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ORIGINAL PAPER

# USE OF BIG DATA ANALYSIS TO IDENTIFY POSSIBLE SOURCES OF SUPPLY CHAIN DISRUPTION THROUGH THE DOTMLPFI METHOD

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**ABSTRACT. Backgrounds:** The presented research deals with the investigation of how big data analytics can help predict possible disruptive events in supply chains. The supply chain can be considered a complex system with a wide spectrum of possible sources of internal and external disruptions. Since the individual entities of the supply chains operate in a particular environment and interact with this environment, there is a certain level of mutual interdependency. This set of interconnected interactions within the supply chain will be the unit of analysis.
**Methods:** There are many internal and external sources of supply chain disruption, which opens up the potential application of Big Data Analysis (BDA) as an early warning tool. To analyse the possible application of the BDA to identify sources of supply chain disruptions, we conduct a bibliometric analysis to define an appropriate structure for supply chain risk classification as well as appropriate keywords that make data collection quicker and easier. The DOTMLPFI methodology was used to systematically identify the most relevant risks threatening the supply chains.
**Results:** The proposed research approach creates a possible framework to support the operational sustainability and resilience of the supply chain as a system, toward internal and external disruptions. The research results also point out the most explored attributes of supply chain disruption. The conducted bibliometric research and content analysis support the theoretical framework of using BDA as a possible early warning tool, especially for the identification of possible sources of supply chain disruption. The approach of grouping Big Data sources into categories based on DOTMLPFI groups allows to identify the appropriate keywords for their later BDA analysis. The analytical framework provides a starting point for individual supply chain entities to understand risks and systematically collect the appropriate data in the required structure about them.
**Conclusion:** The complexity of supply chains, together with the increasing possibility of digital applications, requires a new analytical framework for evaluating the overall supply chain, with the possible application of new data sources and analytical approaches regarding the risks threatening the chain. DOTMLPFI methodology allows covering all the relevant categories of supply chain risks, and by proposing relevant keywords and data sources it can help companies to find the appropriate open-source, up-to-date information and be prepared for disruptive events.

**Key words:** Supply chain disruption, supply chain resilience, Big Data analysis, DOTMLPFI method

## INTRODUCTION

Supply chain security and resilience are the key aspects of the long-term sustainability and well-being of current societies. As a complex phenomenon, a supply chain is made up of companies, organizations, and the complex relationships that link those [Rehak et al. 2014]. Therefore, supply chains can be approached from a systems theory perspective. At the same time, current supply chains have to operate in a particularly turbulent and dynamic environment. A very important issue in such circumstances is the supply chain's ability to successfully maintain its operations while adapting to a dynamically changing environment.

The origin of threats to supply chains is most likely to be irregular, catastrophic, or hybrid emerging from hostile intentional or nonintentional activities, e.g. natural or disasters [Freier 2008 p. vii]. Supply chain disruption can happen inside or outside of the supply chain [Narashimhan and Tallurin 2009], intentionally



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or unintentionally [Foltin 2011], in supply chain flows such as material flow, information flow, knowledge flow, control and coordination flow [Neiger et al. 2009]. The consequences of catastrophic events are also investigated by supply chain research teams [Knemaver et al. 2009], similarly to the consequences of socio-economic, political, man-made, and natural disasters [Singh and Singh 2019].

Due to the complexity of supply chains, the number of individual supply chain elements and their interconnections carry an inherent risk [Rehak et al. 2016]. Identification of unexpected events is a prerequisite for the possibility to manage the supply chain resiliently [Stepanek et al. 2013].

The operations and resilience of supply chains can be supported by the application of emerging technologies. Digitalisation helps to optimise processes, create transparency, and monitor the supply chain environment [Bahrami and Shokouhyar 2021; Modgil et al. 2021; Ivanov et al. 2019].

The paper is structured as follows: In the literature review, we interpret supply chains as systems and reveal their vulnerabilities with the possible sources of the supply chain risks. The second part presents the main research goals, the selected methodological approach, and research limitations. Based on the research goal, the third part presents the analytical framework which can be used for supply chain risk classification and an extensive analysis of these risks. The fourth part summarizes the results of the bibliometric analysis and highlights the next possible steps of follow-up research. The originality of the paper was primary in introducing a systematic classification of supply chain risks with possible data sources for prevention.

