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Muhammad Naveed Khan[a]
Pervaiz Akhtar[b]
Yasmin Merali[c]
[a,b,c]*Management Systems/Logistics, Faculty of Business, Law and Politics, University of Hull, United Kingdom*
IESEG School of Management, France[b]

This is a post-print version:
[b]Pervaiz Akhtar is a corresponding author: Pervaiz.Akhtar@hull.ac.uk

Strategies and effective decision-making against terrorism affecting supply chain risk management and security: a novel combination of triangulated methods

Abstract
Purpose –The aim of this study is to investigate the knowledge gaps in the published research on terrorism-related risk in supply chains, and to develop a framework of strategies and effective decision-making to enable practitioners to address terrorism-related risks in supply chain risk management and security.
Design/methodology/approach – The study adopts a novel combination of triangulated methods comprising a systematic literature review, text mining, and network analysis. These methods have not been jointly utilized in past studies, and our approach constitutes a rigorous methodology that cross-validates results and ensures the reliability and validity of qualitative data.
Findings – Our study reveals a number of key themes in the field of supply chain risk management (SCRM) and security linked with terrorism. We identify relevant mitigation strategies and practices for effective strategic decision-making. This subsequently leads us to develop a strategic framework of strategies and effective-decision making practices to address terrorism-related risk, affecting supply chain risk management and security. We also identify key knowledge gaps in the literature and explore the main contributions by disciplines (e.g., business schools, engineering, and maritime institutions) and countries.
Practical implications – We provide a strategic framework of strategies and effective decision-making practices that managers can use to minimize terrorism-related risk in the context of SCRM and security.
Originality/value – This paper introduces a novel methodological combination for improving the quality of systematic literature reviews. It uses the approach to systematically review the strategies and effective-decision-making practices interlinked with terrorism risk, affecting SCRM and security. It identifies significant knowledge gaps and defines directions for future research.

Keywords Terrorism risk, Supply chain risk management and security, Mitigation strategies, Effective decision-making, Novel combination of triangulated methods.
Paper type Research paper

Introduction

Terrorism is among the top five factors affecting supply chain risk management and security (World Economic Forum 2013). Global supply chains and logistical infrastructures are particularly vulnerable to disruption due to their scope, scale, and complexity (Stecke and Kumar, 2009). The British Standards Institute (2017) reported that terrorist attacks on international trade and supply chains increased by 16% between 2016 and 2017. In 2016 alone, a total of 346 attacks took place on supply chains, averaging at 3.7 per week.The literature highlights the direct and indirect effects of terrorism on the cost and performance of global supply chains (Thissen, 2004). The costs of securing global supply chains vary with the amount of global trade utilized by particular international firms. The supply chain costs triggered by terrorism stem not only from securing the transportation of goods, but also from the need to underwrite the risk of delay or disruption of global supply chains. Examples of cost escalation include the potential for terrorist attacks to increase the cost of contracts due to the requirement for specialized security measures, high insurance premiums, and the need to conform to evolving counterterrorism regulations (MacPherson, 2008). According to the British Standards Institute (2016), global supply chains incurred an extra $56bn worth of combined costs due to terrorist threats, extreme events, the migrant crisis, and crime (Marle, 2016). These implications and impacts of terrorism on supply chain risk management and security clearly demonstrate the significance of the topic and the need for systematic research studies to provide effective strategies and basis for decision-making to counter terrorism risks affecting supply chain security (Markmann., et al., 2013; Shan and Zhuang, 2014; Ni et al., 2016).

Our initial review of the literature on terrorism-related risk in supply chain risk management (SCRM) and security identifies the following major gaps. First, although several authors have carried out literature reviews on SCRM at various stages over the last fifteen years, there is no systemic literature review on terrorism risk and its links with SCRM and security. Second, whilst the frequency of terrorist attacks and associated threats to global supply chains is increasing, existing strategies and relevant decision-making frameworks to address the risk arising from terrorism are inadequate and have not been systematically investigated (Markmann et al. 2013; Ni et al., 2016). Additionally, although a few studies provide some guidelines (Sheffi 2001; Nurthen (2003); Bueno-Solano & Cedillo-Campos 2014; Shan & Zhuang 2014), the contributions to the topic by different academic disciplines and countries

have not been systematically categorized in order to explore differences in academic perspectives or the peculiarities of contextual settings.

In order to address these gaps, this paper seeks to advance our understanding of the terrorism-related risks affecting SCRM and security, providing key insights for developing strategies and effective decision-making to counter the impact of terrorism on supply chains. In carrying out the review and analyzing the data, our contributions are as follows: First, we identify developments in the research on terrorism risk in the context of SCRM and security, and develop a strategic framework to help practitioners in strategic decision-making to counter the impact of terrorism on supply chain performance and security. The framework encompasses three key components: 1) terrorism risk management strategies, 2) effective decision-making practices, and 3) supply chain risk management and security. Second, we identify the knowledge gaps and categorize the key contributions to the topic from different disciplines (e.g. business schools, engineering and maritime institutes) and countries. Lastly, we introduce a novel combination of rigorous triangulation methods (a systematic review with text mining and network analysis) for cross-validating findings and ensuring the reliability and validity of data.

The paper is structured as follows. The next section provides a context for our study. Subsequent section describe our methodology, followed by the results of our systematic literature review and framework development. We then identify the knowledge gaps in the extant literature and discuss our contributions to the field. The final section concludes with proposed directions for future research.

Context for the Study

Terrorism and supply chain risk

Defining terrorism is not a simple matter: there is no single internationally accepted definition of what represent terrorism, and the terrorism literature abounds with competing definitions and typologies (Hyslop and Morgan, 2014). More than 100 definitions of terrorism were provided by various writers between 1936 and 1981, while Simon (1994) reported 212 different definitions of terrorism. Terrorism is the threat or actual use of force or violence to attain a political goal through fear, coercion, or intimidation (Alexander et al., 1979, p.4). United Nations (1999) defines it as criminal acts intended or calculated to provoke a state of terror.

According to Europol, terrorism is not an ideology or movement, it is a tactic or a method for attaining political goals (Europol, 2007, p.9). Thus, individuals, groups, and states can be involved in terrorism, depending on their intent to perpetrate criminal acts against people, areas and state (Locatelli, 2014). The lack of a universal definition is exemplified by the familiar comment that "one state's terrorist is another state's freedom fighter". However, the definitions of terrorism converge around the notion that violence, or the threat of violence, is employed to frighten or intimidate people.

