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Risk Assessment in Managing the Blood Supply Chain

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Risk Assessment in Managing the Blood Supply Chain

Phongchai Jittamai and Wijai Boonyanusith

Abstract

Blood supply chain system involves blood collection, processing, inventory management, and distribution in the network. Blood has its unique characteristics that make its supply chain to be more complex and dynamic than the traditional one. Most research in the blood supply chain management focuses on logistics and practices in operation. However, there is a lack in the study of risk management in this aspect. Supply Chain Risk Management is a new paradigm in the blood supply chain, which can be explored further to manage risks in the complex and dynamic supply and demand networks. A hierarchy based model of supply chain risks was applied as a conceptual research framework to classify risks into four sub-chains; namely, physical, financial, informational, and relational sub-chains. Empirical data were collected by group brainstorming with experts and practitioners as well as by information audits in order to identify risks in the blood supply chain context. Risk assessment was conducted based on two angles, the likelihood of occurrences and the consequences. A summary risk score was calculated for each risk to analyze the values of the risk. Results of risk assessment were presented in a risk matrix to represent the impact of risks in the blood supply chain. This evaluation supports practitioners to prioritize issues in the blood logistics management in order to identify risk management strategies. The contribution of this research is discussed in order to arrive at an innovative and more effective approach to cope with risks and uncertainties in the blood supply chain management.

Keywords: risk, risk assessment, risk management, blood supply chain

1. Introduction

Risk management has become a critical component of supply chain management. Supply Chain Risk Management is a strategic imperative approach to support complex challenges in the global business. Nowadays, extant research has focused on identifying sources of uncertainty and the risk deriving from them. Risk identification consists of quantifying risks and assessment. This information can be used to derive risk management strategies in the supply chain.

Blood supply chain system involves blood collection, processing, inventory management, and distribution in the network. Demand in the blood usage caused by the illness of human, which cannot be controlled. Blood supply acquires from donors who have willingness to donate. Uncertainties in blood demand and supply are unavoidable. Blood has an expiration date, which is usually within a short period of time after acquiring. Moreover, the needs for blood occur unpredictably and uncontrollably. These aforementioned characteristics make blood supply chain to be more complex and dynamic than the traditional one. Thus, it is essential to study for a well-managed approach in order to utilize blood to its maximum benefit, which is the key performance indicator of the blood supply chain.

Most research in the blood supply chain management focuses on logistics and practices in operation. However, there is a lack in the study of risk management in this aspect. Supply Chain Risk Management is a new paradigm in the blood supply chain, which can be explored further to manage risks and uncertainties in the supply and the demand networks. The type of risks in the blood supply chain can be classified by the primary flows of the traditional supply chain; physical, financial, informational, and relational flows. This framework can be used to identify and assess risks in order to better represent the overall blood supply chain risk perspective.

Blood shortage and blood outdated are two main uncertainties that affect the whole supply chain the most. Shortage occurs when there is insufficient of

blood in the inventory to response to high demands. It may lead to the lack of enough blood for treatments. Outdating happens when available blood cannot be utilized and expired. Disposal cost is required to get rid of expired blood (Boonyanusith and Jittamai, 2013). These uncertainties can be defined as the impacts in the blood supply chain and their risks can be evaluated in order to manage and utilize the whole supply chain effectively. Thus, this study aims to assess risks in managing the blood supply chain in order to prioritize risk management issues for practitioners in the network.

2. Literature review

2.1 Risk definition

It has been challenging to demonstrate a definition for the term of 'risk' for both academics and practitioners for many years. There are probably many definitions from authors on each theme (Ritchie and Marshall, 1993). The reason for this variety of definitions indicates different academic and professional disciplines in the specific backgrounds, decision contexts and problems. Sitkin and Pablo (1992) had defined risk as being 'the extent to which there is uncertainty about whether potentially significant and/or disappointing outcomes of decisions will be realized'. In the supply chain context, Zsidsin (2003) had described risk as 'the potential occurrence of an incident or failure to seize opportunities with inbound supply in which its outcomes result in a financial loss for the firm'. March and Shapira (1987) had defined it as 'a variation in the distribution of possible supply chain outcomes, their likelihood, and their subjective values'. According to these definitions, a risk is a potential failure of flows between the components of the supply chain. This variability can possibly affect the flows of information, materials, and money in the supply chain network.

2.2 Risk components

Risk comprises three components (MacCrimmon and Wehrung, 1988). These three components must be readily identifiable and measurable, leading to formulaic and precise resolution. The risk components are briefly described as follows.

