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A Delphi-based risk analysis — Identifying and assessing future challenges for supply chain security in a multi-stakeholder environment

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ABSTRACT

Identifying and assessing the potential impact and likelihood of future events, which might evolve into risks, are a prerequisite to identify future security challenges. In particular, risks associated with global supply chains are special since they involve a multitude of international stakeholders with different perspectives on security needs and measures. Therefore, it is essential to determine which techniques and instruments are best suited for risk assessment in complex and multi-organizational environments. The Delphi expert survey technique has proven to be a valuable instrument for long-term decision making support as well as foresight, and has a potential value for risk assessment. We contribute to this research strand and conduct a Delphi-based risk analysis. Our research concentrates on man-made risks in global supply chains which are particularly uncertain in terms of type, location, and affected supply chain partners and can therefore be classified as inherently "wicked" issues, i.e. issues that are multidimensional with often unpleasant outcomes. We illustrate that Delphi research makes a fivefold contribution to risk analysis by: (1) identifying and quantifying risks; (2) analyzing stakeholder perceptions and worldviews; (3) stimulating a global communication process; (4) identifying weak signals, outlier opinions, and wildcards; (5) and facilitating risk scenario development.

1. Introduction

Much has been discussed about the various sources and impacts of risks likely to affect global supply chains in the 21st century. Increasing complexity, due to globalization, and leanness of structures and processes are major driving forces of supply chain risks and, therefore, supply chain vulnerability [1–3]. Furthermore, the variety of stakeholders involved in managing supply chains, such as suppliers, manufacturers, retailers, logistics service providers, infrastructure providers like port authorities, as well as national and international governmental institutions contributes to the complexity and susceptibility of supply chains [4]. Consequently, disruptions to global flows of goods and related states of affairs around the world have drawn companies' and governments' attention to such situations [5]. The causes of such disruptions include natural catastrophes (e.g. flood or earthquake), man-made accidents (e.g. technological breakdowns), or intentional man-made attacks (e.g. theft or terrorism). Moreover, the UN Millennium Project recently identified organized crime and terrorism as two of the four most impactful global problems for the next 10–20 years. Furthermore, the risk of information warfare and cyber attacks is an emerging problem in our Internet-dependent global economy [6]. The risks associated with the operation of global supply chains, whether these concern the management of maritime shipping lines, supply chain information systems, or logistics infrastructural hubs, are quite high. Especially the substantial and far reaching losses due to man-made attacks – terrorism, crime, cyber attacks or piracy – have drawn attention. For example, maritime piracy was estimated to cost the international economy between $7 and $12 billion in 2010 [7]. Furthermore, re-routing ships due

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to piracy attacks costs Egypt $642 million a year due to lost revenues from Suez Canal fees, Kenya and Yemen together $564 million due to reduced trading activities and the Seychelles around $6 million due to fewer tourists. However, recent natural disasters (e.g. the flood in Thailand) and accidents (e.g. the nuclear accident in Fukushima) have forced industries and governments to re-evaluate their assessments, preparations for and handling of emergency situations. As a consequence, redesigning global supply chains, in order to make them more resilient and less susceptible to various kinds of disruptions by proactive planning, has become a major management issue [5,8,9]. Furthermore, researchers and practitioners seek appropriate strategies to mitigate the impact of harmful supply chain disruptions [5,10,11].

Usually, a common understanding or consensus does not exist about the problems as well as the sources and impacts that cause risks in international supply chains on a global level [12–14]. Furthermore, man-made risks in global supply chains are uncertain in terms of type, location, and affected supply chain partners and are therefore inherently "wicked" issues [13,15]. A wicked problem is defined as an issue that is multidimensional with often unpalatable trade-offs. As described by Camillus [13], "a wicked problem has innumerable causes, is tough to describe, and doesn't have a right answer". A wicked issue often involves multiple stakeholders with different perceptions of the problem, different perceptions of the appropriate procedure to solve the problem, and different perceptions of how the results and success of the solution should be evaluated [13,16]. In such uncertain wicked environments, it is difficult for relevant stakeholders to process information and make effective decisions [17].