Li & Schaub (2004) studied international terrorist incidents in 112 countries from 1975 to 1997. They found that the Middle East had the highest percentage of international terrorist incidents and Europe ranked second. Africa, Asia, and the Americas suffered significantly fewer international terrorist attacks. However, there has been an escalation in international concern with the level of the global terrorist threat in subsequent decades, notably since the 9/11 attack in 2001.

There is no consensus on the definition of supply chain risk (Diehl & Spinler 2013), and supply chain researchers provide a variety of definitions (Wagner and Bode, 2007). Christopher & Lee (2004), assert that there is no exact definition of risk, but rather a list of possible risk sources. They define supply chain risk as the "effect of external events such as wars, strikes or terrorist attacks and the impact of changes in business strategy" (p., 388). Table I provides a summary of key definitions.

(Insert Table I)

Zsidisin et al. (2005) define supply chain risk as the product of two separate but interrelated elements: uncertainty and impact. There are two features of uncertainty that are linked to viability and supply chain continuity. The first is the lack of awareness of all the events that might occur and cause disruption for supply chain players. The second is the probability of occurrence of those events and its impact that deals with the potential costs generated by the events. Terrorism-related risks can have severe impacts in terms of magnitude on the area of their occurrence and are relatively unpredictable (Kleindorfer and Saad, 2005). In this study, the researchers examine supply chain risks related to the external environment and their sources at the country level by considering the macroeconomic environment and terrorism risk.

The concept of terrorism-related risk in SCRM became prominent in the literature in 2001 (Zegordi and Davarzani, 2012). Whilst there is extensive literature available on SCRM, supply chain disruption, and supply chain security, only a limited number of studies deal with terrorism-related SCRM and how to secure supply chain activities from terrorist attacks (Sheffi 2001) . A few researchers have conducted studies on terrorism-related risks affecting different activities of supply chains such as supply chain logistics performance (Czinkota et al. 2005; Bueno-Solano & Cedillo-Campos 2014), supply chain security performance (Sheffi 2001; Thibault et al. 2006; MacPherson 2008; Marlow 2010; Reilly et al. 2012), supply chain resilience (Cox et al. 2011; Urciuoli et al. 2014), communication between supply chain partners after terrorist attacks (Degeneffe *et al.*, 2009), and the impact of terrorism on employees working in those supply chains (Reade, 2009).

Similarly, while supply chain security is widely discussed in the supply chain risk literature, studies in the new supply chain security regulations due to terrorism-related risk and their impact on supply chain performance are limited (Sheu el at, 2006). Markmann et al. (2013) analyzed the influence of terrorism-related risk on global supply chain security, and other studies are related to specific sectors. For example, Barnes & Oloruntoba (2005) and Raymond (2006) examine the new security initiatives' impact on the maritime supply chain. There are some studies on transportation security in the context of terrorism-related risk (Prentice 2008; Ekwall 2010; Reilly et al. 2012; Strandberg 2013). Nganje et al. (2008) and Pinior et al. (2015) discussed food supply chain security and bio-terrorism. A few studies addressing supply chain disruption management in context of terrorism-related risk (Stecke & Kumar 2009; Knemeyer et al. 2009), include not only operations performance (Bueno-Solano and Cedillo-Campos, 2014; Kauppi *et al.*, 2016), but also financial performance (MacPherson, 2008;Ni *et al.*, 2016). Several studies have examined the relationships between government initiatives and security strategies and efforts to avoid terrorist threats (for example Sheu et al., 2006, Vance, 2008 and Ni et al.,2016).

The rise of terrorism-related risk has motivated firms to develop long-term strategies for supply chain sustainability and risk management. This area of research is an emergent one and there is a need for more studies (Shan and Zhuang, 2014), particularly ones that rigorously explore extant theoretical aspects of terrorism risk and their impacts (Hong and Ng, 2010).

Our study makes a substantial contribution to this domain by mapping the literature on the impacts of terrorism-related risk on supply chains and explicitly defining the significant aspects covered in the specific content of relevant articles, and exploring the developments in this emerging knowledge domain (Shan and Zhuang, 2014).

Methodology — systematic literature review, text mining and network analysis

In order to extract and analyse the large volume of information and data generated by the scientific community, we deployed a novel combination of systematic literature review (SLR), text mining, and network analysis These methods enable us to systematically identify and select existing studies, evaluate them against set criteria and analyse them, producing valid results by limiting the research bias. The SLR approach used in this study consists of the following major steps.

Database and article selection

This study collected research articles and their related citation data from the EBSCO Host, Science Direct, Emerald Insight, Web of Science, Scopus, Summon (University of Hull), and ABI/INFORM. These are well-established databases and comprehensively cover scientific sources. To identify the relevant research articles, we first developed a basic set of keywords and their derivatives (e.g. terror*, supply chain) using guidelines from the literature (Tranfield et al., 2003). To begin with, 10 articles (from highly cited journals) related to supply chain management and SCRM were reviewed to identify the initial list of keywords, alongside three brainstorming sessions conducted with three supply chain management academics and two supply chain practitioners. The five experts in supply chain risk were selected for their specialist knowledge of terrorism-related risk in global supply chains. This process delivered the set of initial keywords (and derivatives) used in the subsequent database search to harvest a further set of articles, which were used to generate a list of additional keywords used with high frequency in this field. We subsequently refined these keywords with a set of three experts in order to validate our search. As a result, we identified the following set of keywords:

1. Terror* and Supply Chain Risk
2. Terror* and Supply Chain Disruption
3. Terror* and Supply Chain Vulnerability

4. Terror * and Supply Chain Uncertainty
5. Terror* and Supply Chain Resilience
6. Terror* and Logistics
7. Terror* and Transportation
8. Terror* and Maritime
9. Terror* and Strategic Decision-Making
10. Terror* and Supply Chain Security

A condition was imposed that these search strings had to be included within the title, abstract and/or keywords for a research paper to be considered. The asterisk (*) was also used to find related words (e.g. terrorism, terrorists related to terror*). In this process, we only considered peer-reviewed articles, written in English, and published from 2001 to 2016. We selected 2001 as the start date because this was when the issue of terrorism in the context of supply chains was first introduced (in Sheffi, 2001). This procedure reduced the bibliographic data to a manageable level: the initial search revealed 1371 research papers. Following the deletion of duplicates, 801 research papers met the initial inclusion criteria.

