

Bearzotti, Lorena; Gonzalez, Rosa

## Conference Paper

# A Multi-Agent Based Approach for Risk Management in a Port Container Terminal

### Provided in Cooperation with:

Hamburg University of Technology (TUHH), Institute of Business Logistics and General Management

*Suggested Citation:* Bearzotti, Lorena; Gonzalez, Rosa (2014) : A Multi-Agent Based Approach for Risk Management in a Port Container Terminal, In: Kersten, Wolfgang Blecker, Thorsten Ringle, Christian M. (Ed.): Next Generation Supply Chains: Trends and Opportunities. Proceedings of the Hamburg International Conference of Logistics (HICL), Vol. 18, ISBN 978-3-7375-0339-6, epubli GmbH, Berlin, pp. 515-530

This Version is available at:

<https://hdl.handle.net/10419/209222>

### Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

### Terms of use:

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*



<https://creativecommons.org/licenses/by-sa/4.0/>

# A Multi-Agent Based Approach for Risk Management in a Port Container Terminal

Lorena Bearzotti and Rosa Gonzalez

## **Abstract**

The growth of foreign trade and globalization emphasize the weaknesses of extended supply chain in front of occurrence of disruptive events that impact differently (deviation, disruption, disaster) the normal operation, in some cases the consequences are temporary but the worst scenario is when the event produces a permanent cessation of its activities. Then the ports are a strategic actor because if they have problems with their operations the others in the supply chain will be affected negatively, so the ports resilience determines the level of resilience of multiple supply chain in which they participate.

Because of this it is necessary to have tools that provide support to the process of risk management in order to have proactive and reactive, responses to the different disruption events that may occur in its operation. In this paper a multi-agent approach to risk management in container terminal is presented.

**Keywords:** risk management, event management, multi-agent system, container port terminal

## 1. Introduction

The transfer and storage of containers at port terminals has been growing in recent years. This situation has forced the port terminals have information systems with the goal of to improve the functioning, efficiency and level of customer service. This is achieved through a combined effort of all actors involved in the operations of a port terminal.

The study to improve the operations of a port terminal is necessary because it is a key node in multiple global supply chains, so any problems in the port may affect related organizations. The port terminals are essential in the country import and export processes. Ports are interfaces between different modes of transport and are typically combined transport centers where the products are manipulated, manufactured and distributed. An efficient port requires not only infrastructure, superstructure and proper equipment, but also good communications and a dedicated management team, qualified and motivated and trained workforce.

The container port terminals have a key place called "container yard" where the containers are temporary stored, so their administrators perform research and analysis aimed at improving its management.

In the yard management one of the problems to be addressed is the risks and disruptive events management. The risk and event management permit to analyze and understand the origin and consequences of disruptive events, as well as determine the answers that are provided against its occurrence. The ability of a system to respond to a disruptive event without losing their ability to function is known under the concept of resilience. (Mansouri, 2009; Sanchis, 2011). The event management is defined as the component of the systems management container terminal that reduces the gap between planning and execution, with the objective of minimizing the impact of an event on a plan that is running. (Bearzotti, 2012).

This paper presents a proposal for risk managing in the container yard of a port terminal. This proposal consists of a multi-agent focused on the analysis of

disruptive events and the generation of actions to reduce the impact of the event model. The paper is organized as follows, in the next section the problem description and review of the literature was performed. The proposed model is presented in section 3, while a case study is developed in Section 4. Conclusions and future work are presented in Section 5.

## **2. The Risk Management Problem in a Container Terminal**

### **2.1 The Risk and Event Management Problem**

Risk management is the identification, assessment and prioritization of risk after that the risk management includes the coordination and economical application of resources to minimize, monitor and control the probability and/or impact of disruptive events.

Risk can come from uncertainty, natural causes, social causes, procedures, etc. The risk management goal is reducing the vulnerability and ensuring continuity.

The event management is understood as the component of risk management to reduce the gap between planning and execution systems in order to minimize the impact of an exception or deviation from a current plan allowing in turn the visibility and agility with a consequent resilient (Bearzotti, 2012, 2013). The event management is the activity in risk management process where the actions are analyzed when a risk is a certainty.

