



# 1<sup>st</sup> Conference of the EURO Working Group on Sustainable Supply Chains

July 1 – July 2, 2016, RWTH Aachen University

## Abstract Book



## Schedule

### Friday, July 1

<b>8:45-9:30</b>	<b>Scientific Keynote</b> <b>Peter Letmathe:</b> <b>(Ford-Saal)</b> <b>Cost Structures in International Supply Chains</b>	
<b>9:30-10:45</b>  <b>Parallel Session I</b>	<b>I-A (Ford-Saal):</b> <b>Social Aspects &amp; Triple Bottom Line</b> <i>Session Chair: Martin Grunow</i>	<b>I-B (Generali-Saal):</b> <b>Environmental Performance of SCs</b> <i>Session Chair: Chien-Ming Chen</i>
	Bubicz et al.: Incorporating Social Aspects Towards a Sustainable Supply Chain: Trends and Future Directions	Tuni/Rentizelas: Assessing Environmental Performance of Extended Supply Chains: From a Literature Review to an Innovative Model
	Mota et al.: Social Sustainability-Exploring Organizations' Options to Increase their Social Handprint	Chen/Ho: Does it Pay to be Green? An Empirical Examination of Customers' Role
	Hombach/Walther: Sustainable biofuel supply chains considering economic, ecologic & social objectives	Krannich/Günther: Antecedents and Consequences of Environmental Value Chain Management
<b>10:45-11:00</b>	<b>Coffee Break</b>	
<b>11:00-12:15</b>  <b>Parallel Session II</b>	<b>II-A (Ford-Saal):</b> <b>Food Supply Chains</b> <i>Session Chair: Ana Barbosa-Póvoa</i>	<b>II-B (Generali-Saal):</b> <b>Processes and Innovation in SustSCs</b> <i>Session Chair: Marc Reimann</i>
	Ozinci et al.: Sustainable Supply Chain of Organic and Conventional Products with Different Utilities and Shelf-Lives	Ata: A Process Perspective of Sustainable Supply Chain Management and Information Technology
	Geramianfar et al.: Design of Sustainable Supply Chains: A Case in the Frozen Food Industry	Xiong et al.: Managing Process Innovation for Remanufacturing in a Closed-Loop Supply Chain
	Depping et al.: Economic and Environmental Assessment of New Perishable Dairy Products under Uncertain Price Evolution - Decision Tool based on Multi-Objective Optimization	Boyaci et al.: Product Reuse with Disruptive Innovation
<b>12:15-13:15</b>	<b>Lunch &amp; Posters</b>	

<b>13:15-13:45</b>	<b>Industry Case I (Ford-Saal)</b>	<b>Ford Science Center: Fuels of the Future</b>
<b>13:45-14:15</b>	<b>Industry Case II (Ford-Saal)</b>	<b>Interface: Sustainability Targets 2020</b>
<b>14:15-15:45</b>	<b>Discussion in Groups with Coffee</b>	
<b>15:45-16:15</b>	<b>Presentation of Industry Case Results (Ford-Saal)</b>	
<b>16:15-17:05</b> <b>Parallel Session III</b>	<b>III-A (Ford-Saal): Sust SC - State of the Art</b> <i>Session Chair: Jacqueline Bloemhof</i>	<b>III-B (Generali-Saal): RevLog Models</b> <i>Session Chair: Erwin van der Laan</i>
	Pershina: Sustainability in Supply Chain: Literature Review and Methodologies	Erwin van der Laan: The Impact of Secondary Resale Markets on the Potential of Refurbishing
	Eccher et al.: Application of Simulation Modelling as the Primary Research Methodology in Sustainable Supply Chain Management: An Analysis of Literature	Kozlovskaya et al.: Producer Responsibility Regulations in Production and Recovery EOQ Inventory Model
<b>18:00-19:30</b>	<b>Aachen - Dom and Town</b> (Meeting point: Stairs in front of the city hall of Aachen)	
<b>19:30-23:00</b>	<b>Conference Dinner at the Rotating Tower Belvedere</b> (Address: Belvedereallee 5, 52070 Aachen)	

**Saturday, July 2**

9:00-9:45	<b>Scientific Keynote Thomas Spengler: Recycling of Lithium-Ion Batteries: Closing the Loop for Sustainable E-Mobility (Ford-Saal)</b>	
9:45-10:30	<b>Results PhD School &amp; Award Ceremony (Ford-Saal)</b>	
10:30-10:45	<b>Coffee Break &amp; Poster Presentation</b>	
10:45-12:25  <b>Parallel Session IV</b>	<b>IV-A (Ford-Saal): Recycling &amp; Remanufacturing</b> <i>Session Chair: Grit Walther</i>	<b>IV-B (Generali-Saal): Transportation Models</b> <i>Session Chair: Martin Hrusovsky</i>
	Jakowczyk/Neto: What Hinders Remanufacturing, How Stable Such Obstacles Are and Who Can Remove Them? Evidence from the Field	Đorđević/Krmac: Transportation and Supply Chain Sustainability: Impacts and Possible Solutions with Emphasis on Railway Transport
	Gurita/Bongaerts: Dynamic Evaluation of the Mobile Phones and Smartphones Waste Stream - Critical Metals Recycling Potential	Shabnam: Coupling Passenger and Freight Transportation in Urban Area
	Rogetzer et al.: Sustainable Sourcing of Strategic Raw Materials by Integrating Recycled Materials	Fan et al.: Transportation Mode Planning for Supply Chain Sustainability - Exploring the Application of Driverless Vehicles
	Kieckhäfer et al.: Material Flow-Based Economic Assessment of Landfill Mining Processes	Hrusovsky et al.: Intermodal Transport Planning under Travel Time Uncertainty
12:25-12:35	<b>Closing &amp; Farewell (Ford-Saal)</b>	
12:35-13:30	<b>Lunch &amp; Posters &amp; Farewell</b>	