Article evaluation and coding

We then evaluated each paper by screening its title, abstract and keywords. In this step, we set a series of inclusion and exclusion criteria to capture only those articles related to terrorism-related risk in the context of supply chain risk management and security. Thus, generic supply chain studies on risk management or security were excluded from the initial dataset, unless they also addressed terrorism and its related risks to SCRM and security. Figure 1 shows a decision tree for excluding papers at each stage. Furthermore, we excluded conference papers. The pre-defined selection criteria were then applied to the abstracts of the remaining 626 papers to identify articles that addressed terrorism-related risk and its effects on SCRM and security. The abstract review stage resulted in the exclusion of a further 315 articles. Finally, the full texts of the remaining 311 articles were reviewed and this resulted in the exclusion of a further 247 articles. Our systematic procedure eventually yielded 64 research articles that satisfied the complete set of predetermined inclusion criteria.

(Insert Figure 1)

The 64-collected research articles were then coded in terms of general information (e.g., titles, authors' names, year of publication, and journal name) and additional categories (e.g. disciplines, research methods, university names, schools/departments/institutions, industries, and focus of studies) were identified. In order to mitigate the risk of introducing a subjective bias, two experts were engaged in the process of compiling this database, and the preliminary result of coding was then validated by the third expert. This process was repeated until a consensus was reached between the experts.

In order to use the computational power of text mining methods, the selected articles were imported into NVivo for cross-validation and to ensure that they specifically addressed terrorism-related risks in supply chain management, and to determine the key themes they covered. Word clouds were used to visualize the focus of their content. Figure 2 shows an example of such cross checks, mainly focusing on terrorism, security, and supply chain risk management. The analytics from this Figure confirm the validity and reliability of the selection process in identifying a final set of articles focusing on the core area of interest for this study. It also ensured the validity and reliability of the final articles and their text selected for further analysis, covering the main purpose of this study. Interestingly, it also reveals certain themes that have low values of relative frequency, suggesting that these are under-explored and need further research.

(Insert Figure 2)

Using the variable features and additional categories, we coded and prepared a separate dataset for network analysis. This dataset was prepared based on the final research articles stored in NVivo. The subsequent procedures allowed us to categories interesting and relevant papers for citation analysis. We then examined networks and their clusters, to identify the knowledge gaps and contributions from various disciplines and countries.

The combination of triangulated methods (SLR, text mining, and network analysis) deployed in our study constitutes a methodological innovation in ensuring the cross-validation, reliability, and validity of qualitative data reviewed (this particular combination has not been used in any preceding studies).

Results and framework development

The main purpose of this study is to explore the developments within the field and to develop a strategic framework, consisting of terrorism-related risk management strategies, effective decision-making practices, and SCRM and security. This section presents the descriptive results from the SLR, followed by the thematic analysis that underpins the development of our framework.

Descriptive results and identification of knowledge gaps

More than 20 relevant journals were identified from seven databases, with a total of 1371 articles using the key word search. Table II provides details. After excluding duplicated articles (570), 801 articles were utilized to apply the criteria set for this research. After all exclusions, a total of 64 articles remained for the final analysis. Of the 64 articles, 30 are published in transportation journals, 9 are from supply chain management journals and the remaining articles appear in journals related to operations, production, disaster prevention, economics, and management.

(Insert Table 1I)

The articles were also analyzed with respect to the year of publication. As shown in Figure 3, this clearly reveals that the topic of terrorism-related risk in the supply chain context has been gaining increasing attention since 2001 particularly progressing from 2010. Of the 64 articles analyzed, 34 articles were published between 2010 and 2014.

(Insert Figure 3)

Table III shows the profile of the terrorism-related risk literature, defined in terms of research methods, disciplines, the core focus of studies, geo-location-specific (centric) view of data, and industry sectors.

(Insert Table III)

The distribution of articles with respect to the type of research method is shown in the first column of Table III. More than half of the articles followed a qualitative methodology while 41% focused on quantitative methods. A few of the articles employed mixed techniques. Papers were classified as deploying a qualitative methodology if the research was based primarily on conceptual theories, or deployed methods such as Delphi analysis, focus groups, literature reviews and case studies. Papers classified as deploying quantitative methods were based on surveys, simulation, mathematical modelling, descriptive analysis, and other data mining techniques: none of the studies used the combination of methods utilized in our current paper.

The second column shows that 67% of the articles focused on the discipline of supply chain security (maritime and land transportation), while others dealt with various aspects of supply chain risk management; 23% of the papers discussed terrorism as a catastrophic risk factor in supply chain risk management, 5% of the articles focused on food supply chain security in the face of terrorism-related disruption, 2% discussed strategies for effective communication between supply chains after terrorist attacks, and 2% analyzed effects of terrorism-related risk on supply chain employees.

In the third column, we categorize our 64 sample articles according to the core focus of the papers. The majority (25 %) of articles assessed terrorism risk and 20% suggested mitigation strategies, 23% of the articles analyzed the impact of security initiatives on the performance of businesses and ports, 12% of the articles assessed terrorism risk in the SCS context and fewer than 10% focused on catastrophic risk analysis, terrorism and privacy risk analysis, supply chain performance, and shopping mall security.

The selected articles are also classified with respect to geographical scope, as shown in the fourth column ("centric view of data") of Table III. The geographical analysis of the literature showed that the majority of the articles took a global view (45%), followed by ones focusing on North America (33%) and the US (27%). A limited number of articles focused on Asian or European contexts. Only one article investigated terrorism-related risk in the context of an area that was itself endemically affected by terrorism (Sri Lanka), but many other areas that are highly affected by terrorism (such as Pakistan and Afghanistan) have not been explored: this omission clearly demonstrates an important knowledge gap that needs to be addressed by future research.

The main purpose of classifying articles with respect to industrial sectors was to establish the extent to which different terrorism risk management strategies and effective decision making have been evaluated empirically in particular sectors. The classification of articles with respect to industrial application is shown in the last column of Table III. Most of the articles focused on maritime (40%) and land transportation (11%) industries. This finding is not surprising given the fact that various components of transportation systems have been shown historically to be prone to attacks both in wars and by terrorists (broadly defined). The 'General' category covers a mix of different industries and the corresponding articles either reported multiple case studies or presented interviews/surveys in various industries; 8% of the selected articles were focused on bio-terrorism-related risk in food supply, and our analysis suggests a lack of research on other aspects of terrorist impact on food logistics service providers and on other important sectors (e.g. energy logistics providers). 37% of the articles do not entail industry-specific research. This finding highlights the need for future researchers to carry out a larger number of industry-specific studies on terrorism-related risk in diverse sectors.

With regard to methodological orientation of the papers analyzed we found an encouraging trend in the use of mixed methods in recent years. Figure 4 illustrates that the gap between the numbers of qualitative and quantitative studies has almost disappeared. Another interesting finding is that quantitative methods became increasingly popular in the period 2009–2012. It is possible that this trend may be associated with the improved analytical power associated with "Big Data" and the availability of emerging software tools that can be utilized for more rigorous combinations of research methods and techniques.