### **2.2 Risk and Event Management in a Container Yard**

The port is a convergence point; today is a major node of convergence in international transport and trade, and it is the point of contact between land and sea transport. It needs to improve their process in terms of its agility and ability to respond to unforeseen events. For this, a system that can respond to changes and disruptions in the port terminal is very necessary tool to enhance resilience in the port.

The Container Port Terminal has three principal areas: Quay, Yard and Gate. These areas are related and if one of them has a problem may impact the others. But the Yard is the key element because a bad management in the Yard will be bad operations in Quay and Gate.

One of the main functions of a container terminal is the container transfer to and from ships at Quay. On the other hand the Yard also is related to the Gate giving and receiving containers either by truck or by train. For these operations, the Yard has resources that are used in function-oriented storage and movement of containers in the terminal planning.

In an ideal situation, the plans are executed without problem, but there is variability in the execution. Disruptive events cause deviations in the plan execution and in the expected result.

It is essential in the yard operation that plan will be with slack to handle events that occur in the plan execution. If the slack is used then the event consequences are minimized.

An event management system in the container yard seeks to mitigate the impact of disruptive events using slacks current plans, thus avoiding re-planning. An event management system can generate improvements in the administration of the yard and its relation to the Quay and the Gate.

## **2.3 Related Work**

In this section the related work are presented, specifically to yard event management systems there is not many related work. There are papers related in the monitor and control area.

Gronalt et. al. (2008) present an study about risk in a container terminal. They propose a risk evaluation with three steps: 1) terminal description (internal factors, network factors and environment conditions); 2) risk identification and classification; 3) for each risk, to determine risk consequences. After that a vulnerability analysis is made.

Loh and Thai (2012) indicate the port role in the supply chain. They do an analysis related with the port risks and propose a holistic management model.

Najib et. al., (2013) propose a process for managing risks related to containers on drugs suspicion, establishing a set of rules for inspection. It proposes a framework for multi-agent systems focused on high-risk containers.

MOCONT (Monitoring the Yard in Container Terminals) (Bozzo et. al., 2001), is a monitoring and control system for a container port terminal. This system uses GPS with sensors to monitor container movements and their position. There are three modules: Location Module, Visual Identification Module and Synchronization and Communication Module.

Ngai et. al. (2011) propose a study case for the prototype: ICADSS (Intelligent Context-Aware Decision Support System), to monitor in real time the operations in the Hong Kong container terminal. This system uses a sensors network USN (Ubiquitous Sensor Network).

Zeng et. al. (2011) propose a mathematical model for events in Quay. First, the Berth Allocation Problem (BAP) is presented. After a disruption management is described.

Bearzotti et al., (2012) present an approach for supply chain event management. This work is focused in the mitigation of events in supply chain.

### **3. A Multi-agent Model for Event Management in a Container Yard**

In this section a yard container port terminal event management multi-agent conceptual model is presented YEMS (Yard Event Management System). The PASSI methodology (Cossentino, 2003) is used in the model description.

The YEMS model has six agents: EIA (Execution Interface Agent), PIA (Planification Interface Agent), SEMA (Space Event Management Agent), REMA (Resource Event Management Agent), Resource Agent and RE (Relations with the exterior).

The PIA and EIA agents have the function of to interact with the planning system and execution system. The SEMA and REMA agents manage the events related with space and resources. The agent Resource represents the

resources in the Yard, its function is coordinating the tasks with the SEMA and REMA agents. RE agent is related with the Quay and the Gate to collaborate in the event management.

The next sections the different agents are presented and how they are related.

### 3.1 A Conceptual Model for Event Management

YEMS interact with the event management system in Quay and Gate, this is important when a disruptive event affect the terminal. In the Figure 1 the different subsystem are presented. In other hand YEMS is related with the planning and execution systems. There are agents specialized in these interrelationship.