# Abstracts



# Session I

## A: Social Aspects & Triple Bottom Line

**Friday July 1, 2016**

**9:30 – 10:45**



## Incorporating Social Aspects Towards a Sustainable Supply Chain: Trends and Future Directions

**Marta Bubicz, Ana Carvalho, Ana Paula Barbosa-Póvoa (University of Lisbon IST, Portugal)**

Competitiveness in the global markets has highly increased leading to a dramatic intensification of market pressures. Organizations are forced to improve value-added processes intimately related to the organizations' supply chains. Such situation is imposing multiple burdens on societies creating a growing awareness towards sustainability. These concerns have raised the concept of sustainable supply chains, which integrates supply chain management practices with the three pillars of sustainability. Traditionally only two pillars have been commonly taken into account at the sustainable supply chain management, being these the environmental and the economic ones.

The aim of the present research was to analyze recent publications (2008 to 2014) about sustainability in SCs, aiming to provide an integrated view that organized and systematized the prevailing concepts in the literature, with a particular emphasis on the social dimension. The results have shown various trends and patterns in the data extracted from the content analyses performed.

This study provides several suggestions for future research, highlighting the importance of the social sustainability dimension. The reason for this focus is that organizations with successful social sustainability policies and practices can bring significant benefits to their stakeholders and society, in general. We found some contradictions in several articles, which may be a reflection of the subjectivity of the analysis, or even different situations experienced in organizations, in different socio-economic and geographical contexts.

To sum up, the analysis and findings of this research point out the need for scientific publications to keep up with the growing concern of integrating sustainability in SCs, without underestimating the importance of the social dimension. This is crucial to provide a solid background in which organizations can seek support in the process of implementing the three dimensions of sustainability along their SCs.

This work is an important contribution to researchers and practitioners in their ultimate goal of achieving a sustainable supply chain.



## Social Sustainability: Exploring Organizations' Options to Increase their Social Handprint

**Bruna Mota (University of Lisbon IST, Portugal), Maria Isabel Gomes (Universidade Nova de Lisboa, Portugal), Ana Carvalho, Ana Paula Barbosa-Póvoa (University of Lisbon IST, Portugal)**

The design and planning of sustainable supply chains has revealed itself to be challenging due to the complexity of the systems and to the difficulty of defining appropriate social indicators. Furthermore, most of the research has been focused on what companies are doing wrong, which has been translated as their footprint. This work goes beyond this narrow view and proposes a framework that allows companies to explore their handprint. Specifically, it motivates their contribution to society through job creation, directly and indirectly stimulating economy. Furthermore this work explores companies' options following sustainable development objectives established by the European Commission for the 2014-2020 period: socio-economic growth and employment. The proposed framework encompasses two levels: European level, with goals of economic growth and employment; and country level, with goals of regional employment and population relocation to regions with lower population density. A multi-objective optimization model is used to support supply chain strategic and tactical decisions at both levels and applied to a European case-study of a tire supply chain. Results show how the socio-economic goals differ in terms of outcomes. Insights are attained on what should be prioritized by the governmental institutions in funding allocation decisions.





## Sustainable Biofuel Supply Chains Considering Economic, Ecologic, and Social Objectives

**Laura Elisabeth Hombach, Grit Walther (RWTH Aachen University, Germany)**

In order to ensure supply security as well as targeted emission savings within the transportation sector, the usage of fossil fuels must be reduced in the future. In the mid-term, the substitution of fossil fuels by biofuels might help to reach these goals. A switch from fossil fuels to biofuels affects simultaneously all three aspects of sustainability (economic, ecologic and social). To ensure that the positive effects of substituting fossil fuels by biofuels like GHG emission savings are not overlaid by negative sustainability impact of biofuel supply chains, like e.g. the competition with food production or land use change, political regulations must lead to sustainable biofuel supply chains. Thus, political decision maker must simultaneously combine ecologic and social aspects with economic considerations, known as the triple-bottom-line dimensions of sustainability. With regard to the ecologic aspect, biofuels have lower GHG life cycle emissions than fossil fuels. In contrary, assessed from an economic perspective the production of biofuel generates higher costs due to higher process specific costs and high investments in new production plants. Therefore, there is a trade-off between the economic and ecologic achievements of the biofuel sector. Additionally, biofuels are made from biomass that might be used for other purposes, e.g. as food, fodder, or bio-based materials in industry. Thus, there is a competition for land which can lead to unintended land use change with resulting negative social impacts, e.g. on food prices. So, the aimed-for win-win-win effect of sustainability does not necessarily result. Therefore, the conflicting triple-bottom-line dimensions have to be considered simultaneously to find political regulations leading to sustainable biofuel supply chains.