2.2.1 Likelihood of occurrence

The likelihood of occurrence or probability of a particular event or outcome can be expressed in objective terms or in subjective terms, each being capable to measure. Objective measurement relies on previous accounts of the occurrence of such events. Subjective assessment of the likelihood of occurrence relies on the translation of previous experience. Practically, it is probable to apply subjective judgments on any objective data.

2.2.2 Consequences

The consequences of the particular event or outcome occurring are usually expressed as a multiple of simultaneous outcomes, many of which interact with one another.

2.2.3 Exposure

The exposure or causal pathway leading to the event has an important implication for risk management. Understanding the nature, sources and causes of factors that generate the events, which might influence the type and scale of consequences and the likelihood of occurrences are fundamental requirements for effective risk management.

2.3 Supply chain risk management

Supply Chain Risk Management (SCRM) represents a more proactive approach to manage risks in the supply chain in order to avoid potential unexpected consequences (Ritchie and Brindley, 2009). The main components of SCRM would incorporate the following clusters of activities as below.

2.3.1 Risk identification and modeling

This activity aims to identify the sources and characteristics of risks, what may trigger them and the relationship to the supply chain performance in terms of effectiveness and efficiency.

2.3.2 Risk analysis, assessment, and impact measurement

It is an analysis of the values of the risk by the likelihood of occurrence and potential consequences assessment.

2.3.3 Risk management

Risk management proposes the considering alternative solutions, judging their respective merits, selecting solutions and undertaking the implementation.

2.3.4 Risk monitoring and evaluation

It aims to monitor, control, and manage solutions, and assess their impact on business performance outcomes.

2.3.5 Organizational and personal learning

It is knowledge, experiences, and lessons transferring among members within the organization and its associated supply chain members.

2.4 Blood supply chain management

Blood supply chain comprises of logistics activities, which affiliate links between nodes within the network including blood donors, blood centers, blood banks in hospitals, and patients (Pierskalla, 2004). Blood supply can be collected from a single source, only voluntary human (Chapman, Hyam and Hick, 2004). Blood collection and production are main functions of blood centers, which are located in different regions. Blood processing is to detect blood screening and to determine blood group and type of such primary resource. This process also includes the separation of blood components to produce other blood products. These products are stored in the inventory of blood centers. Then, blood

centers allocate and distribute blood products to various hospitals in the network by proper transportation (Williamson and Devine, 2013). Blood bank has a main responsibility in managing blood products within the hospital. It performs logistics activities as inventory tasks related to the acquisition and requisition of blood. Blood products must be reserved by doctors and cross-matched in preparation before usage. Blood also needs to be warmed to adjust temperature before transfusion to patients (Jennings, 1973). Monitoring and tracking blood are important safety issues as well. An effective logistics management in blood supply chain will increase the effectiveness in blood utilization (Lowalekar and Ravichandran, 2013), which is the key performance indicator of the blood supply chain.

2.5 Research framework

Faisal (2009) proposed a hierarchy based model of supply chain risks in order to prioritize them. The model presented the types of risk in supply chain classifying into four sub-chains; physical, financial, informational, and relational, following Cavinato (2004), Spekman and Davis (2004), and Jüttner (2005).

2.5.1 Physical sub-chain

Physical sub-chain represents traditional logistics, in the activities of transportation, warehousing, handling, processing, manufacturing, and other utility activities. They can be termed as the risk in physical flow of the supply chain. Risks in physical sub-chain are classified into 10 types, which are delays, disruptions, supplier capacity constraints, production technological changes, transportation, inventory, procurement, capacity Inflexibility, design, and poor quality risks.

2.5.2 Financial sub-chain

Financial sub-chain deals with the flow of money in the supply chain. Risks due to the flows of cash between organizations, incurrence of expenses, and use of investments for the entire network, and accounts receivables and payables

processes can be classified under financial risks. Major risks in financial sub-chain are represented in 10 types, which are cost/price risk, business risks, fiscal risks, untimely payments, settlement process disruption, volatile oil prices, lack of hedging, investment risks, unstable pricing, and exchange rate risks/currency fluctuations.

2.5.3 Informational sub-chain

Informational sub-chain carries the physical and financial chains through the processes and information systems and technologies applied to create activities and trigger product flows and service utilization. Risks in materials flows are not associated to the risks in information flows. Risks in informational sub-chain can be broadly classified by Faisal, Banwet and Shankar (2007) as information security/breakdown risks, forecast risks, and information systems/information technology outsourcing risk.