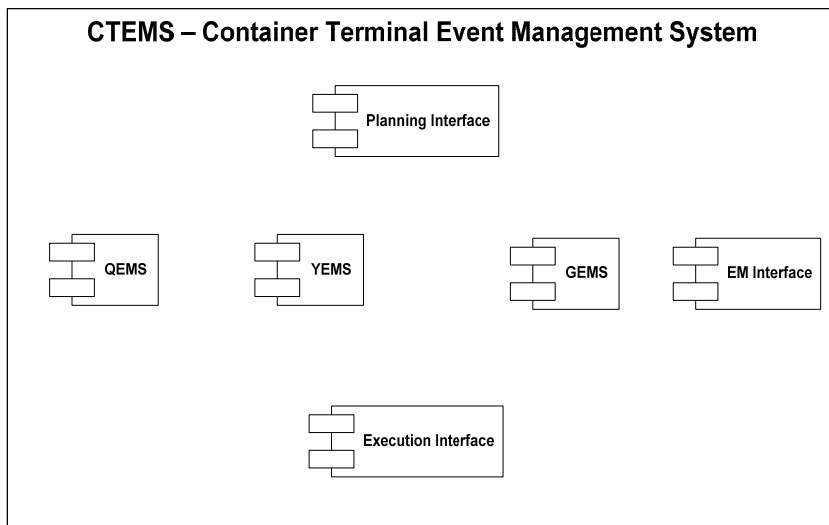


Fig. 1: Container Terminal Event Management System - Subsystems

The YEMS receives the plan from Planning System and the events from the Execution System. When a disruptive event can not solve in the quay or gate, the event management in these subsystems sends a call for participation to YEMS.

### 3.2 Agent PIA

This agent performs the task communication between YEMS and planning level. Get updates and planning and communicating if an exception occurs. Upon receipt of planning makes the difference between planning and resource spaces, initializing the amount of resources that should be considered in the YEMS. PIA sends schedules to respective agents (Resource agent and SEMMA agent).

Use Case	Description
Receive Plan	Plan related with resources and spaces from Planning System, with this information it sends the information to SEMA agent and to Resource Agent.
Inform Exception	Send an exception message to planning system when a disruptive event cannot solved.
Consult	Consult if there is a change in the plan

Tab. 1: PIA Uses Case.

### 3.3 Agent Resource

This agent represents each resource within the yard and manages tasks. It contributes to cooperation and works with other agents. Check availability for additional tasks and delivery proposals for performing tasks. This agent contains two lists, a list of the tasks set by planning to have the first priority to be executed and a second list of tasks requested from other resources, which have made a second priority. These last recourse is performed only when the time available to perform them, that is, when not performing a task from the list of first priority.



---

Uses Case	Description
Check availability of resource	Review each resource and check availability for extra task.
Check task list	Check the task list searching for time to do an extra task.
Assign task	If there is availability, a task is assigned to the resource.
Enter resource	This UC register the information about the resources.

---

Tab. 2: Agent Resource Uses Case.

### 3.4 Agent SEMA

This agent manages the spaces within the yard. Get and set space planning and which are available. This manager check availability of spaces and allocating containers involved in an event. Also it participates in the cooperative when it comes to an external event. In the latter case provides alternative spaces according to features delivered by the request for cooperation. Also makes a negotiation with the resource agents when trying to coordinate a task either, mobilizing, positioning or removing a container. Finally a proposed solution delivery if they reach a settlement proposal or an exception if the search is negative spaces available.

Uses Case	Description
Receive Event Space	The Agent EIA notifies about an event related with the space in the yard.
Manage Space Event	With the information, the agent begins the process to find an action plan.
Check space availability	This UC finds spaces in the yard.
Assign space to container	This UC register the information about the container in the available space.
Send proposed solution	Notify to EIA the new plan.
Send exception	If there is not solution, it sends the information about the exception to PIA agent.
Manage external event	Receive information. Consult space availability and inform propose to RE agent.
Initialize spaces	Receive planning information. Set availability of spaces.
Coordinate Task	Coordinate task of moving and positioning with resource agents.

Tab. 3: Agent SEMA Uses Case.

### 3.5 Agent REMA

This agent manages the resource events. Get the event and consulting resource availability of a resource agent to perform additional tasks, thus distributing the tasks of the affected resource among other resources. If negotiations are successful make a settlement proposal and sends it to EIA agent, otherwise make an exception and sends it to the PIA and EIA agents.