Against this background, we develop a three-objective, multi-period optimization model considering cultivation of biomass, production of biofuels, import of biofuels and biomass, as well as blending of fuels. Our aim is to identify Pareto-efficient solutions and to derive trade-off relations for political decision makers regarding profit maximization (economic), emission minimization (ecologic), and land use change minimization (social). To do so, the  $\epsilon$ -constraint method will be applied to the multi-objective optimization model.

The multi-objective optimization model will be applied to the case study of the German (bio)diesel market.



# Session I

## B: Environmental Performance of SCs

**Friday July 1, 2016**

**9:30 – 10:45**



## Assessing Environmental Performance of Extended Supply Chains: From a Literature Review to an Innovative Model

**Andrea Tuni, Athanasios Rentizelas (University of Strathclyde, UK)**

Companies are facing increasing pressures from various stakeholders to improve their environmental performance, including stricter regulations and an increased green awareness of customers. However, more than 80% of the environmental impacts in a typical supply chain can arise beyond the focal firm boundaries. Thus, metrics and performance measurement systems addressing a single tier of the network are inadequate to provide an accurate understanding of the supply chain environmental performance and a holistic approach is needed. Even more, a large variety of green supply chain performance assessment methods can be found in the relevant literature, being applicable to various supply chain depths.

This work's aim is to evaluate current developments in the field by initially presenting results of a systematic literature review on environmental performance measurement for green supply chain management (GSCM). Additionally, it provides insights on features of a new proposed method to assess environmental performance at the supply chain level, focusing on the extended supply chain and offering benchmarking capabilities.

The first part consists of a systematic review that covers publications in peer-reviewed academic journals over the last twenty years. The literature is critically reviewed according to several dimensions including environmental impacts considered, the main purpose of measurement, type of models and the extent of supply chain covered by performance measurement systems. Moreover, the benchmarking potential of various methods is assessed.

The emerging gaps in the literature highlighted in the review support the need for an innovative method to assess environmental performance of an extended supply chain, which is proposed in the second part of this work. The method focuses on a number of key characteristics, including the easiness of applicability for SMEs and an enhanced benchmarking potential.

This work therefore provides a state-of-the-art academic landscape at the intersection of performance measurement and GSCM, which can be used as a guide to understand current developments in the field and opportunities for future research directions. Moreover, it proposes a novel method that will contribute to enhanced applicability of methods to assess the environmental performance of extended supply chains.



## Does it Pay to be Green? An Empirical Examination of Customers' Role

**Chien-Ming Chen, Dixon H. Ho (Nanyang Technological University, Singapore)**

The question whether superior corporate environmental performance (CEP) is correlated with higher profitability has attracted a lot of academic attention. While numerous studies have been done in the past two decades to explore the link between CEP and profitability, the findings thus far are still inconclusive and even contradictory.

This paper attempts to contribute to this literature by examining on how a firm's customers (or corporate buyers) may influence this CEP-profitability link. Customers are critical for at least two reasons. The stakeholder theory suggests that customers are primary stakeholder groups that are influential to the development of environmental management practices. Anecdotal evidence also suggests that many supplying firms adopt beyond-compliance practices to meet customers' expectations. Moreover, customers are the source of the focal firm's revenue. Thus, customers play a substantive role at the both sides of the CEP-profitability link. However, most studies in the literature overlook customers and customers' influence in the link has not been empirically tested. It is also unclear what mechanisms can be used to explain customers' influence on the link.

To fill the above void, we draw on multiple theories from strategic management and marketing research to explain how customers' environmental stance may alter the effect pattern within this link. We assemble longitudinal data from multiple databases to gather information about financial accounting, customer segments, and environmental and social performance. The initial results confirm our hypotheses that customers' attitude may affect the CEP-profitability link.



## Antecedents and Consequences of Environmental Value Chain Management

**Teresa Krannich, Edeltraud Günther (Dresden University of Technology, Germany)**

Protecting the environment, as a part of sustainable development, is a priority topic throughout all societal areas. Therefore it is essential to consider the value chain in management decisions and additionally in corporate reporting. A comprehensive literature review shows that implementing environmental value chain management performance (EVCMP) is inevitable for companies and that companies should definitely invest in EVCMP. The central goal of this paper is to identify the influence of EVCMP on corporate financial performance (CFP) and whether it is worth for companies to invest in EVCMP. Financial performance is measured with profitability indicators such as return on assets (ROA) and return on sales (ROS). In order to measure EVCMP, a content analysis is conducted. Environmental and sustainability reports of 68 companies are considered in this content analysis and are coded with a scheme which regards all the steps of the value chain regarding Porter's value chain model. Multiple regression analysis reveals significant positive relationships between EVCMP and financial performance.



# Session II

## A: Food Supply Chains

**Friday July 1, 2016**

**11:00 – 12:15**



## **Sustainable Supply Chain of Organic and Conventional Products with Different Utilities and Shelf-Lives**

**Yaacov Ozinci, Yael Perlman and Sara Westrich (Bar Ilan University, Israel)**

We consider an agri-food retailer offering an organic version and a non-organic (conventional) version of a single type of agricultural product in the same retailing location with varying utilities and shelf lives for each product version. In addition, due to the expense of traveling to, and transporting products back from, the retailer, the consumer incurs a traveling cost that is directly influenced by the product's shelf life. We then address the retailer's option of mitigating traveling costs for the consumer by taking such steps as offering delivery services, facilitating remote purchases etc. Our findings show that, under a pricing strategy that maximizes the retailer's profit, organic products tend to have a higher price due to their higher perceived utility and product shelf lives have a strong impact on pricing and profitability. In addition, the practice of mitigating traveling costs is beneficial to the retailer but may ultimately harm consumers, causing them to pay even higher prices for the same products.