(Insert Figure 4)

Terrorism risk, supply chain risk management, and strategic decision making (thematic analysis)

The thematic analysis shows that terrorism-related risk affects supply chains at all three decision levels (operational, tactical, and strategic). The literature highlights the potential role of terrorism-related risk management (TRM) strategies in reducing risk by utilizing tools for effective strategic decision-making in the supply chain management context (Navarrete and Esteban, 2016). However, Snyder et al. (2006) argued that once a disruption happens, there is

very little recourse in relation to supply chain infrastructure because strategic decisions cannot be adjusted and implemented quickly enough. Hale & Moberg (2005) proposed a strategic decision-making model that utilizes location science to assist logistics managers to more efficiently develop a system of safe and secure locations for the storage of critical equipment and supplies under terrorism threats. Modarress et al. (2012) developed a strategic decision-making process for making strategic investments in maritime transportation supply chains to mitigate risks associated with terrorism. In the manufacturing sector Czinkota et al.'s (2005) study shows how managers can hold the ideal inventory level in face of terrorism-related disruption by determining the ideal balance between make and buy. Their study also assists managers' strategic decisions regarding foreign market entries. In a similar vein Nejad & Kuzgunkaya (2014) devolved a strategic decision making model for supply chain resilience, incorporating strategic stock and reconfigurable back-up suppliers in disruptions due to terrorism. Das & Lashkari (2015) formulated a model-based strategic decision-making approach to create risk readiness and resilience in the face of terrorism-related and other risks to supply chain operations. A summary of key terrorism risk mitigation strategies proposed in the literature is presented in Table IV.

(Insert Table IV)

The thematic analysis reveals that almost 40% of the articles address the issue of effective decision-making in the face of terrorism-related risk. The articles are identified in Table V, and their findings can be used effectively to inform managers in making decisions about current and prospective terrorism risks and their potential impact on supply chain revenue.

Effective SCRM and security are predicated on combining mitigation strategies for terrorism risk management with effective-decision making practices. The framework presented in Figure 5 captures the key factors and relationships derived from our detailed review and analysis of the literature summarized in Tables IV and V.

(Insert Table V)

(Insert Figure 5)

Network Analysis, knowledge gaps, and contributions

The results of our Citation Network Analysis (CNA) are presented in Figure 6. The network shows the reviewed papers (depicted as nodes in the network) and their related citations (depicted as color-coded directed links/edges between nodes). The size of node and font represents the number of citations associated with each paper and the color of edges represents the source paper that is citied in the target paper. This reveals clusters of papers addressing particular topics in the research domain as summarized in the following paragraphs.

The most cited paper (Sheffi, 2001) first addressed the topic of terrorism risk in supply chain management. He discussed the supply chain investments and re-organization needed to prepare for terrorist attacks in terms of the challenges of dealing with the aftermath.

Certifications: The second most cited paper is by Sheu et al. (2006). They examined several cases to determine how certifications such as the Customs-Trade Partnership against Terrorism (C-TPAT) affect international supply chain collaborations. They found that four out five companies significantly benefited from them through border inspections, lower costs, and higher customer satisfaction. The third most cited paper was by Thibault et al. (2006). Their findings suggested that the new supply chain security-measures created stronger public-private collaborations. Ni et al. (2016) found that early adopters of C-TPAT were not driven by economic benefits but rather by the need to minimize their exposure to the risks associated with failing to satisfy the goals associated with C-TPAT.

(Insert Figure 6)

Economic Considerations and Geography: Thissen (2004) examined the increase in transportation costs due to the indirect effects of terrorist attacks on transport infrastructure. He also developed an approach for government to find the most vulnerable economic links in the infrastructure network and proposed to use a spatially applied general equilibrium model in the new economic geography tradition to measure the indirect economic effects. Raymond (2006) found that there are inherent weaknesses existing in the maritime industry that can be exploited by terrorist groups with maritime capabilities to target supply chains linked with specific geographical areas. Knemeyer et al. (2009) developed a process to proactively plan for catastrophic risk events (i.e. terrorism) through an integration of diverse research streams linked to risk management. In addition, they proposed a process building upon a current risk

analysis model by incorporating an innovative methodology adopted by the insurance industry to calculate the risk of multiple types of catastrophic events on key supply chain locations.

Identification and Management of Risks and Threats: Ekwall (2012) analyzed the nature of four antagonistic threats (threats: theft, terrorism, smuggling, and piracy) and concluded that antagonistic threats are wicked problems. Reade (2009) found that there is a statistically significant negative relationship between employees' sensitivity to terrorism and employees' attitudes toward the company, team, and job. Markmann et al. (2013) quantified man-made risks in global supply chains and analyzed stakeholder perceptions and communication processes. Pero & Sudy (2014) developed an approach to support managers in selecting activities, methods, and technologies to increase supply chain security, without reducing its efficiency. Their approach consists of the following steps: First, the identification and assessment of threats along the supply chain. Second, the identification of weak points. Third, the identification, development, and provision of suitable target processes that increase security without negatively affecting efficiency. Fourth, the evaluation of expected impacts of the identified target processes on supply chain security and efficiency. Last, the implementation and monitoring of performance of the identified target processes. Yang et al. (2014) introduced a novel fuzzy evidential reasoning approach for the quantitative analysis of port facility security assessments. They used the major key security performance indicators and identified current port facility and security assessment practices. Männistö et al. (2014) and Urciuoli et al. (2014) identified the most prominent potential security threats to supply chains as terrorism, piracy, and wars. They also discussed the comprehensiveness of the portfolio of strategies built by the EU to deal with scarcity issues. However, they found these approaches were not often coordinated with supply chain strategies.

The results of our network analysis shows a fragmentation of the literature in the domain and suggests the need for an integrative conceptual framework to define and articulate the relationship between supply chain risk management strategies, terrorism risk management strategies, and relevant decision-making strategies. Our framework (Figure 5), based on the results of the SLR and text-mining makes a significant contribution towards addressing this knowledge gap.

Contributions by disciplines and countries

The results of our analysis of the contributions by different disciplines and countries are depicted in Figures 7 and 8. We found that the largest cluster of contributions originated from business schools, mainly focusing on supply chain risk management, supply chain security, maritime, and food supply chains. The second largest contribution was from engineering schools. They emphasized energy supply chains, supply chain risk management, transportation, and supply chain security. The third largest cluster of contributions was from maritime departments, focusing on supply chain security in the maritime industry. The rest of the clusters comprised contributions from various social science disciplines, including economics, law, political science, geography, defense, and strategic studies. They generally focused on supply chain security, food, energy, and transportation industries.