---

Uses Case	Description
Receive Resource Event	The Agent EIA notifies about an event related with the resource in the yard.
Manage Resource Event	With the information, the agent begins the process to find an action plan.
Check resource availability	This UC finds resources available in the yard.
Assign space to container	This UC register the information about the container in the available space.
Send proposed solution	If a solution exists notify action plan.
Send exception	If there is not solution, it sends the information about the exception to PIA agent.

---

Tab. 4: Agent REMA Uses Case.

### 3.6 Agent RE

This agent is responsible for communication with the external actor (or Quay Gate) when requested cooperation to resolve an event that occurred in its domain. Receives the request and determines whether cooperation is a request

for space, or resource allocation. For the first two sends an availability check to the respective agents (SEMA or Resource) in the case of an application for allocation refers to the allocation request either one or more spaces or containers of a task to one or more resources. This allocation request may be a response to Quay Gate or a proposal previously submitted by YEMS space before the application or resource.

Uses Case	Description
Receive Request	Quay or Gate sends a request.
Send Request	Send the request to SEMA or REMA
Order Allocation	Request allocation of spaces or tasks to a resource. This action is in response to the proposal previously submitted by this agent to the request for cooperation from the outside.
Send proposals	Receive proposals from the SEMA agents and REMA and then sent to external stakeholders.

Tab. 5: Agent RE Uses Case.

### 3.7 Agent EIA

The agent in charge of receiving events from the monitoring system and communicate them to the corresponding agents is. Also manages the congestion event, negotiating with external actor Gate entrance dwell time of containers (or trucks) yard to thereby relieve it.

Uses Case	Description
Receive Event	Get captured by the monitoring system event. The YEMS consults to establish what type of event it is. It requests a data update to PIA agent.
Notify Event	Send the request to SEMA or REMA
Congestion Management	If the data indicate that the event is an event of congestion, then this use case takes over. According to a set time of "backwardness" of operations in patio, sends a request to terminate the entry of vehicles through the Gate of the use case Send request time, for a period equal to time set as "backwardness."
Analyze time proposals	Analyze the answer sends from Gate for the extra time.
Notify action plan	Notify the answer plan to execution system

Tab. 6: Agent EIA Uses Case.

#### **4. Study Case: San Antonio Port**

This preliminary model has been tested with information from the container port terminal in San Antonio Port. Some events were simulated and the behavior of model analyzed. Yard port terminal operations planning and execution was developed. This scenario consists of a window of 40 hours of operation of the terminal. It has created a planning yard detailed spaces and resources with their respective missions to store and mobilize import containers and export terminal. It considered the arrival and departure of six ships with the respective containers to be unloaded and loaded at these for this schedule.

After establishing the overall planning, involving the shipping planning, yard planning and spaces, we proceeded to simulate the execution of operations to carry out the provisions of this general planning. For the simulation of the execution of operations Monte Carlo simulation was used to establish statistical distributions among other things, the arrival times of containers between the Gate, service times by Reachstackers container, the working times of Gantry cranes (on the Quay), and so on, always under the care of these details were as representative of the reality of a terminal of its kind. And then the simulation was done considering various events. In the event presentation pre and post-event state is detailed, highlighting the main changes resulting from the implementation of the action plans offered by the YEMS.

#### **5. Conclusion and Future Work**

In this paper the risk and event management problem in the port terminal container yard is presented and a model is obtained. In the Supply Chain, a port terminal is a strategic actor which converge multiple global supply chain. Because of this is important propose a solution to the risk and event management in this domain. The events impact in a terminal can cause considerable losses and impact on other actors in the global supply chain. It arises is why the interest in having information systems that enable the

management of disruptive events within a port terminal. This model emerges as a precedent in the development of a software solution that is able to provide timely and effective plans deviations answers.