2.5.4 Relational sub-chain

Relational sub-chain relates to the linkages between demand and supply sides as well as logistics organizations among them. The type of the relationship affects the supply chain risks (Ojala and Hallikas, 2006). Risks in relational sub-chains are categorized into 5 types, reputational risk, lack of trust risk, legal risk, intellectual property rights risk, and collaboration risk (Barratt and Oliveira, 2001; Callioni and Billington, 2001).

This study aims to assess risks in managing the blood supply chain. Initially, the research framework was developed by applying a hierarchy based model of supply chain risks (Faisal, 2009). A brainstorming with the experts in the blood supply chain was discussed in order to identify the associated types of risk in this study. Irrelevant types of risk were partially removed. Only 10 types of risk remain, covering all 4 sub-chains as well. The research framework is presented in Figure 1. The definition of each type of risk in this study is described in the next section.

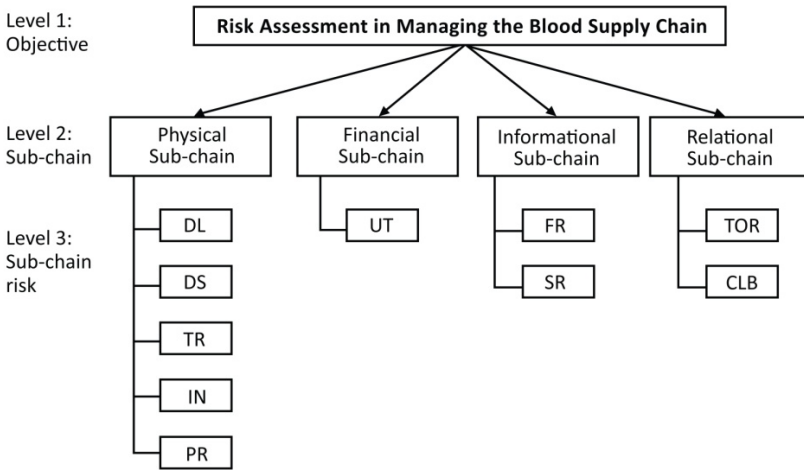


Fig. 1: Research Framework, A hierarchy based model of risks in blood supply chain management

Abbreviations: DL= delay; DS=disruption; TR=transportation; IN=inventory; PR=procurement; UT=untimely payment; FR=forecast; SR= information security; TOR=lack of trust; CLB=collaboration.

3. Methodology

This study was carried out using semi-quantitative risk analysis method in order to identify and assess risks in managing the blood supply chain. The main purpose of this method is to present the overall risk framework, which can reflect all related risks, better than the traditional analyses. The method simultaneously provides the level of risk description linked to the values of the risk. It is regularly used if the risk's value cannot be explicitly quantified. Moreover, it usefully lessens the erroneous scoring in risk assessment based on the experts' experiences.

Initially, a hierarchy based model of supply chain risks was applied as a research framework to classify risks into four sub-chains; namely, physical,

financial, informational, and relational sub-chains. Empirical data were collected by group brainstorming with the experts and practitioners in the blood supply chain context in order to identify and assess such risks. The research steps were conducted according to SCRM activities as mentioned in section 2.3.

3.1 Risk identification

Risk identification is a fundamental step in the risk management. By identifying the risks, a group of decision-makers have become aware of events that cause uncertainty. The risk identification focuses on recognizing future uncertainties for managing these scenarios.

This study applied a hierarchy based model of supply chain risks. Then, the researchers had discussed the framework with the experts in the blood supply chain management context to identify the associated types of risk in this study. Insignificant types of risk were partially removed and there were 10 categories remaining, covering all 4 sub-chains. It was able to represent an overview of risk in the blood supply chain. Blood shortage and outdated were applied to identify the impacts of such types of risk. Brainstorming with the experts group in the blood supply chain management context was conducted to express these risk definitions as described briefly in the following.