## Design of Sustainable Supply Chains: A Case in the Frozen Food Industry

**Ramin Geramianfar, Amin Chaabane (École de technologie supérieure, Canada), Jacqueline Bloemhof (Wageningen University, the Netherlands)**

To achieve a sustainable development in supply chain networks; equal consideration of three dimensions of sustainability is required. For many industrial sectors, sustainability is becoming more and more a competitive advantage. Indeed, stringent environmental legislation put prices on carbon emission and waste to reduce the environmental impacts of manufacturing, distribution and transportation. On the other hand, many consumers, nowadays, prefer to purchase their products from companies which are socially and environmentally responsible. However, in the fact of the significance of sustainability in supply chain, the related literature review suffers from the need of planning and decision making tools and methods.

The Food industry is one example where we observe more and more attention during the last years in different regions (Europe, North America and Asia). This sector consumes a lot of energy especially for product that need to be conserved for a certain time such as Fast Moving Consumers Goods (FMCG) frozen foods. In addition, as we all know these traditional supply chains are extremely associated with social structures since many players and agents (i.e. costumers at one side and farmers at the other) are involved with this system. Therefore, in this study, in order to take the right decisions while considering sustainability objectives, we propose a multi-product, multi-echelon and multi-period, planning model for managing “sustainable” supply chains. A case study of a North American Frozen Food industry is used to illustrate the applicability of the proposed model. The key contribution of this work is that it will help mangers to (i) make analysis and planning of “sustainable” supply chains, and (ii) to evaluate the supply performance based on total cost, GHG emissions, delivery efficiency and social responsibilities.

A mathematical formulation based on multi-objective optimization is proposed. The first objective minimizes the total logistic costs, whereas the second objective monitors the carbon footprint of the production-distribution system. The social pillar of sustainability is also considered as the third objective in this problem. In this objective, we aim to maximize the social responsibilities of the network by increasing the number of job opportunities created from manufacturing and transportation as well as decreasing the amount of food wastes caused at the manufacturing sites.





The emphasis of this research is much more on modelling aspects rather than on the solution methodology and experimentation. The multi-objective optimization problem is solved with  $\epsilon$ -constraint method which reveals how the supply chain performances and therefore the flow within the supply chain changes with different specifications of service level.



## **Economic and Environmental Assessment of New Perishable Dairy Products under Uncertain Price Evolution: Decision Tool Based on Multi-Objective Optimization**

**Verena Depping, Bryndis Stefánsdóttir, Martin Grunow (Technical University of Munich, Germany)**

Large amounts of energy are used every day in the food industry and in particular in the dairy sector, in which concentration and drying of powders are the most energy intensive processes. By omitting the drying process of powders and producing instead concentrates, enormous amounts of energy can be saved. However, the shelf life of concentrates is significantly lower than of powders. As raw milk costs are seasonal, powders can therefore be produced and stocked when raw milk costs are low. Furthermore, also the price evolution of the finished products is uncertain. Due to their longer shelf life, the powders allow to delay the sale until a higher price level is reached.

The goal of the present study is to determine to which extend powders can be substituted by concentrates. We develop a multi-objective optimization model to evaluate the products both from an economic and an environmental perspective. Powders and concentrates can be processed to different dry matter contents with various technology combinations (i.e. product-technology paths), which we model in detail. Environmental impacts (i.e. cumulated energy demand, greenhouse gases, eutrophication potential and acidification potential) of the different product-technology paths are determined through a life cycle assessment and used as environmental parameters in the model. The model is implemented in a rolling horizon scheme to capture the fluctuating prices of raw milk, powders, and concentrates. The applicability of the methodology is shown for a German dairy supply chain. The extent of volatility in product prices affects the economic and environmental advantage of the products, with larger fluctuations leading to a preferred choice of products with a longer shelf life.



## Session II

### B: Processes and Innovation in SustSCs

**Friday July 1, 2016**

**11:00 – 12:15**



## A Process Perspective of Sustainable Supply Chain Management and Information Technology

### U. Zeynep Ata (Boğaziçi University, Turkey)

Sustainability is an issue that is moving up the agenda of global organizations. Industry leaders are addressing sustainability challenges and re-designing their internal and supply chain operations. In this respect, information is not only one of the major drivers of supply chain performance but also information and communication technology (ICT) plays a critical role in sustainable development. ICT is essential for achieving efficient and responsive supply chains, maintaining operational accuracy, successful collaboration among partners, and performance measurement.

Specifically the role of ICT in performance of supply chain processes and relationships deserve special attention. Investments in ICT affect business processes which, in turn, affect performance. These investments are also an important enabler of organizations' collaboration capability. There is need for cooperation among partnering companies in sustainable supply chain management, and this is only possible with information technologies playing a vital role in the supply chain.