A multi-agent called YEMS model has been developed under the PASSI methodology. This multi-agent model was designed to manage internal events (resources, space and congestion) and external events generated in the Quay Gate and subsystems. The main agents are: EIA (this agent is the interface between YEMS and Execution System, it receives the disruptive events and notifies the plan changes), PIA (it is the interface with Planning Systems; it receives the plan and notifies the exceptions), SEMA (it manages the space on yard events, also it participates in the coordination process when an external event is received), REMA (it is similar to SEMA but it has to manage events related with resources), Resources (this agent represents the resources in the yard, there will be an resource agent by each resource considered in the plan) and RE (the relationship with the other sub-system is carried out by this agent). This model offers the first action oriented in the disruptive event mitigation process.

The future works include the model implementation and the model validation with a study where the proposal will work with real events in a simulated environment in first place. In the future and with the alliance with a port terminal the information system will be test in a real environment.

Another future work is developing the risk and event management in the gate and quay, and the three model integration.

## References

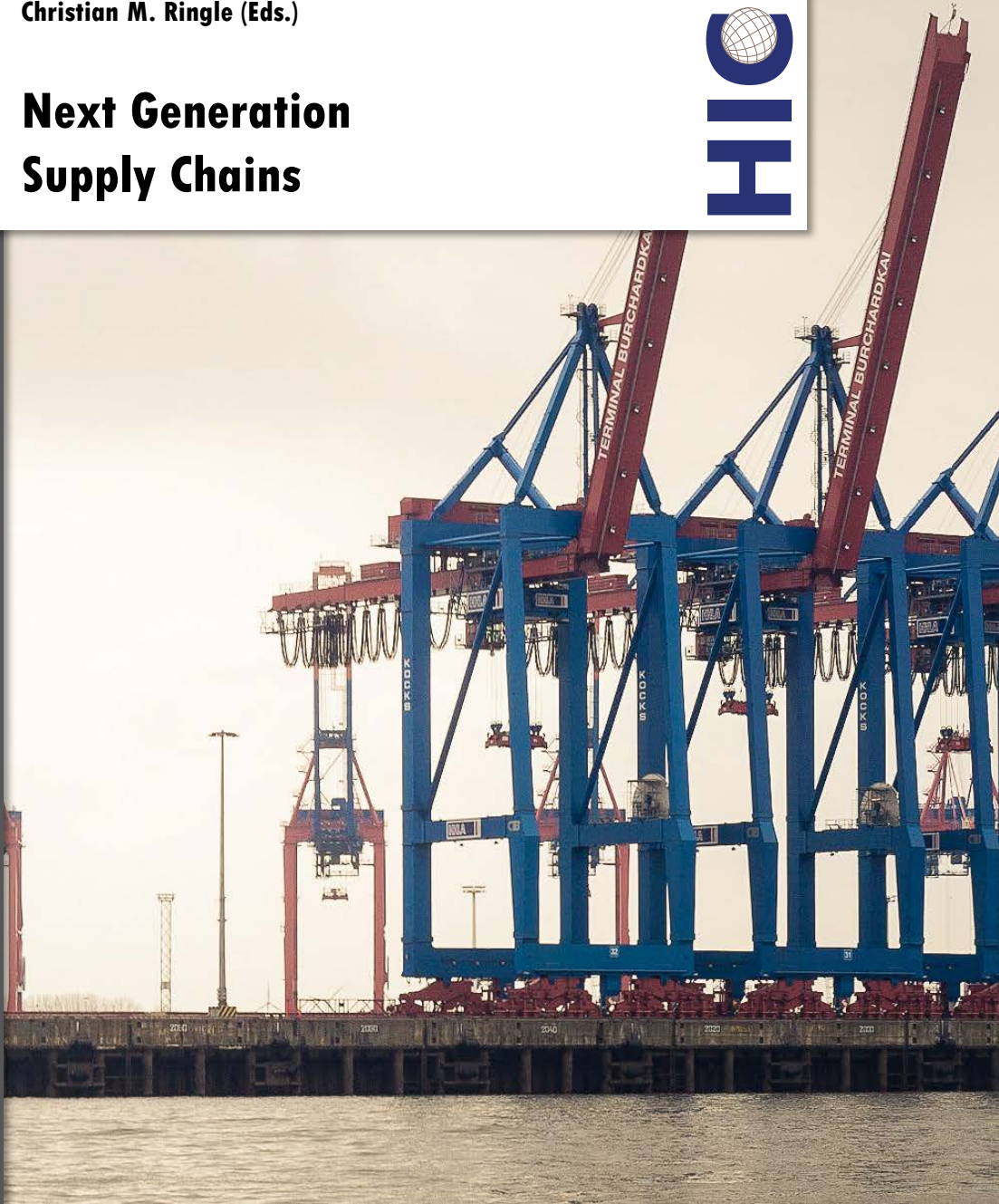
- Bearzotti, Lorena A.; Salomone, E.; Chiotti, O. 2012. An autonomus multi-agent approach to supply chain event management. *International Journal of Production Economics*. September 2011, ISSN 0925-5273.
- Bearzotti, Lorena A.; Gonzalez-Ramirez, Rosa; Miranda González, Pablo (2013). The Event Management Problem in a Container Terminal. *Journal of Applied Research and Technology*, Vol. 11, February 2013.
- Bozzo, Riccardo; Derito, Andrea; Nurchi, Renzo (2001). MOCONT: a new system for container terminals monitoring and control. *IEEE Intelligent Transportation System Conference Proceedings*. Oakland, USA. August, 2001.
- Cossentino, Massimo; Sabatucci, Luca (2003). *Modeling Notation Source - PASSI*. 2003 Foundation for Intelligent Physical Agents.
- Gronalt, Manfred; Häuslmayer, Hans; Jammerneegg, Werner; Schindlbacher, Edith; Weishäupl, Monika, (2008). A risk assessment approach for inland container terminals. *11th International Workshop on Harbor, Maritime Multimodal Logistics Modeling Simulation*, Campora S. Giovanni, 17-19 September.
- Heneseey, Lawrence E. (2006). *Multi-Agent Systems for Container Terminal Management*. Phd Thesis.
- Kleindorfer, P. R.; Saad, G. H. (2005). *Managing Disruption Risks in Supply Chains*. *Production and Operations Management Society*. Vol. 14, No. 1, Spring 2005, pp. 53–68.
- Lavastre, O.; Gunasekaran, A.; Spalanzani, A. (2011). *Supply Chain Risk Management in French Companies*. *Decision Support Systems*, Volume 52, Issue 4, March 2012, Pages 828-838, ISSN 0167-9236.
- Liu Yan; Takakuwa, Soemon. (2011). Modeling the material handling in a container terminal using electronic real-time tracking data. *Proceedings of the 2011 Winter Simulation Conference*.
- Loh, Hui Shan; Thai, Vinh V., (2012). The Role of Ports in Supply Chain Disruption Management. *Proceedings of the International Forum on Shipping, Ports and Airports (IFPSA) 2012: Transport Logistics for Sustainable Growth at a New Level*, pp 325-340.
- Mansouri, Mo; Mostashari, Ali; Nilchiani, Roshanak (2009). A decision analysis framework for resilience strategies in maritime systems.
- Najib, Mehdi; Boukachour, Jaquad; El Fazziki, Abdelaziz, (2013). A multi agent framework for risk management in container terminal: suspect containers targeting. *International Journal of Computer Science and Applications*, Vol. 10, No. 2, pp, 33 – 52, 2013.