## COMPLEXITY AND VULNERABILITY OF SUPPLY CHAINS

In the presented research, the supply chain is interpreted as ‘systems theory views organisations as interconnected processes with a high level of integration and intensive information sharing between business processes of the supply chain’ [Fatorachian and Kazemi 2020 p. 3]. Systems thinking enables the identification of system elements, different business processes/actors within the supply chain, and the relationships between them and allows the analysis of the relationships between each system element and its environment.

### Supply chain in system approach

Supply chain design can be very complex given the size of the network and the number of factors that influence the design. The SCOR model approaches supply chains from a process-based point of view and applies six topics along which it analyzes the supply chain entities [Huan et al. 2015]. Since there is no other complex theoretical model that is fully applicable for analyzing supply chain operations, especially risk preparedness from multiple aspects, the DOTMLPFI methodology will be adapted. The DOTMLPFI classification approach is used in the military environment as a mnemonic tool to tackle Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, and Interoperability. Generally, any military planning process at the strategic level should be driven by this acronym, not to forget any important planning aspect on the final operation [Hodicky 2020]. This approach could be applied to evaluate the supply chain operational sustainability and resilience to external and internal sources of disruption.

## RESEARCH GOAL, METHODOLOGY AND RESEARCH LIMITATIONS

Based on the initial problem description and identification of possible supply chain disruptions, we identified a research gap laying in the limited analytical framework, which could help with the systematic identification of the data sources suitable for overall system evaluation of the capabilities and activities that determine the operational sustainability and resilience of the supply chain.

For this reason, the research goal was formulated as to investigate how big data analytics help to mitigate the negative effects in

case of disruptive events threatening the supply chains. The focal research questions (RQ) are:

RQ1: How can supply chain disruptions be systematically analysed from all the relevant aspects?

RQ2: What are the most important keywords to identify the risks which cause disruptions?

RQ3: What data sources are available for companies to collect data on these risks for preventive purposes?

There are many sources in the literature on supply chain disruption and the potential risks to supply chains, but no comprehensive and systematic study has been carried out. The presented research aims to contribute to fill this research gap, and introduce an analytical framework, a structure, which helps the systematic identification of the data sources suitable for general system evaluation of the capabilities and activities that determine the operational sustainability and resilience of the supply chain.

The DOTMLPFI methodology allows for this type of detailed review and integrates the aspects identified in the literature. This DOTMLPFI methodology is primarily used on defence sector as a mnemotechnic tool to help identify suitable conditions, sources, and possibilities to develop and sustain defence capabilities in long-term period. The letters of the abbreviation DOTMLPFI represent the main capabilities areas, when D stands for Doctrine, O for Organization, T for Training, M for Material, L for leadership and education, P for Personnel, F for facilities and I for Interoperability. This approach could be considered as a general approach with possible application to other areas when system capabilities are considered. The purpose of developing an analytical framework in this way is to see for which risks we need to identify data sources that would allow us to build an early warning system.

In DOTMLPFI qualification, the required capabilities of supply chain network [marked as C] could be described (1) [Hodicky and Prochazka 2020]:

$$C_{[t]} = min_i C_i(t),\ i \in I = \{D, O, T, M, L, P, F, I\}, C_i[t] \in \langle 0,1 \rangle \quad (1)$$

The optimal supply chain system composition supposed to reach $C_{[t]}$ is equal to or approaches the value of 1.

Due to supply chain complexity, the presented research will focus on the main risk sources each representing the DOTMLPFI categories for which we propose a relevant data source.

Bibliometric analysis was used as a methodology. The Web of Science (WoS) and Scopus databases were searched for preliminary determined search phrases to thematically structure papers dealing with supply chain disruptions. With this method, we proved the validity of applying the DOTMLPFI methodology which allows to analyse disruptive events from many aspects. The documents were also subsequently searched using the search terms given in Table 1, to see which types of risks are typically focused on in supply chain disruption articles, what keywords were given in the case of the different types and in which direction researchers should focus their future research.

## LINKING THE POSSIBLE SUPPLY CHAIN RISKS WITH BDA DATA SOURCES

Information sharing at the supply chain level is a widely accepted tool for supply chain management [Mentzer et al. 2001]. Sharing the right information with the right actors can provide business benefits to the supply chain, increasing competitiveness. Extensive data analysis plays an important role in predicting these events and mitigating the risks of threats. High quality information can lead to appropriate risk control [Shamala et al. 2017].