Currently, attempts at model building regarding supply chain sustainability lack incorporation of information sharing and ICT capability issues. Development of a comprehensive model where dimensions of supply chain sustainability from a process point of view are identified and operationalized will contribute to current literature. Furthermore, investigation of the role and effect of information technologies on supply chain process and sustainability performance will contribute to endeavors of achieving organizational performance excellence.



## Managing Process Innovation for Remanufacturing in a Closed-Loop Supply Chain

**Yu Xiong (Northumbria University, UK), Yu Zhou (Chongqing University, China), Marc Reimann (Northumbria University, UK; University of Graz, Austria)**

Remanufacturing is an opportunity to deliver all-round sustainability benefits. In this paper, we focus on remanufacturing at the level of the component, which can be performed by either the supplier or the manufacturer, and the supplier has the opportunity to lower the unit remanufacturing cost via process innovation. We find that, although the traditional manufacturing process accepts incremental improvement, remanufacturing requires radical innovation; in addition, inefficiency resulting from the decentralisation of decisions in the closed-loop supply chain may lead to over- or underinvestment in process innovation for remanufacturing when compared with an integrated supply chain. Our analytical results characterise the relationship between the optimal process innovation level and the optimal remanufacturing strategy. A key insight is that the remanufacturing decision induced by process innovation follows an all-or-nothing structure. This means, that there is either no remanufacturing at all (in which case there is no process innovation), or that all returned units are remanufactured. Additionally, the manufacturer may start up remanufacturing even if the supplier makes no investment in process innovation. Finally, our numerical analysis shows that letting the supplier remanufacture could be a dominant strategy from the perspective of the manufacturer.



## Product Reuse with Disruptive Innovation

**Tamer Boyaci (ESMT European School of Management and Technology, Germany), Vedat Verter, Shumail Mazahir (McGill University, Canada)**

Most of the industries such as consumer electronics are characterized with high innovation, rapid technological growth and fast product obsolescence. Innovation is distinguished into two categories (i) Sustaining innovation: where a product is improved along the traditional lines as perceived by mainstream customers; (ii) Disruptive innovation: where product improvement is brought along alternate performance attributes typically those which are not valued by the mainstream consumers. The earlier work has demonstrated that under sustaining innovation, there are diminished incentives for firms to incorporate product reusability in design or adopt product reuse as a strategy. We extend this discussion to investigate the incentives for reusability and product reuse in presence of a disruptive innovation. We model the problem as a game between an incumbent which offers a product along traditional performance attributes and may adopt reuse as a competitive strategy against an entrant which introduces a product with disruptive innovation in the market. Based on our game theoretic analysis (Nash and Stackelberg setting); we demonstrate that reusability and product reuse may deter the entry of the firm which introduces disruptive innovation in the market. Furthermore, we note that there are some prospects for the incumbent and an entrant to adopt to a cooperative strategy like acquisition and we explore the role of product reusability and reuse on these prospects. Moreover, considering disruptive innovation as a process rather than an event; we extend our model in a dynamic setting where the entrant improves the product along the traditional dimension and analyze the role of product reusability for the incumbent while developing a response strategy. Our findings offer an enhanced understanding of the role of product reuse extending beyond the conventionally held role of being only a 'sustainable' practice and present important insights to the firms and the policy makers.



## Session III

### A: Sust SC – State of the Art

**Friday July 1, 2016**

**16:15 – 17:05**



## Sustainability in Supply Chain: Literature Review and Methodologies

**Elena V. Pershina (Edinburgh Napier University, Scotland)**

Since the 1990s business conducted globally grew at a rate at least three times as high as typical domestic transactions (Bowersox, D. J Calantone, 1998). To respond to the growing internalization firms developed globally distributed supply chains and set-up their production facilities in various countries (Kusaba, Moser and Rodrigues, 2011).

Recent debates arising around the “horse-meat scandal” and “banking crisis” reveal the complexity of issues based on the supply chain: a company which is responsible for the end-product cannot be held responsible for the actions of “the supplier’s supplier” - at least in a legal perspective. However, businesses have to accept loss of customer’s trust and bad reputation. In order to avoid risk exposure and manage “supply chain risk” companies need to gain insight into the supply chain complexity. One way to answer this question was the introduction of the concept of sustainability into the body of supply chain literature.

This research project sets out to investigate the literature in the sustainable supply chain discipline. The literature is systematically reviewed and important insights into the methodologies and design of sustainable supply chain research are gained.

The contribution of this project can aid decision-makers to manage their supply chain effectively according to aspects of functionality. It also gives researchers in this topic a more concise overview of the existing body of knowledge in the sustainable supply chain literature and provides valuable insights into the methodology used when conducting research in this sphere. Additionally, further research gaps are identified and suggestions for the methodology design are made.

### References:

Bowersox, D. J Calantone, R.J., 1998. Executive insights: Global Logistics. *Journal of International Marketing*, p.83-93.

Kusaba, K., Moser, R., and Rodrigues, A.M., 2011. Low-Cost Country Sourcing Competence: A Conceptual Framework and Empirical Analysis. *Journal of Supply Chain Management*, (October), pp.73-93.