3.1.1 Physical sub-chain risk

Risk in physical sub-chain consists of delay, disruption, transportation, inventory, and procurement risks. Delay risk (DL) is defined as delay in blood allocation and distribution in the network. The delay in obtaining blood causes blood shortage for usage within the system. It affects blood expiration as well. Disruption risk (DS) refers to various uncertainties such as power failure, fire, and uncontrolled lab equipment malfunctioning in the blood inventory. Disrupted logistics process for a period can affect blood processing and production and inventory management directly. Transportation risk (TR) associates with the uncertainty in the transport of blood. Due to delays, temperature fluctuations and unstandardized packaging in delivery have

significant effect on the quality of blood for further usage. Inventory risk (IN) involves the uncertainty in managing blood in the inventory. Storing excess blood units in a certain time can increase blood expiration rate without usage. Allocation a small amount of blood products can cause shortage condition in the inventory system. Blood distribution without analyzing the utilization rate has impacts on shortage and outdating in the network. The uncertainties in managing blood inventory directly affect blood utilization. Procurement risk (PR) is the requisition of more blood than the actual demand. The excess amount of blood in the requisition may lead to a lack of blood for distribution to other hospitals in the network.

3.1.2 Financial sub-chain risk

Financial sub-chain risk involves untimely payment risk (UT). It is defined as the delay of the blood requisition cost payment by the hospitals. This may lead to additional opportunity cost for further operations in the blood logistics tasks.

3.1.3 Information sub-chain risk

Information sub-chain risk includes forecast and information security risks. Forecast risk (FR) occurs when there is an imbalance of blood demand analysis to meet supply. This leads to an inaccurate planning to acquire blood. Information security risk (SR) relates to the instability of information management system and its network system. Such system may be damaged by unexpected incidents such as virus, worms, system failure, and so on. It may affect the logistics activities during a daily blood operation.

3.1.4 Relational sub-chain risk

Risk in relational sub-chain risk composes of lack of trust and lack of collaboration among members in the network. Lack of trust risk (TOR) concerns with the confidence level in the blood distribution for fulfilling its requisition in the network. Staff are not conscious of the actual demand for blood usage in the system and blood demand is uncertain. Collaboration risk (CLB) occurs

when there is a lack of properly information sharing between the blood center and hospitals. Blood controlling and monitoring cannot be achieved without an appropriate information system linkage within the network.

3.2 Risk assessment

Risk assessment is an important process to select suitable management actions for the identified risks in the supply chain. The two components of risk, the likelihood of occurrences and the consequences of risk events, are assessed separately on a five-class scale, applied from Hallikas, et al. (2004). Tables 1 and 2 present the assessment scales for the likelihood of occurrences and the consequences of risk events.

Rank	Subjective Estimate	Description
1	Very unlikely	Very rare event
2	Improbable	There is indirect evidence of event
3	Moderate	There is direct evidence of event
4	Probable	There is strong direct evidence of event
5	Very probable	Event recurs frequently

Tab. 1: Likelihood of Occurrences Assessment Scale

When assessing the subjective probability of the risks, the experts' own experiences and organizations' performance are used and incorporated. Some risks may increase the likelihood of occurrences and some may decrease. The potential consequences were assessed from the viewpoint of the experts in the blood supply chain management context. The data collection for risk assessment is described in the next section.

Rank	Subjective Estimate	Description
1	No Impact	Insignificant in terms of the blood utilization, both shortage and outdated
2	Minor impact	Single small impact
3	Medium impact	Causes short-period difficulties
4	Major impact	Causes long-period difficulties
5	Catastrophic impact	Directly affect highest rates of blood shortage and outdated

Tab. 2: Consequences Assessment Scale

3.3 Data collection

Blood supply chain involves linkage among blood donors, blood centers, blood banks in hospitals, and patients. This study focuses on risk assessment in the blood center because it is a superior level performer of technical proficiency in the blood supply chain. It performs both routine and specialized operations in blood collection, blood processing, blood components production, blood inventory management, blood allocation, and blood distribution, covering all significant logistics activities in the network. Hospitals by themselves do not have enough sufficient capacity to acquire blood for further use. Thus, the blood center is a proper and legitimate organization for the study of risk assessment to manage blood in the supply chain.

This research is a novel study to explore the risk management in the blood supply chain. Data collection was conducted in the blood supply chain context in Thailand as a case study. Generally, the blood supply chain management in Thailand is similar to other countries' context. The National Blood Center is a central organization for blood operation management and it decentralizes to 12 Regional Blood Centers (RBCs) all over the country. The Regional Blood Center VII, Ubon Ratchathani province, is one of 12 RBCs in Thailand. It serves

7 northeastern provinces of Thailand to allocate blood to more than 100 hospitals in the network. Empirical data were collected by brainstorming with experts and practitioners in the blood center in order to identify and assess all types of risk. The research findings are presented in the next section.

4. Research findings

The research findings are categorized into three sub-subjects; values of the risk, risk matrix, and risk diagram. Values of the risk are derived by the expert panel discussions in order to analyze the risk assessment. Risk matrix is used to categorize the level of risks into the overall risks perspective. Risk diagram presents the risk management strategies according to risk assessment. The results are presented as follows.