Big data is created in multiple organizational processes in high volume, with high velocity and in high variety, which exceeds the capabilities of traditional data processing

systems [Wang et al. 2016]. Big data analysis therefore incorporates skills, technologies, and practices to structure and process data and provide useful information for decision makers [Demeter et al. 2020].

However, BDA can support the resilience of supply chains in several ways. According to Papaodopoulos et al. [2017], Big Data has great potential to optimize recovery strategies and for supply network management. Bahrami and Shokouhyar [2021] consider the greatest achievement of BDA the deep understanding the changes in the business and market environment, which allows companies to prepare for disruptions.

In Table 1 the main categories of risks that threaten supply chains are summarized. The DOTMLPFI framework was used to classify risks and indicate strategic planning areas. This approach should be involved as an integral part of risk management.

The Doctrine category summarises the basic principles of system design in the original DOTMLPFI methodology, similarly to the definition of strategic management, with appropriate strategy formulation, implementation, and evaluation [David 2011]. In the analytical framework that examines supply chains, strategic goals were considered, e.g., UN Sustainable Development Goals 2030 [UN 2022], EU Global Gateway 2050 [EU 2021], and environmental circumstances that determine the operational conditions of the supply chain. Within presented research results, these strategic goals also mean possible impacts and potential threats from the political, social, economic, and natural environment, together with threats from the behavior of competitors and the immediate business environment.

In the Organization section, we identify risks within the organization that may have an impact on the sustainable operation of the supply chain. The Training category summarises the risks arising from the skills or lack of skills of supply chain actors and their key skilled personnel, but also indicates the capability to avoid the potential of losing key personnel. In the Materiel category, we identify risks related to the availability, quality, and lack of materials, resources, products, and services used in the supply chain within the operations and the value-creating process, but also raw materials and spare parts. The Leadership and Education category summarises the risks inherent in supply chain leadership and management. It also includes issues related to the appropriate training of workers. The Personnel theme specifically covers issues related to the availability of human resources, its international mobility, and, in the long term, the consequences of industry 4.0 applications and the possibility of replacing some professions with advanced robotic systems [Cellan and Jones 2019]. It also includes risks related to occupational safety, worker health, and workers' rights. The Facility category includes all risks related to the physical infrastructure of the supply chains and its operation, e.g. ports, airports, maintenance facilities, etc. It also covers information and communication infrastructure, including also hardware, software, and data security. The interoperability group covers the area of the acceptation and follows the international standards, regulations, and recommendations.

The BDA application has significant potential in the identification of disruptive events. In this process, it is necessary to identify disruptive events, their accompanying phenomena, and potential triggers. Due to the breadth of influencing factors, it is appropriate to apply a systematic approach, such as the DOTMLPFI methodology.

As possible data sources, spam or topical filters could be applied to filter important information from available data. By applying appropriate filters and classifiers, it is possible to convert unstructured data to structured data, allowing further analytical steps. A possible approach to the description of exemplary data sources according to DOTMLPFI is shown in Table 1. In the following table, keywords were assigned to the risks identified in each category of analysis, which was used to conduct a systematic analysis of the literature and identify the topics that are most emphasized in articles on supply chain disruption.

Table 1: Example BDA sources and keywords of disruption in the DOTMLPFI classification

Source: Own work

| Category | | Risk types (BCI, 2021, ISO 31000) | Source of Big Data | Examples of Category Keywords |
|---|---|---|---|---|
| **Doctrine [Strategy]** | | Extreme weather events<br>Natural disaster<br><br><br>Regulatory changes<br>Political violence/ civil unrest<br>Enforcement by regulator<br>Political change<br>Exchange rate volatility<br>Energy price shock | <br>Global Disaster Alert and Coordination System | design<br>network<br>natural disaster<br>threat |
| **Organization** | | Economical integrity<br>Stability and credibility of trade relations<br><br>Overall economic stability<br>Interdependency risk<br>Organizational culture difference as risk | Logistics Performance Index (LPI)<br><br><br>Atlas of Economic Complexity<br><br>Globe of Economic Complexity | agility<br>viability<br>dynamics |
| **Training** | | Lack of talents/ key skills<br>People, skills and availability risks | Labor Force Index<br>Poverty Rates<br>GINI Index<br>Shared Prosperity | flexibility<br>collaboration |
| **Materiel** | | Supply chain disruption<br>Interruption to utility supply<br>Natural resources shortage<br>Product safety recall | EM-DAT | business continuity<br>resilience |
| **Leadership and education** | | Leadership risk<br>Control risk | post, news, reports | management<br>project |