Research Project: Governance Framework for Embedding Sustainability in a Supply Chain

Supervisors: Dr. Kenny Crossan, Dr. Miles Weaver (Edinburgh Napier University)





## **Application of Simulation Modelling as the Primary Research Methodology in Sustainable Supply Chain Management: An Analysis of Literature**

**Cristiani Eccher, Barbara Minardi- Kwiatkowska, John Geraghty (Dublin City University, Ireland)**

The purpose of this literature review is to provide a deeper understanding the application of Simulation Modelling technology to issues in the Supply Chain Management. Simulation Modelling are widely applied in Industrial environments in order to evaluate performance, identify improvements, and establish the best results in Production Processes. Notwithstanding, Simulation Modelling are essential to support long term and short term decisions and understand the impact of the flow of material and information throughout the Supply Chain processes. Three questions are explored in this paper: RQ1. What Supply Chain Management research has been conduct using Simulation Modelling approaches? RQ2. What is the extent of the use of Simulation Modelling approaches in research on Sustainable Supply Chain and what is the potential for this technology?

RQ3. With respect to the question above, it was desired to determine the types of decision levels to which simulation technology has been applied i.e., Strategic, Tactical and Operational? A structured literature review was conducted to for the purpose of answering these questions and for the purpose of identifying what contributions have been made to Sustainable Supply Chain Management.



# Session III

## B: RevLog Models

**Friday July 1, 2016**

**16:15 – 17:05**



## The Impact of Secondary Resale Markets on the Potential of Refurbishing

**Erwin van der Laan (Erasmus University Rotterdam, the Netherlands)**

Manufacturers may choose to collect end-of-use products to deter cannibalization from the second-hand market or to potentially refurbish and sell them at a reduced price alongside their new products. The rise of the second-hand market for electronics online has an important impact on these decisions. In this paper, we model the pricing, collection and refurbishment decisions of an original equipment manufacturer in the electronics market in face of competition from a secondary resale market. We show that an increased competition of the second-hand market provides an additional stimulus for manufacturers to collect and refurbish their products. In particular, we show that in some settings with competition from the second-hand market, it is beneficial to collect more than strictly necessary to supply the refurbishment operations.



## Producer Responsibility Regulations in Production and Recovery EOQ Inventory Model

**Nadezhda Kozlovskaya, Nadezhda Pakhomova, Knut Richter (Saint Petersburg State University, Russia)**

In this presentation a deterministic inventory model with constant demand and return is considered. One supplier and buyers constitute the underlying supply chain. The supplier is supposed to manufacture new products, delivered to the buyers according to fixed demand. He is also capable of recovering cores, returned back by the buyers. The manufacturing and recovery processes are lot-for-lot.

The cost structure of the supplier consists of three types of costs. First, the EOQ non related cost, which is independent on the numbers of batches and batch sizes (the dismantle and assemble cost), the EOQ related cost, which depends on dynamics of the inventory, the batch sizes and numbers of batches (the holding cost), and the EOQ related cost, which depends on the numbers of batches and production scheduling (the switching cost).

This presentation is devoted to the consideration of Extended Producer Responsibility (EPR) scheme, i.e. any system or scheme set up by one or several producers to implement the EPR principle. EPR implies that producers take over the responsibility for collecting or taking back used goods and for sorting and treating for their eventual recycling. In this presentation the EPR regulation instruments such as minimum recovery target and environmental fee are analyzed by the help of above mentioned model.



## Session IV

### A: Recycling & Remanufacturing

**Saturday July 2, 2016**

**10:45 – 12:25**



## What Hinders Remanufacturing, How Stable Such Obstacles Are and Who Can Remove Them? Evidence from the Field

**Marta Jakowczyk (University of Manchester, UK), Joao Quariguasi Frota Neto (Manchester Business School, UK)**

Prior research presents barriers to the adoption of product recovery, i.e. why companies are not actively engaged in product remanufacturing, leaving open the question of what actually hinders remanufacturing. We examine the view of remanufacturers as to where the barriers to the financially viable remanufacturing operations lie. We interview twenty-two key informants from eleven companies working in the most relevant B2C and B2B sectors. This is perhaps one of the first papers to carry out such systematic examination. It is also the first to interview a large number of organisations that are already strongly engaged in product remanufacturing (as opposed to organizations asking themselves whether they should enter it). We believe that the former is fundamental to enhance our understanding, as these are organisations that have faced real rather than anticipated issues with respect to product remanufacturing. An organisation that does not engage in product remanufacturing can only speculate what the difficulties may be, whereas a remanufacturer can actually report what issues it faces in its day-to-day operations.

An attribution model is subsequently developed, based on the causal understanding of engagement in product remanufacturing, and its characterisation in terms of level of control, stability and locus. This paper explores both the sources and attributions of barriers to remanufacturing performance in order to gain more understanding on how current recovery practices are constrained by different stakeholders (sources), as perceived by organisations engaged in this industry, and to learn why they cause these obstacles (attributions).

Our interviews point to the direction that all obstacles can be assigned to stakeholders and indeed companies involved in remanufacturing face problems that result mostly from external pressure while the past literature shows that barriers to adoption of remanufacturing are internal and refer to company's attitude towards product recovery, investment and attention paid to operation efficiency. The use of attribution theory leads to new insights of not only listing the barriers but also interpreting them from the remanufacturer's perspective. It helps to examine characteristics of barriers in order to determine their possible causes. Moreover, we show the importance of the link between issues that hinder remanufacturing operations and the actions that are taken to solve them.