4.1 Values of the risk

This study uses the following formula to evaluate the score of each risk from the likelihood of occurrences and the consequences (Mitchell, 1995).

Risk score = likelihood of occurrences * consequences

Risk consequences are categorized into two types; shortage and outdated. Panel discussions with the experts at the blood center were held in order to obtain the risk values. Each risk score was calculated as its likelihood multiplied by a sum of each risk-consequence category. Values of the risk illustrated in Table 3 yields the risk scores used to prioritize risks in the supply chain.

Considering the likelihood of occurrences in each type of risk, untimely payment risk has the highest likelihood of occurrence. Transportation risk happens occasionally. The types of risk that are not likely to occur are disruption risk, inventory risk, procurement risk, lack of trust risk, information security risk, and collaboration risk. Delay and forecast risks are not likely to take place.

Type of Risk	Likelihood	Consequences		Risk Score
		Shortage	Outdating	
1. DL	1	4	1	5
2. DS	2	3	3	12
3. TR	3	2	3	15
4. IN	3	4	4	18
5. PR	2	3	2	10
6. UT	4	1	1	8
7. FR	1	3	2	5
8. SR	2	2	1	6
9. TOR	2	1	1	4
10. CLB	2	3	1	8
Total		26	19	

Tab. 3: Values of the Risk

The consequences of each risk type were assessed in terms of effectiveness of the blood supply chain, blood shortages and blood outdating. For blood shortage, inventory risk has the highest risk score, followed by disruption risk, procurement risk, and collaboration risk, respectively. Lack of trust risk has the lowest risk score. For blood outdating, transportation risk has the highest risk score, followed by inventory risk. Delay and lack of trust risks have the lowest risk scores.

Moreover, prioritizing of the risk score has a significant impact on the overall utilization of blood. Inventory risk has the highest risk score, followed by

transportation, disruption, and procurement risks, respectively. Risks with lower scores listed in descending order are untimely payment, collaboration, information security, delay, forecast, and lack of trust risks. The total risk scores have shown that the risks in the blood supply chain management identified in this study have significant impact on blood shortage over blood outdating.

4.2 Risk matrix

When all risk types have been evaluated, it can be expressed in the risk matrix. The purpose is to demonstrate the overall risk, showing risk level from low to high. Moreover, it can be used to establish methods to reduce the likelihood of occurrences or the consequences of each risk. The risk matrix is shown in Figure 2.

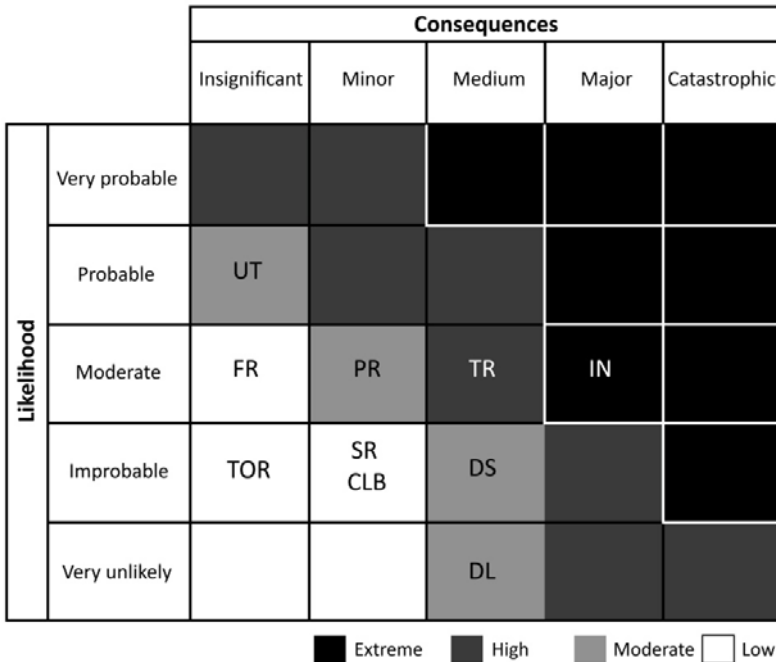


Fig. 2: Risk Matrix

This study classified risk levels into 4 levels; low, moderate, high, and extreme. Low level risk composes of lack of trust, information security, collaboration, and forecast risks. Moderate level risk composes of delay, disruption, procurement, and untimely payment risks. High level risk composes of transportation risk. Extreme level risk composes of inventory risk.

