, Nordamerika und Asien*. (Dissertation). Universität zu Köln, Köln.

Schumpeter, J. A. (2008). The circular flow of economic life as conditioned by given circumstances. In M. Augier (Ed.), *Sage library in business & management. Fundamentals of business strategy* (pp. 33–66). Los Angeles: SAGE.

Sheu, J.-B., Chou, Y.-H., & Hu, C.-C. (2005). An integrated logistics operational model for green-supply chain management. *Transportation Research Part E: Logistics and Transportation Review*, *41*(4), 287–313. doi:10.1016/j.tre.2004.07.001

Soffer, P., & Wand, Y. (2007). Goal-Driven Multi-Process Analysis. *Journal of the AIS*, 8(3), 175–203.

Srivastava, S. K. (2007). Green supply-chain management: A state-of-the-art literature review. *International Journal of Management Reviews*, *9*(1), 53–80. doi:10.1111/j.1468-2370.2007.00202.x

Seuring, S., & Müller, M. (2008). Core issues in sustainable supply chain management - a Delphi study. Business Strategy and the Environment, 17(8), 455–466. doi:10.1002/bse.607

Stewart, G. (1997). Supply-chain operations reference model (SCOR): the first cross-industry framework for integrated supply-chain management. *Logistics information management*, 10(2), 62–67.

Supply Chain Council, I. (2010). *Supply Chain Operations Reference (SCOR) model: Overview - Version 10.0*. Cypress.

Supply-Chain Council. (2008). *Supply-Chain Operations Reference-model: SCOR Overview Version 9.0*.

Teuteberg, F., & Wittstruck, D. (2010). A Systematic Review of Sustainable Supply Chain Management Research: What is there and what is missing? In M. Schumann, K. M. Lutz, M. H. Breitner, & A. Frerichs (Eds.), *Proceedings of the MKWI2010* (pp. 1001–1015).

Wohlfahrt, M. & Vogt, S. *Green SCM - Von der lokalen Einzelmaßnahme bis zur globalen ökologisch optimierten Lieferkette: Die Roadmap zur Vereinigung ökonomischer und ökologischer Effizienz*.

World Commission on Environment and Development. (1987). Our Common Future: Report of the World Commission on Environment and Development.

Yanglei, J. (2011). Modeling green supply chain of the manufacturing industry under circular economy in

China. In Y. Zhang (Ed.), *Agriculture, tourism and education. Proceedings for the 2010 Euro-Asia Winter Conference on Environment and CSR, November 23 - 25, 2010, Huangshan, China* (pp. 57–61). Berlin: wvb Wiss. Verl.

Ying, J., & Li-jun, Z. (2012). Study on Green Supply Chain Management Based on Circular Economy. *Physics Procedia*, *25*, 1682–1688. doi:10.1016/j.phpro.2012.03.295

Yoffie, D. B., & Gomes-Casseres, B. (1994). *International trade and competition: Cases and notes in strategy and management* (2nd ed.). *McGraw-Hill series in management*. New York: McGraw-Hill.

Zhu, Q., Sarkis, J., & Lai, K.-h. (2008). Green supply chain management implications for "closing the loop". *Transportation Research Part E: Logistics and Transportation Review*, 44(1), 1–18. doi:10.1016/j.tre.2006.06.003