## Dynamic Evaluation of the Mobile Phones and Smartphones Waste Stream - Critical Metals Recycling Potential

**Nicoleta Gurita, Jan C. Bongaerts (Freiberg University of Mining and Technology, Germany)**

Over time, through incremental innovation, mobile phones and smartphones have more and more functions, not only for phone calls and messaging, but also for photography, internet, email, personal information management, synchronization etc. As a mini PC, they are indispensable for everyday life. This innovation has many consequences: a) Users replace their mobile phones and smartphones at ever shorter time intervals to benefit from the most recent attributes and features; b) Sales of these devices have grown and grow exponentially over time; c) The demand for (critical and precious) metals needed for the production of mobile phones and smartphones steadily increased and will increase; d) The increase of sales overcompensates the reduction in size of mobile and smart phones and, hence, the demand for these metals continues to increase (this phenomenon is called the miniaturization paradox); e) End-of-life mobile phones and smartphones constitute one of the fastest growing electrical and electronic equipment waste streams in the world; f) The miniaturization paradox can explain why end-of-life mobile and smartphones are easily stored at home instead of being properly recycled. For example in Germany, the collection rate is around 5%. The paper is devoted to a dynamic evaluation of the economic perspective for mobile phones and smartphones recycling with a focus on Germany. It accounts for the different growth rates of sale of mobile phones and smartphones respectively and for the differences in precious and critical metals contents. Possibilities to increase collection rates are explored. Three end-of-life management scenarios with gradually increasing collection rates will be economically evaluated. One scenario is based on the EU Waste Electrical and Electronic Equipment Directive proposed recycling and recovery rates. As a result, the present and future economic potential of recycling mobile phones and smartphones can be assessed.



## Sustainable Sourcing of Strategic Raw Materials by Integrating Recycled Materials

**Patricia Rogetzer, Lena Silbermayr, Werner Jammerneegg (WU Vienna University of Economics and Business, Austria)**

Recycling makes it possible to integrate raw materials out of steadily increasing waste streams back into production processes and at the same time contributes to a reduced dependency on imports. Considering such an alternative supply option can increase the economic, environmental and social sustainability of supply chains. Moreover, it enables resources being used more efficiently. Currently, a lot of research is done in the area of establishing technical possibilities for efficient recycling of strategically important raw materials for the electronics industry. Though, quantities resulting from recycling processes are still uncertain and therefore, demand cannot be met by this secondary source alone and the primary mining source is still needed. Nevertheless, having an alternative supply source in place enables manufacturers to reduce supply risks and increase sustainability.

In this paper, we investigate a company's sourcing decision where strategic materials can be procured from a primary raw materials supplier and from a secondary recycling source, hence taking into account new and recycled materials simultaneously. Considering uncertain prices for recycled materials, uncertain recycling quantities and uncertain demand as well as their potential dependencies we develop a single period inventory model.

We derive the order quantities for recycled and primary materials, the related costs and evaluate the effectiveness of the sourcing strategy. We provide managerial insights in the economic and environmental benefits of multiple sourcing with recycling and compare this strategy to the option without recycling. We conduct a detailed numerical sensitivity analysis on the key input parameters.

The aim of this paper is to show to what extent recycling contributes to the company's value by means of improving the supply security through a secondary sourcing option and enhancing the company's image by being more sustainable.





## Material Flow-Based Economic Assessment of Landfill Mining Processes

**Karsten Kieckhäfer, Anna Breitenstein, Thomas S. Spengler (Braunschweig Technical University, Germany)**

This contribution provides an economic assessment of alternative processes for landfill mining compared to landfill aftercare with the goal of assisting landfill operators with the decision to choose between the two alternatives. A material flow-based assessment approach is developed and applied to a landfill in Germany. In addition to landfill aftercare, six alternative landfill mining processes are considered. These range from simple approaches where most of the material is incinerated or landfilled again to sophisticated technology combinations that allow for recovering highly differentiated products such as metals, plastics, glass, recycling sand, and gravel. For the alternatives, the net present value of all relevant cash flows associated with plant installation and operation, supply, recycling, and disposal of material flows, recovery of land and landfill airspace, as well as landfill closure and aftercare is computed with an extensive sensitivity analyses. The economic performance of landfill mining processes is found to be significantly influenced by the prices of thermal treatment (waste incineration as well as refuse-derived fuels incineration plant) and recovered land or airspace. The results indicate that the simple process alternatives have the highest economic potential, which contradicts the aim of recovering most of the resources.



# Session IV

## B: Transportation Models

**Saturday July 2, 2016**

**10:45 – 12:25**



## Transportation and Supply Chain Sustainability: Impacts and Possible Solutions with Emphasis on Railway Transport

**Boban Dorđević, Evelin Krmac (University of Ljubljana, Slovenia)**

Transportation is a crucial part of supply chains. Freight transport has significant impact on the competitiveness of European economy, as well as on the quality of life of the population. The European Union uses road, rail, water and air transport in supply chains. Railway freight transport has a lower position on the transport market. The primary task of this paper is to show the connection between transport and supply chains. Quantitative analysis illustrates all adverse effects which have impact on transport sustainability. Due to the direct connection between transport and supply chains, adverse effects of transportation cause the devastation of supply chains sustainability. Each type of transportation carries advantages and disadvantages for supply chains sustainability. Accordingly, one needs to find the best possible solution for combined transport. Literature review has identified various concepts of transport combinations which aim at improving sustainability of supply chains. Finally, the paper summarizes strengths and weaknesses of European rail transport in terms of sustainability as the inevitable element of combined transport, i.e. as transport partner within supply chains.