| | | | | |
|---|---|---|---|---|
| | | Agency risk<br><br>Decision maker risk | Fluctuation % of C-level managers at supply chain companies | |
| **Personnel** | | Non-occupational disease<br>Health incident<br>Safety incident | post, news, reports<br><br>Number of safety incidents in the supply chain in a given period of time | human mobility<br>human resources<br>labor force |
| **Facilities** | | IT and telecom outage<br>Cyber-attack and data breach<br><br><br><br>Introduction of new technology<br>Critical infrastructure failure<br>High cost of borrowing<br>Lone attacker / active shooter incident<br>Malfunction of the Facilities | Cyber-threat real-time map<br>OTCAD<br><br>Cyber-threat real-time map<br>Digital Attack Map<br><br><br>World Container Index<br>Terrorist Attacks<br><br>Marine Traffic<br>Flight Radar – Live Air Traffic | security<br>sustainability<br>location<br>network |
| **Interoperability** | | Lack of IT interoperability<br><br>Disruption to interoperability between trade partners (e.g. visibility and transparency)<br>Non-compliance with international standards | Logistics Performance Index (LPI) | flexibility<br>coordination<br>standard |

## RESULTS

To identify the thematic structure of articles dealing with supply chain disruptions, a search has been conducted. Using the search string <("supply chain" or 'distribution chain' or "logistics") and ("disruption" or 'threat' or "risk")> in the WoS database, a content analysis was carried out to examine the disciplinary approaches of articles and studies on supply chain disruption. The first search resulted in 19,385 publications, which, after filtering out the natural sciences and other disciplines that did not fit the current topic, 14,926 papers left. As WoS analytics can only handle 1000 articles at a time, the studies with the highest citation counts (Clarivate, 2022) were selected for analysis. The studies are categorised thematically as shown in Figure 1.


Fig. 1 Thematic structure of articles in the WoS database covering the field of supply chain disruption.

Source: own work

Once the thematic structure of the articles on supply chain disruption was identified, it became apparent that the topic indeed requires the kind of complex approach that the authors have proposed through the DOTMLPFI methodology mentioned earlier. Doctrine includes the economic, business and natural environment elements, while Organization, Training, Personnel and Leadership can also be linked to the business and management themes mentioned in Fig. 1. Materiel and Facility can be covered by the Engineering Industrial, Manufacturing, and Electrical Electronics blocks, while Interoperability and Facility can correspond to Computer Science Information System and Interdisciplinary Applications. This demonstrates that supply chain disruption analysis must simultaneously consider several aspects to help identify all relevant risk factors, and the DOTMLPFI is a suitable and detailed structure to summarise the analytical aspects.

As a second step, a bibliometric analysis has been carried out using also the databases of Web of Science and Scopus. In the first step, the keyword <("supply chain disruption")> was applied to select articles, conference papers, book chapters, etc. which deals with the focal topic. After merging the databases and filtering out the redundancies with R Studio, 1 112 publications remained. In the third step, the list of keywords is applied, which was provided in Table 1. These keywords have been used to reveal the approach of the selected papers in analysing supply chain disruptions.

The following graph (Figure 2) shows the frequencies of keywords in the publications, recognizing that one paper might address multiple supply chain threats.