It is notable that the main contributors (business schools, engineering, and maritime institutes) historically are not specialised in combatting terrorism. This finding clearly highlights the need for future research to engage inter-disciplinary or transdisciplinary teams in order to develop a more complete and coherent understanding of terrorism-related risks for supply chain management. This is an important pre-requisite for enabling managers to devise appropriate strategies for addressing the factors that give rise to these risks, and for developing more resilient business and operational models to avoid or mitigate the impact of potential threats and risks associated with terrorist activity in their environment.

There is a view that universities should invest in institutions to address the roots of terrorism in their research and teaching, developing measures to counter terrorist activity and reduce or eliminate those factors that encourage terrorism. Such institutions would potentially have an important role in society by promoting peace and countering terrorism through education.

(Insert Figure 7)

(Insert Figure 8)

Our analysis of the countries that the research is based in shows that US universities comprise the largest cluster (40 % of the total selected articles 64), followed by European universities (34%) with Asian institutions contributing only 7 articles. This is an important observation as the Asian, Middle Eastern, and African countries are amongst those

experiencing the highest levels of terrorist activity (British Standards Institute, 2017). It is possible that researchers from these countries are inhibited from researching or publishing on this issue due to security considerations and/or the fear of reprisal from powerful individuals/groups/countries. However, their absence constitutes an important knowledge gap as published accounts risk omitting critical contextual factors that shape the situated impact of terrorist activity on supply chains located in those countries.

Conclusions and future research

This study is the first to provide a systematic review on terrorism risk, decision-making practices and interlocking effects on supply chain risk management and security. Our further contribution is in introducing a novel methodology combining SLR, text mining, and network analysis to explore the knowledge gaps in the published research. . The methodology enhances the rigor of our identification and exploration of the corpus of literature. By deploying our novel methodology to explore the published research on terrorism-related risk in the context of supply chain risk management and security, our study makes a substantial contribution to this domain by mapping the literature on the impacts of terrorism-related risk on supply chains and explicitly defining the significant aspects covered in the specific content of relevant articles, and exploring the developments in this emerging knowledge domain..

Our analysis of the content of individual research papers identified clusters of papers dealing with particular aspects of risk and security, showing a fragmentation of the literature in the domain. To address the fragmentation, we developed an integrative conceptual framework to define and articulate the relationship between supply chain risk management strategies, terrorism-risk management strategies, and relevant decision-making strategies.

Our analysis highlights the need for future research to:

- engage inter-disciplinary or transdisciplinary teams in order to develop a more complete and coherent understanding of terrorism-related risks for supply chain management
- develop more sector-specific studies and cover a greater diversity of sectors
- conduct more studies based in Asia, the Middle East, and Africa (with increased participation of scholars and practitioners from those regions)

These are important pre-requisites for academics and practitioners active in this research domain for mitigating against academic, cultural, and national biases. Incorporating these features will generate more robust research and enable managers to:

- devise appropriate strategies for addressing the entire range of factors that give rise to risks, and
- develop more resilient business and operational models to avoid or mitigate the impact of potential threats and risks associated with terrorist activity in their environment.

Finally, we detected a recent rise in the popularity of quantitative methods, and this suggests that there is a positive appetite in the research community to develop large-scale investigations to quantify the relationship between the types of terrorism risks and individual indicators of supply chain performance. This is particularly important for practitioners concerned with global data-rich supply chains in which data analytics can play an important role in identifying terrorism-related activities and their impact on supply chain risk management.

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Table I. Key definitions of supply chain risk

Authors	Definitions of Supply Chain Risk
March & Shapira 1987, p.1404)	Variation in the distribution of possible supply chain outcomes, their likelihood, and their subjective values.
Jüttner et al. (2003, p.7)	Any risks for the information, material and product flows from original supplier to the delivery of the final product for the end user
Wagner and Bode (2007, p.303)	Risk as the negative deviation from the expected value of a certain performance measure, resulting in negative consequences for the focal firm.
Manuj & Mentzer (2008, p. 197)	The distribution of performance outcomes of interest expressed in terms of losses, probability, speed of event, speed of losses, the time for detection of the events, and frequency.

Table II. The number of articles and duplicates in each database

Search Terms	EBSCO Host	Science Direct	Emerald Insight	Web Science	Summon	Scopus	ABI/ INFORM	Total
Supply Chain Disruption and Terrorism	14(2)	4(1)	0	21(3)	24(6)	22(4)	13(2)	98 (18)
Supply Chain Risk and Terrorism	28(9)	5(2)	10	40(12)	38(12)	48 (21)	17(9)	186(65)
Supply Chain Vulnerability and Terrorism	1	2	4(4)	11(7)	10(6)	17(8)	5(2)	50(27)
Supply Chain Resilience and Terrorism	1(1)	1	3(2)	5(5)	4(3)	6(4)	3(2)	23(17)
Supply Chain Security and Terrorism	6(4)	4(3)	7(4)	33(20)	65(28)	45(21)	26(14)	186(94)
Maritime and Terrorism	0	17(4)	4(2)	6(3)	13(9)	74(7)	13(9)	127(34)
Strategic DM and Terrorism	4	2	5(2)	8(6)	23(15)	19(16)	14(12)	75(51)
Logistics and Terrorism	14(5)	3	15(8)	19(5)	122(8)	32(14)	16(2)	221(42)
Transportation and Terrorism	34(6)	5(1)	16(5)	5(4)	136(120)	85(15)	124(71)	405(222)
Total	102(27)	43(11)	64(27)	148(65)	435(207)	348(110)	231(123)	1371(570)

Table III. The status of terrorism-risk literature (n=64)

Methods	Discipline Base	Core Focus	Centric view of Data	Industry Sector
Qualitative (53%)	SCS (67%)	Terrorism Risk Analysis (25%)	Global (45%)	Maritime (40%)
Conceptual (44%)	SCRM (23%)	SC Security Initiatives (23%)	N. America 33%	General (37%)
Review (3 %)	Food SCS (5%)	Mitigation Strategies (20%)	*U.S.A (27%)*	Transportation (11%)
Delphi Analysis (2%)	Energy SC (3%)	SCS Risk Analysis (13%)	*U.S.A & Canada (3%)*	Food (8%)
Case study (2%) Focus Group (2%)	SC HRM (2%)	Catastrophic risk Analysis (6%)	*Canada (3%)*	Energy (2%)
Quantitative (41%)		Terrorism & Piracy Risk Analysis (6%)	Europe 4% (Total 10%)	Logistics Service Providers (2%)
Survey (12 %)		Supply chain Performance (5%)	*UK (2%)*	
Simulation Model (11%)		Shopping Mall Security (2%)	*Germany (2%)*	
Math Model (11%)			*Swiss (2%)*	
Descriptive analysis (5%)			Asia 12%	
Data mining techniques (2%)			*Southeast Asia (3%)*	
Mixed Method (6%)			*India (3%)*	
			Sri Lanka (2%)	
			South Asia (2%)	
			Middle East (2%)	