- Ngai, E.W.T; Li, Chung-Lun; Cheng, T.C.E; Venus Lun, Y.H; Lai, Kee-Hung; Cao, Jiannong; Lee, M.C.M; (2011). Design and development of an intelligent context-aware decision support system for real-time monitoring of container terminal operations. *International Journal of Production Research*. Vol. 49, No. 12, 15 June 2011, 3501–3526
- Sanchis, Raquel; Poler, Raúl (2011). Medición de la resiliencia empresarial ante eventos disruptivos. Una revisión del estado del Arte. 5th International Conference on Industrial Engineering and Industrial Management. XV Congreso de Ingeniería de Organización. Cartagena, 7 a 9 de Septiembre de 2011.
- Steenken, D.; Vob, S.; Stahlbock, R. (2004). Container terminal operation and operations research – a classification and literature review. *OR Spectrum*, 2004.
- Thurston, T.; Hu, H. (2002). Distributed Agent Architecture for Port Automation. 26th International Computer Software and Applications Conference (COMPSAC 2002), Oxford, UK, 2002.
- Zeng, Qingcheng; Hu, Ziangpei; Wnag, WenJuan; Fang, Yan, (2011). Disruption management model and its algorithms for berth allocation problem in container terminals. *International Journal of Innovative Computing, Information and Control*. Vol. 7, Number 5(B), pp. 2763-2773, May 2011.