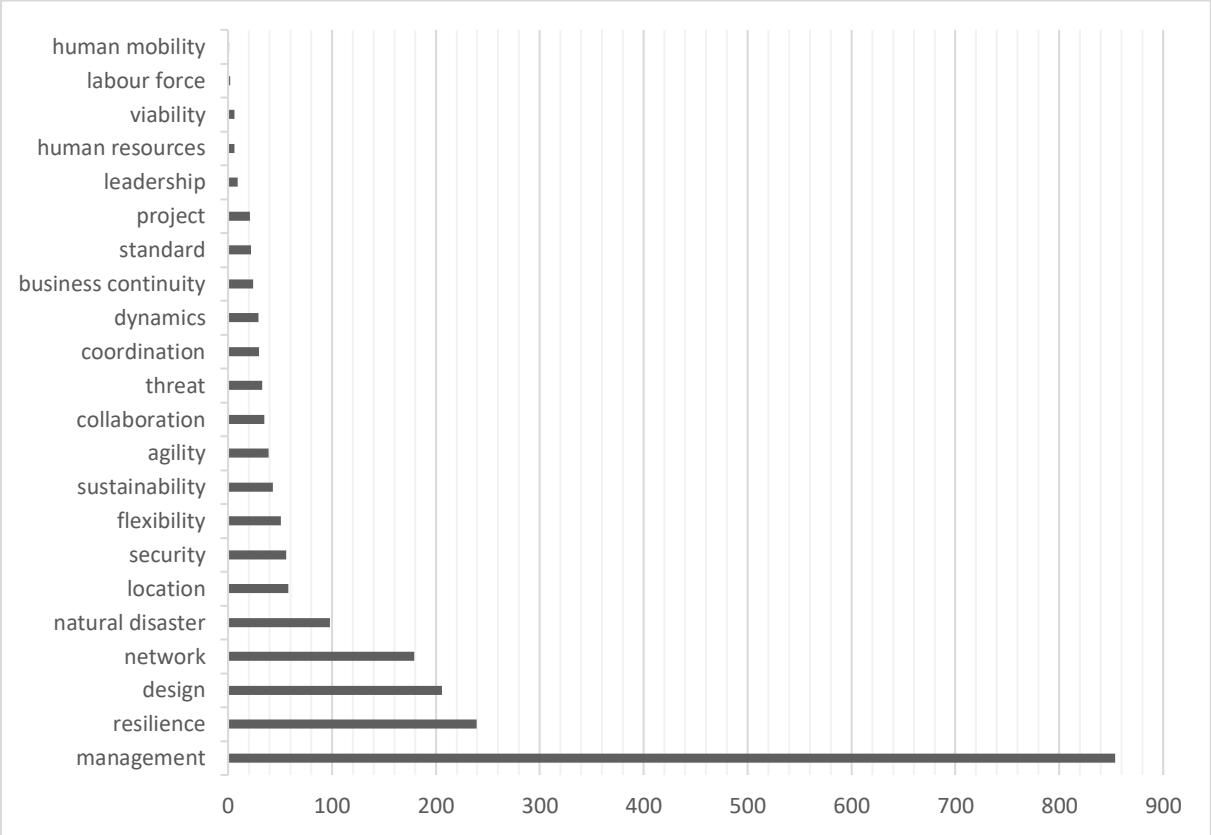


Fig. 2 Frequency of keywords addressing different types of supply chain disruptions

Source: own work

The chart says that the most popular approach when researchers deal with supply chain disruptions is to analyze how to manage them. The next extensively researched areas are how to become resilient to disruptive events and how to design and operate a network that decreases the effects or the exposure of such events. Analyses like this allow further researchers to orient their exploratory efforts towards the risks less discovered and described yet.

## CONCLUSIVE REMARKS

The research results systematically examine the possible framework for supporting the operational sustainability and resilience of supply chains and initiate a framework that helps to systematically analyse the potential risks causing supply chain disruptions.

The theoretical contribution of the research lies in structuring supply chain risks and, from a practical point of view, proposing a framework for collecting data sources for early warning systems that may be necessary to identify these risks, prevent them, and detect disruptions in time.

A structured risk categorisation was developed as an analytical framework, in which a possible grouping of risk factors was proposed along the DOTMLPFI categories, applied from the area of defence capability planning. Since the risks that threaten supply chains are very diverse, there is a strong need for a structured categorisation of these risks. If a methodology, such as the DOTMLPFI, can be found to do this systematically, it can be used to identify data sources from which information can be obtained about the threats themselves. The results of the bibliometric analysis, which was conducted to see the thematic structure of the articles and studies indexed in the WoS and Scopus databases dealing with supply chain disruption and threats, supported that DOTMLPFI is a wide-ranging methodology and is appropriate as a framework. It was proved that DOTMLPFI methodology

allows covering all the relevant categories of supply chain risk.

The secondary objective of the analysis was to identify the most popular approaches to supply chain disruptions and to risk exploration and provide keywords that reveal the areas most researched and less researched, as well as propose possible bid data sources that companies can reach and can build early warning system on, becoming prepared to the risks listed.

The presented research results create an initial theoretical framework for the next research phases, where selected keywords will be tested and further developed based on real situation and disruption within supply chains. These next analytical steps should be focused on BDA sources, grouped in DOTMPFI, through identified keywords and their possible connection to sources of supply chain disruption.

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