Gonzalez [18] emphasized the importance of empirical studies to identify and assess relevant information in uncertain environments in order to derive appropriate strategies. Duncan [19] elaborated on the characteristics of the organizational environment and perceived environmental uncertainty in a seminal paper. Both authors argued that possible images of the future significantly affect strategies to cope with future uncertainties. Stakeholders from different regions and cultures often have different perceptions of situations and risks which could affect security in supply chains, depending on national or cultural backgrounds, their own position within the value chain, their experience, and so on [20,21]. In such situations, it is common to accidentally neglect relevant factors and important information, or draw misleading conclusions [22].

In order to be better prepared for the future, we need to systematically consider different stakeholder conditions, contexts, and limitations in order to gain a complete perspective of the wicked problem: supply chain security (SCS) [15]. An appropriate procedure which collects and evaluates all stakeholder aspects, including stakeholders' images of the future and opinions of the greatest challenges in SCS needs to be applied. Therefore, the first step is to identify which risks stakeholders perceive to be relevant in long-term SCS. These risks are inherently uncertain and have varying impacts and severity on supply chain partners [23]. The risk conditions are shrouded by ambiguity, information asymmetry, and organizational fragmentation [15]. In a second step, the identified risks need to be evaluated in a risk analysis process, which includes an estimation of risk probability and risk impact [24]. Due to similar challenges and characteristics of risk analysis and foresight, Koivisto et al. [25] recently proposed to investigate foresight methods for risk analysis due to their proactive nature. Several authors [18,26,27] have already proclaimed the potential value of the Delphi method to analyze risks in a future setting. The authors argued that in uncertain environments it is necessary to analyze how uncertainties can impact business and supply chains. The conventional Delphi technique follows a structured, anonymous, multi-round survey process in written form, where expert opinions on future events and developments are summarized [28]. Thereby, this method overcomes drawbacks of traditional group discussions, such as the halo and bandwagon effects [29], and produces answers quicker and more accurately than individuals on the average [30,31]. Furthermore, the Delphi technique has been found to be helpful in examining uncertain world events, such as geopolitical changes, terrorist activities or volatile military actions [32].

Following this logic, we contribute to the field of supply chain security by examining the potentials of Delphi research for risk analysis. Our overall aim is to gauge to what degree the Delphi technique can support and improve risk analysis. We conduct a Delphi survey on the future of supply chain security in 2030 and aggregate the perceptions and views of the world of 80 international top decision makers from a multitude of stakeholder groups, such as industry, academia, politics and other associations. Thereby, this multi-stakeholder approach improves the general validity of our findings concerning the future of SCS.

The remainder of the paper is organized as follows: In Section 2, we provide an overview of literature that points to the challenges of risk analysis or presents experiences with the Delphi method in the field of risk analysis. In Section 3, we present the methodology of the Delphi survey that was applied to gather data and the perceptions of stakeholders for the future of SCS. In Section 4, we propose how the Delphi data can be applied for risk analysis, before we discuss and evaluate the benefits of the collected Delphi data for risk analysis in Section 5: we illustrate how we (1) identify and quantify security risks for global supply chains, (2) determine stakeholder perspectives and world views, (3) stimulate a global communication process, (4) identify weak signals, outlier opinions, and wildcards, and finally (5) facilitate a risk scenario development. Section 6 concludes with overall reflection, limitations and suggestions for future research.

2. Literature review

Having uncertainties in supply chains is – as the name suggests – unfavorable for running stable processes. Therefore, uncertainties in supply chains are commonly described as risks and require more specific information regarding probability of occurrence and potential consequences [33]. Furthermore, risks usually refer to a certain event or development, which disrupts the ordinary course of action by inducing exceptional conditions. The scope of such disruptive events can range from high-probability, low-impact events (e.g. a screw missing in the production process) to low-probability, high-impact events (e.g. nuclear contamination of an entire region). Risk may also pertain to natural disasters and man-made accidents or attacks.

Sheffi [34] firstly addressed the topic of SCS management in the direct aftermath of the 9/11 attack in the US. He noted that

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