Table IV. Terrorism risk management strategies adopted by authors

Authors	Approaches
Sheffi (2001) and Pero & Sudy (2014)	Buffer stock, Knowledge backup, Shipment visibility, Improved collaboration, Risk pooling (*postponement, build-to-order, product variability reduction and centralized inventory management*), Sharing information and security.
King (2005)	Security, Ensuring accountability, Creating smart borders, Recapitalizing the coast guard, Reforming immigration services, Container Security Initiative, 24 hour rule for cargo declarations, Customs-Trade Partner- ship Against Terrorism, Operation Safe Commerce by the Transportation Security Administration.
Barnes & Oloruntoba (2005)	Contingency and Business continuity planning.
Hale & Moberg (2005)	Secure site locations.
Manning et al. (2005)	Rapid response to incidents, Adequate resources available for investigation, Preparedness planning and Developing surveillance systems.
Suder & Czinkota (2005) and Degeneffe et al. (2009)	Communication strategies.
Nganje et al. (2008)	Policy incentives and Cost-effective strategies.
Stecke & Kumar (2009)	Proactive Strategies, Advance Warning Strategies, Coping Strategies and Cost Benefit Trade-Offs of Mitigation Strategies.
Cox et al. (2011)	Conservation, input substitution, Inventories, Excess capacity, Relocation, Resource un-importance, Import substitution, Export substitution, Technological change, Production recapture, Logistics raffinement.
Belzer & Swan (2012)	Shift Risks.
Shah (2013)	Intelligence, Information sharing, Crisis response, Finances for internal security and the nation's legislation for battling terrorism.
Urciuoli et al. (2014)	Portfolio diversification, Flexible contracts, Transport capacity planning and Safety stocks.
Shan and Zhuang, (2014)	Subsidization.

Table V. Effective decision-making practices

Authors	Effective decision-making practices
Sheffi (2001), Marlow (2010) and Yang et al. (2014)	Decisions regarding SCS practices
Thissen (2004)	Decisions about prevention measures and relevant practices
Barnes & Oloruntoba (2005)	Decisions regarding crisis situations
Hale and Moberg, (2005)	Decisions for selection of secure site location
Czinkota et al. (2005)	Decisions about Make-or-Buy and foreign market entry
Suder & Czinkota (2005)	Decisions about performance of SCS
Thibault et al. (2006)	Decisions regarding funding
Degeneffe et al. (2009)	Decisions about consumer needs and concerns
Stecke & Kumar (2009)	Robust decisions during supply chain disruption
Taquechel (2010)	Decisions about trade-offs security cost
Cox et al. (2011)	Decision-making in allocating the resources on risk-based manner
Aggarwal & Bohinc (2012)	Decisions about mitigating the impact of black swan events (e.g. Terrorism)
Reilly et al. (2012)	Decisions about which routes to use with what frequencies in response to these prohibitions and the underlying threat of terrorism.
Markmann et al. (2013)	Long-term decisions for risks
Wang & Ouyang (2013)	Decisions of investment in transportation security
Shan & Zhuang (2014)	Decisions about subsidization
Pinior et al. (2015)	Decisions in the supplier selection process
Navarrete & Esteban (2016)	Decision- making regarding the issue of food defense

Figure 1. A decision tree showing the reasons for excluding articles at each stage

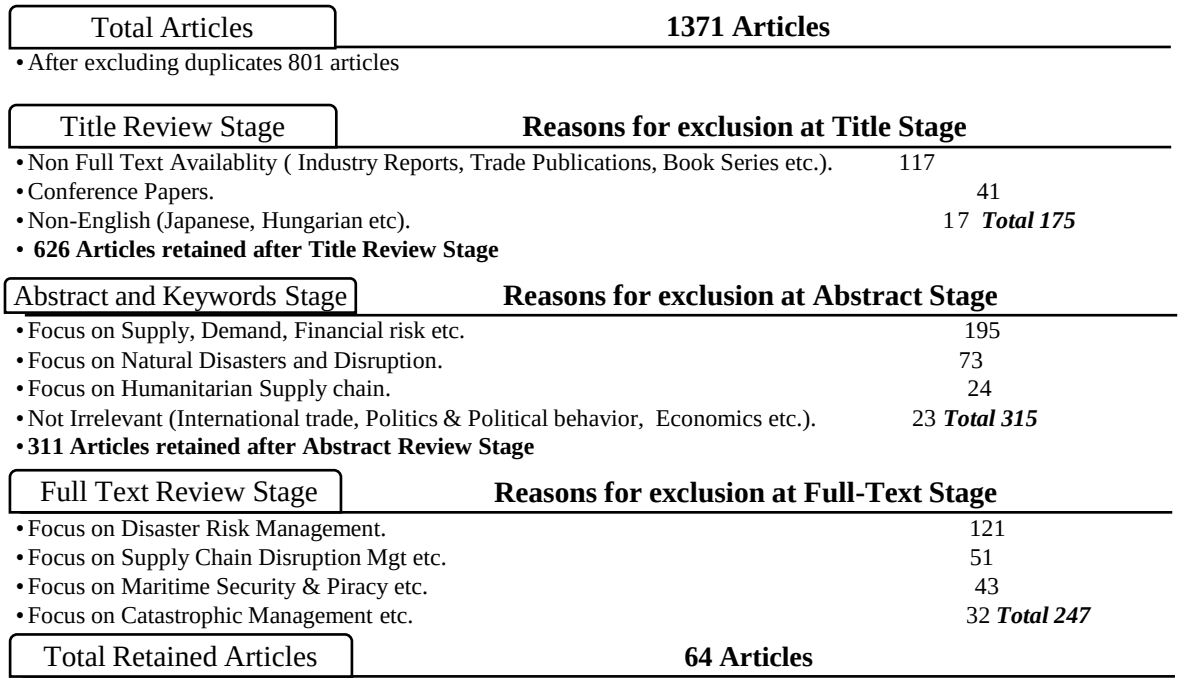


Figure 2. Most frequent used words in articles and words cloud

Word	Count	%
Security	4783	1.45
Terrorism	3248	.99
Chain	2393	.73
Risk	2300	.70
Management	2232	.68
International	1573	.48
Maritime	1516	.46
Transport	1472	.45
Cost	1365	.41
Port	1294	.39
Attacks	1049	.32
Trade	967	.29
Ships	943	.29
Economics	889	.27
Development	818	.25