4.3 Risk diagram

Risk diagram is constructed using results from the aforementioned sub-section. Risk diagram is used to define strategies to respond to various risks in the appropriate levels. The strategic risk management framework has been adapted from the work done by Centrec Consulting Group LLC (2002). It is divided into 4 quadrants as follows.

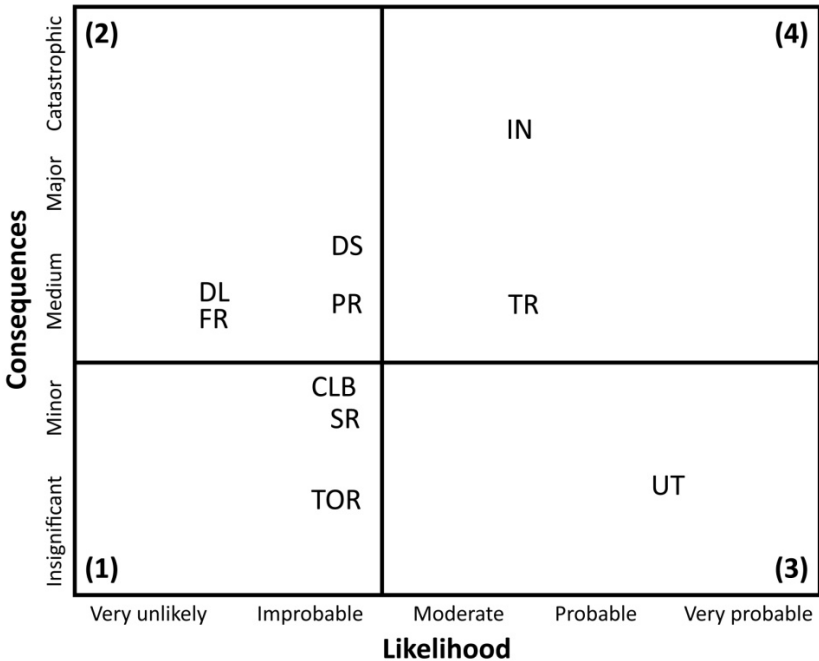


Fig. 3: Risk Diagram for the Quadrants of Likelihood/Consequences

Brainstorming with the experts in the blood center is as essential approach to identify guidelines to manage risk in this context. Summary of expert discussion is presented below.

The acceptable risks in the first quadrant are lack of trust, information security, and collaboration risks. These risks are insignificant because of their unlikely occurrence and low impact. However, the confidence in the blood requisition and distribution between blood center and hospitals is in a satisfactory level. For information security risk, the practitioners should check the equipment of computer and network system quarterly. For collaboration risk, the linkage of information within the blood supply chain system can be better managed by enhancing the cooperation among hospitals in the network to share blood information properly.

Risks that are relatively low occurrence but have high impact are categorized in the second quadrant. They should be managed by transferring or sharing associated risks with other related members in the supply chain. Risks in this quadrant include disruption, procurement, delay, and forecast risks. Disruption of logistics processes in the blood operation usually occurs during the times when accidents happen. These incidents cause higher demand of blood than in the normal period and staff have to put more effort to cope with this difficult situation. Blood center and hospitals should ensure the plan to reserve blood in order to support hospitals when such events occur. In order to minimize procurement risk, blood center and hospitals should work together closely to disclose supply and demand information so that blood allocation can be managed effectively. Blood delay generally occurs in the distribution process. Transportation for blood should be scheduled for distribution in a timely manner. Demand forecasting is hard to analyze. Hospitals should have the instruction for blood demand analysis in each period to predict the rate of blood usage in order to support blood collection planning by blood center.

Risk that needs to be mitigated is shown in the third quadrant. Untimely payment risk relates to the delayed payment of the cost of requested blood.

Blood center must urge the hospitals to pay the bills on schedule or set up rules to request blood and payment criteria.

Risks that need to avoid are presented in the fourth quadrant. They are transportation and inventory risks. Even though these risks occur moderately, they have significant and direct effect on blood shortage and outdating. Hospitals must control the transportation environment to ensure the quality of transported blood to be on par with the national and the international standards in order to avoid transportation risk. Risks in blood inventory management are associated with uncertainties in both blood supply and demand. Constructing a balance between blood supply and demand is an appropriate strategy to minimize and avoid such risks. Blood center should emphasize on the proper blood collection plan as well as the blood allocation and distribution to the hospitals based on the actual needs of the patients within the hospital network. Moreover, information sharing enhancement can reduce uncertainties and risks in the imbalance between blood supply and demand. Applying the blood management information systems that can be linked among the blood center and the hospitals in the network is an essential tool to monitor and control the blood logistics activities within the network effectively.