**Wolfgang Kersten, Thorsten Blecker and  
Christian M. Ringle (Eds.)**

# **Next Generation Supply Chains**



Prof. Dr. Dr. h. c. Wolfgang Kersten  
Prof. Dr. Thorsten Blecker  
Prof. Dr. Christian M. Ringle  
*(Editors)*

# **Next Generation Supply Chains**

Trends and Opportunities

Edition 1<sup>st</sup> pdf edition, August 2014  
Publisher epubli GmbH, Berlin, [www.epubli.de](http://www.epubli.de)  
Editors Wolfgang Kersten, Thorsten Blecker and Christian M. Ringle

Coverdesign Frederik Duchâteau, Moritz Petersen  
Coverphoto Viktor Rosenfeld / [flic.kr/p/e7ujk3](https://www.flickr.com/photos/7ujk3/) (CC BY-SA 2.0)

ISBN 978-3-7375-0339-6

Copyright:

This book are licensed under the Creative Common Attribution-ShareAlike 4.0 International License.

This book can be downloaded at HICL ([hicl.org](http://hicl.org)) or at the TUBdok – Publication Server of the Hamburg University of Technology ([doku.b.tu-harburg.de](http://doku.b.tu-harburg.de)) –

ISBN: 978-3-7375-0339-6

A printed version of this is available in your library or book store –

ISBN 978-3-8442-9879-6

An alternate version for your ebook reader is available through online ebook stores – ISBN: 978-3-7375-0340-2

## Preface

Today's business environment is undergoing significant changes. Demand patterns constantly claim for greener products from more sustainable supply chains. Handling these customer needs, embedded in a sophisticated and complex supply chain environment, are putting the players under a constant pressure: Ecological and social issues arise additionally to challenges like technology management and efficiency enhancement. Concurrently each of these holds incredible opportunities to separate from competitors, yet also increases chain complexity and risks.

This book addresses the hot spots of discussion for future supply chain solutions. It contains manuscripts by international authors providing comprehensive insights into topics like sustainability, supply chain risk management and provides future outlooks to the field of supply chain management. All manuscripts contribute to theory development and verification in their respective area of research.

We would like to thank the authors for their excellent contributions, which advance the logistics research progress. Without their support and hard work, the creation of this volume would not have been possible. We would also like to thank Sara Kheiravar, Tabea Tressin, Matthias Ehni and Niels Hackius for their efforts to prepare, structure and finalize this book.

Hamburg, August 2014

Prof. Dr. Dr. h. c. Wolfgang Kersten  
Prof. Dr. Thorsten Blecker  
Prof. Dr. Christian Ringle

# Table of Contents

## **I. A Look Into the Future - Opportunities and Threats**

Identification of Megatrends Affecting Complexity in Logistics Systems.....3

*Wolfgang Kersten, Birgit von See and Henning Skirde*

Planning Approach for Robust Manufacturing Footprint Decisions .....29

*Philipp Sprenger, Matthias Parlings and Tobias Hegmanns*

Future Problems in Logistics Due to Demographic Change .....51

*Matthias Klumpp, Sascha Bioly and Christian Witte*

Logistics Trends 2020: A National Delphi Study Concerning the German  
Logistics Sector .....69

*Stephan Zelewski, Alessa Münchow-Küster and René Föhring*

Vision of a Service Value Network in Maritime Container Logistics.....87

*Jürgen W. Böse, Carlos Jahn and Raman Sarin*

## **II. Sustainability Efforts Within the Supply Chain**

Logistics Performance Measurement for Sustainability in the Fast Fashion  
Industry.....113

*Anna Corinna Cagliano, Muhammad Salman Mustafa, Carlo Rafele and  
Giovanni Zenezini*