Figure 3. The publication trends on terrorism risk management

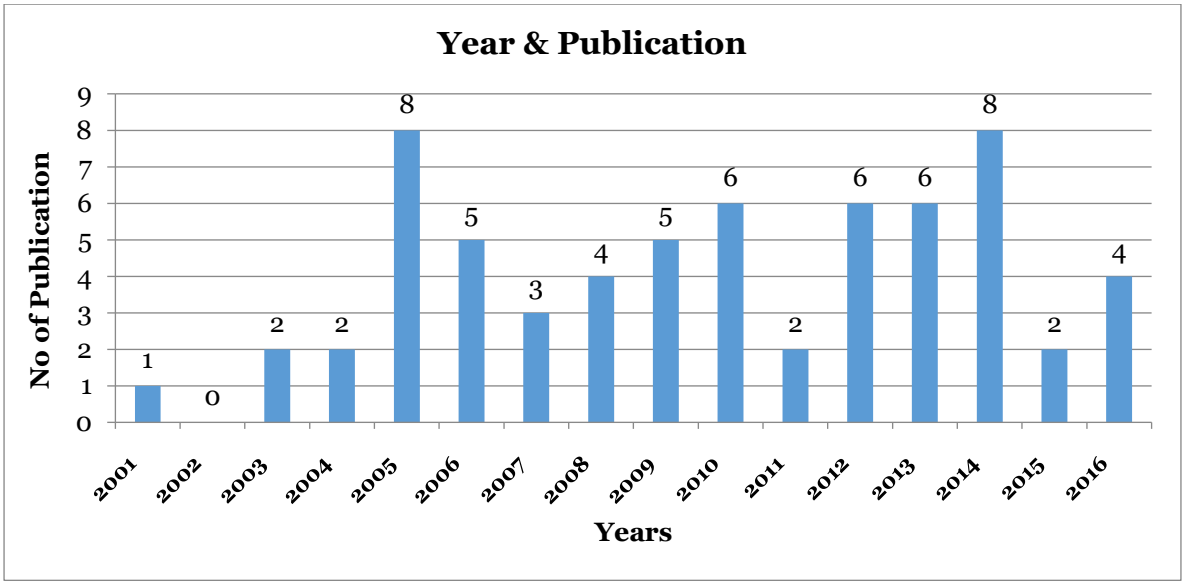


Figure 4. The number of articles by methods over the time

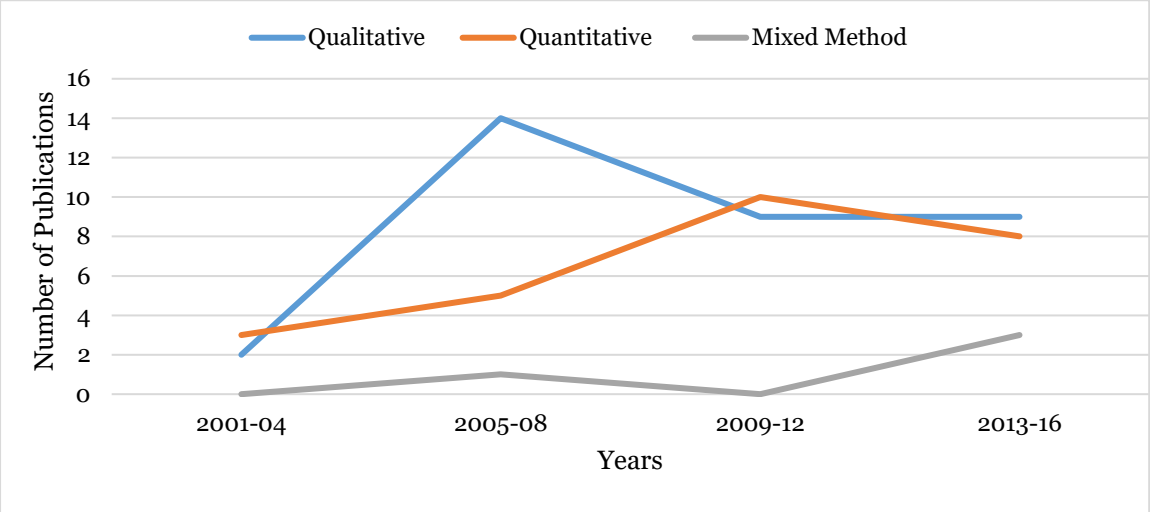


Figure 5. Strategies for terrorism risk and effective-decision making practices for SCRM and security

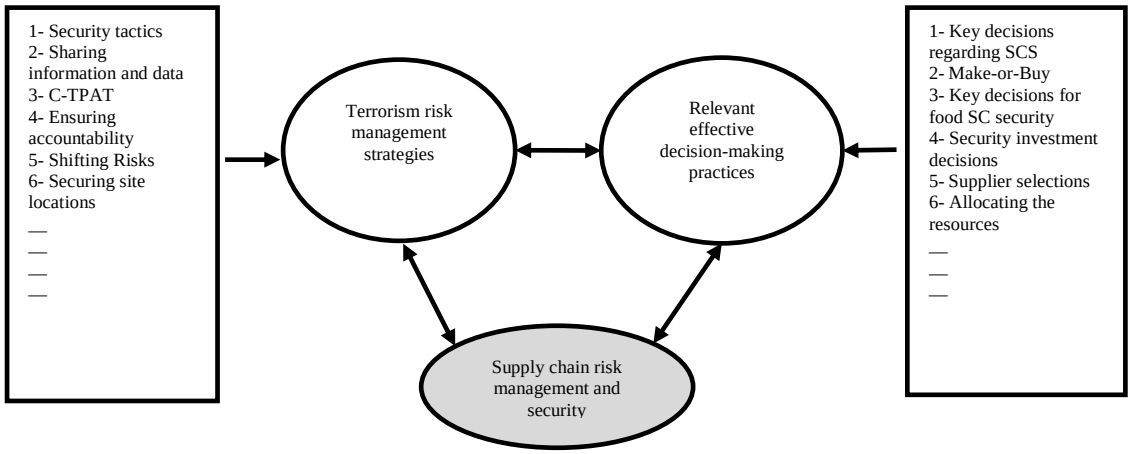


Figure 6. Evaluation of terrorism and SRRM and security related studies (network analysis)