5. Discussion and conclusions

Blood supply chain comprises of logistics activities, which affiliate links between nodes within the network including blood donors, blood centers, blood banks in hospitals and patients. Its system involves blood collection, processing, inventory management, allocation and distribution, transportation, and blood bank operation. Blood demand and supply are uncertain, which are hard to manage. Blood has an expiration date and can be used within a short amount of period. The needs for blood generally occur unpredictably and uncontrollably. An effective logistics management in the blood supply chain will increase the effectiveness in blood utilization, which is the key performance indicator of the blood supply chain. Most research in the blood supply chain

management focuses on logistics and practice in operation. However, there is a lack in the study of risk management in this context. Supply chain risk management is a new paradigm in the blood supply chain, which can be explored further to manage risks and uncertainties in the network. This study aims to identify and assess risks in managing the blood supply chain.

This study was carried out in semi-quantitative risk analysis method in order to identify and assess the risk in the blood supply chain management. A hierarchy based model of supply chain risks was applied as a research framework to classify risks into four sub-chains; namely, physical, financial, informational, and relational. A brainstorming with the experts in the blood supply chain management was discussed in order to identify the associated types of risk in each sub-chain. Irrelevant types of risk were partially removed. There are only 10 types of relevant risks remaining to study that covered all 4 sub-chains. The risks in physical sub-chain consist of delay, disruption, transportation, inventory, and procurement risks. The risk in financial sub-chain involves untimely payment risk. The risks in informational sub-chain comprise of forecast and information security risks and the risks in relational sub-chain include lack of trust and collaboration risks. Data were collected by group brainstorming with the experts and practitioners in the blood supply chain context. The research steps were conducted by the Supply Chain Risk Management, which incorporates risk identification, risk assessment, and risk management.

Risk identification was conducted by experts group in the blood center. The two components of risk, the likelihood of occurrences and the consequences of a risk event, were assessed separately on a five-class scale in order to analyze the values of the risk. Blood utilization, shortage and outdating, were applied to assess the impacts of the risks' consequences. By prioritization of the risks in the supply chain to enhance blood utilization, inventory risk has the highest risk score, followed by transportation and disruption risks. The overall risks in this study have impact on the blood shortage over the blood outdating. Risk matrix was applied to categorize risks into 4 levels; low, moderate, high, and extreme. The high level consists of transportation risk while inventory risk is in the

extreme level. Discussions with the expert groups have brought an initiation plan to manage risk in the blood supply chain.

In conclusion, the well understanding in risk assessment can support the practitioners in making better decisions and management of risks for any single blood center as well as the whole blood supply chain network. This study provides valuable information for practitioners and researchers in a certain level. It improves the understanding of all related risks, their likelihood of occurrences and consequences, providing a good basis for managing risks in the blood supply chain. There is a necessity for further research using more extensive data. It would be beneficial to further analyze the other aspects of risk and its effects in the blood supply chain management.