## Coupling Passenger and Freight Transportation in Urban Area

### Najafi Shabnam (Koç University, Turkey)

Cities are locations with high level of accumulation and concentration of economic activities. They are complex spatial structures supported by transportation systems. Nowadays Urban Transportation is considered as an important subject in urban planning. It consists of passenger and freight transportation. Congestion is one of the most prevalent transport problems in large urban agglomerations. Pollution, including emissions, generated by different types of vehicles has become a serious impediment to the quality of life and even the health of urban populations.

In this work we develop a bi-objective sustainable optimization model with congestion constraint. Two objective functions in this model include: minimizing freight and passenger transportation cost and CO emission. In this model we consider freight and passenger transportation together as a new challenging framework in urban transportation area which has not considered before. We solve our model with  $\epsilon$ -constraint method in order to obtain Pareto points.

We consider cost function as our objective function and put CO emission function in constraints.

At last we compare the results of proposed integrated model with the results of separate passenger and freight transportation models. We check if there is any improvement in value of objective functions.



## Transportation Mode Planning for Supply Chain Sustainability - Exploring the Application of Driverless Vehicles

**Yingjie Fan, Frederik Schulte, Stefan Voß (University of Hamburg, Germany)**

A sustainable supply chain (SC) can be realized by adopting a proper transportation mode for a batch of products -- transportation mode planning. In addition to traditional transportation modes like transport by air, by truck, by train and by ship, more transportation modes will emerge in the next few years such as delivery with driverless vehicles. In comparison with traditional transportation modes, a driverless vehicle has following advantages: it can work day and night, even on public holidays; it works in environments which are inappropriate for human beings such as in very hot summer or very cold winter; the transportation speed of a driverless vehicle can be controlled and traced at real-time by the downstream SC partner. During the next decades, using driverless vehicles will be a complementary mode to traditional transportation modes. This is also likely to fundamentally change the business models of transport providers within a SC. Since a central control instance is an inherent element of driverless fleets, centrally coordinated vehicle sharing systems owned by specific service providers may widely replace transport vehicles owned by all kinds of SC members. The application of transportation with driverless vehicles is explored in this work. A stochastic programming model with multiple SC stages is built. By considering factors, including transportation time, transportation fee, the emission of a transportation mode, as well as potential SC operational and disruption risks, a proper transportation mode will be chosen for each batch of products in order to minimize SC costs with a low level of emissions. Demand fluctuation and possible disruptive events are also incorporated in the model. Numerical results prove that transportation mode planning will enable a flexible SC in stochastic environment with low emission levels. Managerial insights of adopting driverless vehicles for a sustainable SC are also derived from computational results.



## Intermodal Transport Planning under Travel Time Uncertainty Considering Environmental Criteria

**Martin Hrusovsky (WU Vienna University of Economics and Business, Austria), Emrah Demir (University of Technology Eindhoven, the Netherlands), Werner Jammerneegg (WU Vienna University of Economics and Business, Austria), Tom Van Woensel (University of Technology Eindhoven, the Netherlands)**

The growing road freight transport contributes to increased traffic volumes on roads that lead to congestion, disruptions, and delayed deliveries of goods and negatively influence the environment and society. As an alternative, different transport modes can be combined in intermodal transport chains in order to exploit their advantages and reduce the negative impact of transport. In order to efficiently coordinate the actors in intermodal transport chains, advanced planning algorithms are required to consider individual characteristics of each transport mode (e.g., fixed schedules, capacity) and create robust plans that minimize the risk of disruptions. Furthermore, additional objectives (e.g. environment) besides the transport costs should be considered in the planning process in order to ensure a more sustainable way of transporting goods.

In order to fulfill these requirements, we present a simulation-optimization approach for intermodal transport planning considering uncertain travel times. The proposed methodology uses an agent-based simulation to represent the transport network and transport services with variable travel times depending on different kind of disruptions. Based on the simulated travel time scenarios, the optimal transport plan for each customer is generated using a mixed-integer linear program. The transport plans are optimized according to three objectives - transport costs, time and CO<sub>2</sub>e emissions - that can have different weights. In this way different transport alternatives can be compared and then the best option can be chosen depending on the preferences of the transport planner. The costs as well as the emissions are calculated according to different models which take into account specific characteristics of each considered transport mode.

In order to test the model, a case study reflecting intermodal connections in the Central European region has been created including road, rail, and inland waterway services. Based on this case study the performance of the model for creating robust transport plans can be shown. These plans are created either before the start of the transport (offline planning) or in cases where the offline transport plan becomes infeasible during transport execution due to a disruption (online planning).



**COMMITTEE:**

**Grit Walther (RWTH Aachen University, Germany)**

**Jacqueline Bloemhof (Wageningen University, the Netherlands)**

**Ana Barbosa-Póvoa (University of Lisbon, Portugal)**

**Charles Corbett (UCLA Anderson School of Management, USA)**

**Erwin van der Laan (Erasmus University Rotterdam, the Netherlands)**