Design of Sustainable Transportation Networks.....137

*Wendelin Gross and Christian Butz*

Exploring Sustainability in Construction Supply Chains.....161

*Margherita Pero, Eleonora Bottani and Barbara Bigliardi*

## Table of Contents

---

Is Money Really Green? - An Investigation Into Environmental Supply Chain Practices, with a Cost Focus .....183

*John Bancroft*

Relevant Purchase Criteria or Basic Requirement: Customer Perspectives on Green Logistics ..... 195

*Matthias Klumpp, Julia Naskrent and Nikolaus A. D. Hohl*

Information Systems and Reverse Logistics: Examining Drivers of Implementation on Multiple Case Study Scenario .....211

*Josip Maric, Florence Rodhain and Yves Barlette*

Analysing the Role of Rail in Urban Freight Distribution .....223

*Katrien De Langhe*

Truck Loading Dock Process – Investigating Integration of Sustainability .....245

*Niels Hackius and Wolfgang Kersten*

How to Attract Air Freight Business: Defining Critical Success Factors for Regional Airports .....273

*David M. Herold, Simon Wilde and Natalie Wojtarowicz*

Early Supplier Integration in Cast Product Development Partnerships – A Multiple Case Study of Environmental and Cost Effects in the German Foundry Value Chain .....289

*Robert Christian Fandl, Tobias Held and Wolfgang Kersten*

Sustainable Logistic Scenarios in the NSR Region .....311

*Jacob Kronbak, Angela Münch, Liping Jiang and Lisbeth Brøde Jepsen*

### **III. Handling Risk - Concepts Towards Robust SCM**

A Service Production Planning Model Integrating Human Risk Factors .....345

*Nguyen Vi Cao and Emmanuel Fragniere*

How to Cope with Uncertainty in Supply Chains? - Conceptual Framework for Agility, Robustness, Resilience, Continuity and Anti-Fragility in Supply Chains .....361  
*Immanuel Zitzmann*

Flexible Supply Chain Design under Stochastic Catastrophic Risks .....379  
*Yingjie Fan, Frank Schwartz and Stefan Voß*

A Risk Management Approach for the Pre-Series Logistics in Production Ramp-Up .....407  
*Patrick Filla and Katja Klingebiel*

The Imbalance of Supply Risk and Risk Management Activities in Supply Chains: Developing Metrics to Enable Network Analysis in the Context of Supply Chain Risk Management .....423  
*Christian Zuber, Hans-Christian Pfohl and Ulrich Berbner*

Risk Assessment in Managing the Blood Supply Chain .....447  
*Phongchai Jittamai and Wijai Boonyanusith*

Supply Chain Risk Management in International Trade Operations Between Germany and Brazil .....469  
*Meike Schroeder and Renato Barata Gomes*

The Forest Supply Chain Management: An Entropic Perspective .....487  
*Tarik Saikouk, Ismail Badraoui and Alain Spalanzani*

A Multi-Agent Based Approach for Risk Management in a Port Container Terminal .....515  
*Lorena Bearzotti and Rosa Gonzalez*

**Authors** ..... XI



## **About HICL**

Since 2006 the annual conference Hamburg International Conference of Logistics (HICL) at Hamburg University of Technology (TUHH) is dedicated to facilitate the exchange of ideas and contribute to the improved understanding and practice of Logistics and SCM. HICL creates a creative environment which attracts researchers, practitioners, and industry thinkers from all around the world.



Innovation is increasingly considered as an enabler of business competitive advantage. More and more organizations focus on satisfying their consumer's demand of innovative and qualitative products and services by applying both technology-supported and non technology-supported innovative methods in their supply chain practices. Due to its very characteristic i.e. novelty, innovation is double-edged sword; capturing value from innovative methods in supply chain practices has been one of the important topics among practitioners as well as researchers of the field.

This volume, edited by Thorsten Blecker, Wolfgang Kersten and Christian Ringle, provides valuable insights into:

- Innovative and technology-based solutions
- Supply chain security management
- Cooperation and performance practices in supply chain management

ISBN: 978-3-7375-0339-6