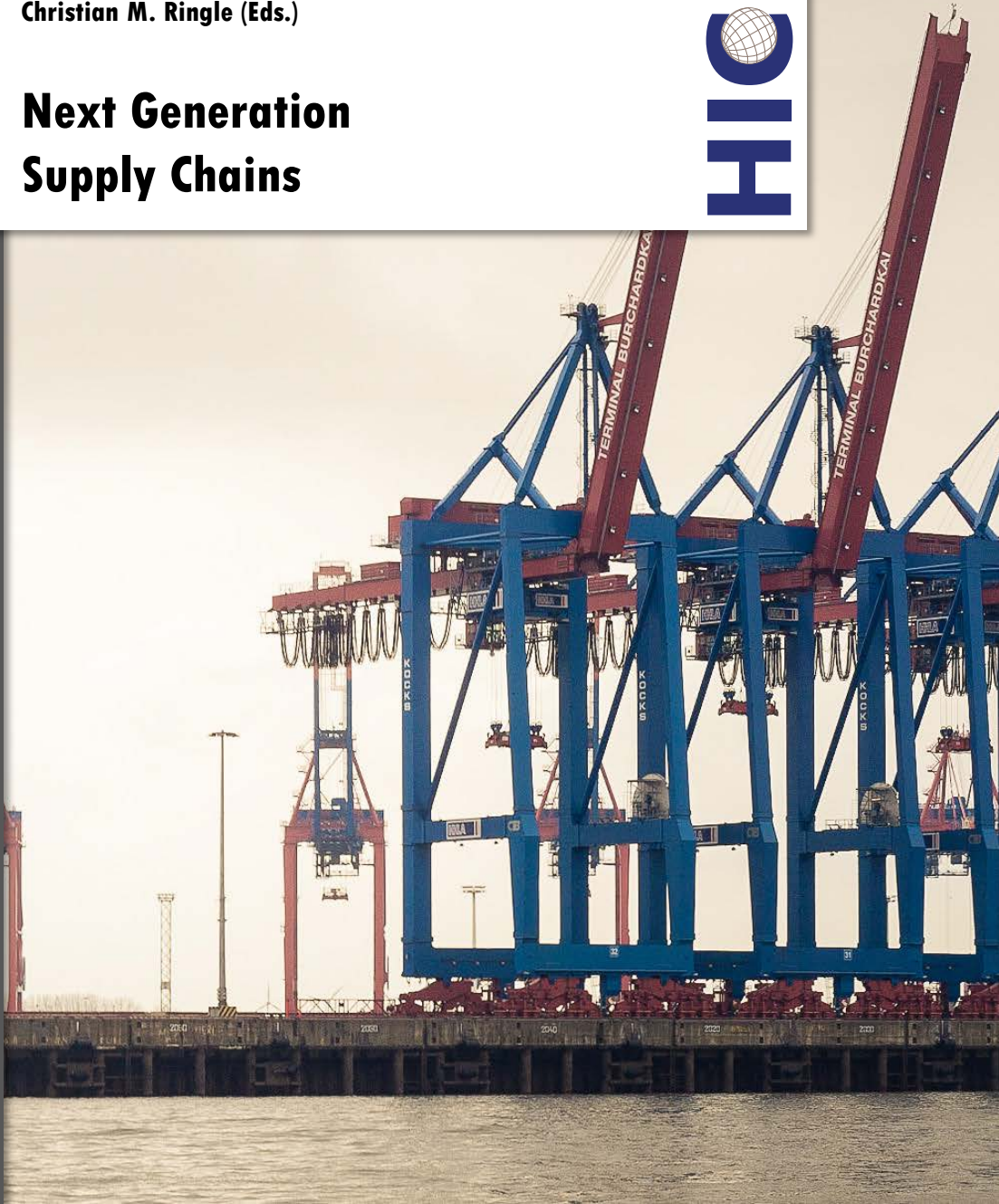
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**Wolfgang Kersten, Thorsten Blecker and
Christian M. Ringle (Eds.)**

Next Generation Supply Chains



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(Editors)

Next Generation Supply Chains

Trends and Opportunities

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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 Decisions29

Philipp Sprenger, Matthias Parlings and Tobias Hegmanns

Future Problems in Logistics Due to Demographic Change51

Matthias Klumpp, Sascha Bioly and Christian Witte

Logistics Trends 2020: A National Delphi Study Concerning the German
Logistics Sector69

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 Focus183

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 Scenario211

Josip Maric, Florence Rodhain and Yves Barlette

Analysing the Role of Rail in Urban Freight Distribution223

Katrien De Langhe

Truck Loading Dock Process – Investigating Integration of Sustainability245

Niels Hackius and Wolfgang Kersten

How to Attract Air Freight Business: Defining Critical Success Factors for Regional Airports273

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 Chain289

Robert Christian Fandl, Tobias Held and Wolfgang Kersten

Sustainable Logistic Scenarios in the NSR Region311

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 Factors345

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 Chains361
Immanuel Zitzmann

Flexible Supply Chain Design under Stochastic Catastrophic Risks379
Yingjie Fan, Frank Schwartz and Stefan Voß

A Risk Management Approach for the Pre-Series Logistics in Production Ramp-Up407
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 Management423
Christian Zuber, Hans-Christian Pfohl and Ulrich Berbner

Risk Assessment in Managing the Blood Supply Chain447
Phongchai Jittamai and Wijai Boonyanusith

Supply Chain Risk Management in International Trade Operations Between Germany and Brazil469
Meike Schroeder and Renato Barata Gomes

The Forest Supply Chain Management: An Entropic Perspective487
Tarik Saikouk, Ismail Badraoui and Alain Spalanzani

A Multi-Agent Based Approach for Risk Management in a Port Container Terminal515
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

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