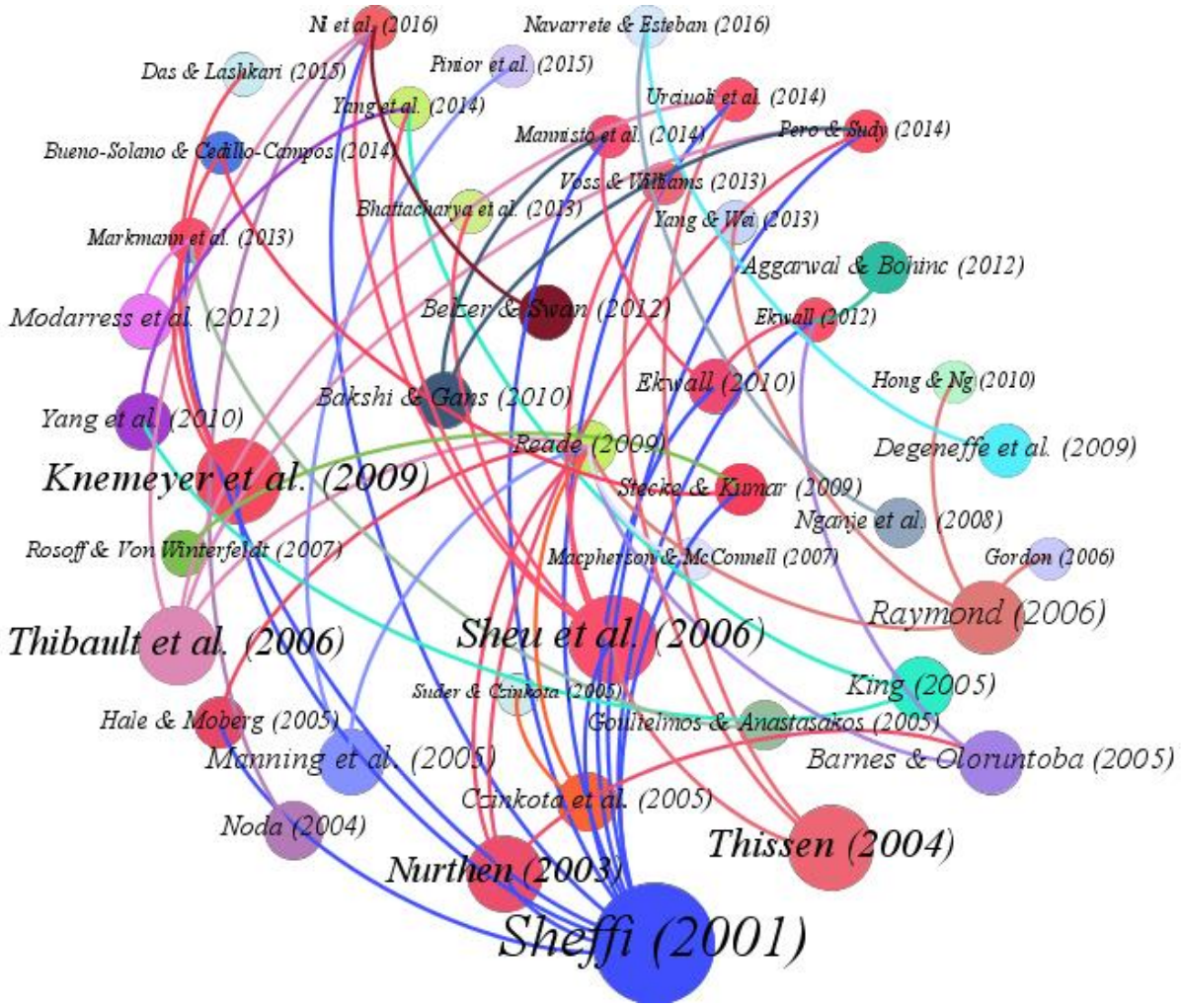
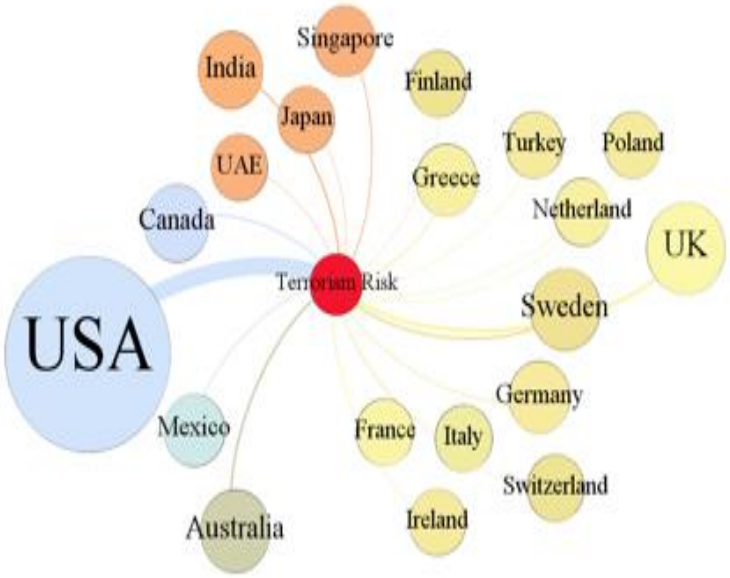


Figure 7. Contributions by types of schools

Figure 8. Contributions by universities, operating from specific countries



Biographies:

Muhammad Naveed Khan is a PhD student at Hull Business School, the University of Hull. He gained his MSc in Financial Management at the University of Hull, UK. Naveed has worked as a lecturer and practised as a Senior Finance Manager in different industries, His research interests are supply chain risk management, supply chain security management, and financial risk management. He can be contacted at mnaveed76@ hotmail.com.

Pervaiz Akhtar is currently Reader and Programme Director of BSc Logistics & SCM at University of Hull Business School, UK. He is also an External/Visiting Professor in Big Data and Analytics, IESEG School of Management (France). Capitalising on over 15 years of academic and industrial experiences from public, private and non-profit-making organizations, his expertise encompasses a vast range of specialised domains from Business Analytics and Data Science to Supply Chain Planning and Control. His research has appeared in leading journals. He is a corresponding author (*) and can be reached at pervaiz.akhtar@hull.ac.uk.

Yasmin Merali is currently Professor of Systems Thinking and Director of the Centre for Systems Studies at the University of Hull Business School. She was Co-director of the Doctoral Training Centre for Complexity Science at the University of Warwick until 2013. Her research draws on complex systems science to study socio-economic systems at all scales in the network economy. Her collaborations include academics across disciplines and practitioners from public, private and third sector organisations. She is an Expert Evaluator for the EU, and received a BT Fellowship and an IBM Faculty Award for her work on knowledge management and complexity.