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## Reconfigurable Supply Chain Performance: A Bibliometric Analysis

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**Abstract.** Market disruptions and changes make the assessment process of supply chain performance more complex. Hence, the implementation of key indicators to evaluate the ability of the supply chain to cope with these disruptions has received increasing attention. Reconfigurability provide the ability to quickly change supply chain structure and functions by increasing its responsiveness and flexibility to deal with disruptions. This paper aims to analyze the contributions of researchers in the field of performance evaluation under supply chain disruption. A bibliometric analysis is conducted to identify publications dealing with performance evaluation under supply chain disruption field. The analysis started with the selection of articles using the following keywords (Reconfigurability, Evaluation, Supply Chain). Then, the selected articles were analyzed based on the criteria of the bibliometric analysis. The paper aims to capture the current research and potential research related to the evaluation of performance in reconfigurable supply chain under disruption.

**Keywords:** Reconfigurable Supply Chain, Performance Evaluation, Supply Chain Disruption, Bibliometric Analysis.

### 1 Introduction

The need to adapt to market changes requires the implementation of new supply chain redesign strategies. Market disruptions and changing customer requirements are causes that drive managers and decision makers to restructure their supply chains. Reconfiguration of supply chains presents an effective solution to meet new market needs [1, 2]. The reconfigurable supply chain is a flexible chain able to change its structure with minimum resources [3]. It refers to changing the structure and functionality of the supply chain in a cost-effective, responsive, sustainable and resilient manner [4]. The reconfigurability assessment is an important phase to measure the ability of the supply chain to cope with disruptions and meet new market requirements [5].

Several concepts have been discussed in the literature that refer to the ability of the supply chain to adjust its structure and functions with new market needs such as agility, flexibility, etc. [3] consider agility and flexibility as advantages of implementing a reconfigurable supply chain. Reconfigurability is characterized by

modularity, convertibility, integrability, diagnosability, scalability and customization that reduce the effort of reconfiguration. These characteristics can be considered as performance indicators to evaluate the reconfigurability of supply chains [5]. Nevertheless, the lack of works elaborated in the area of reconfigurability evaluation in the network/supply chain level leads us to study the different aspects and concepts that can be addressed in the process of reconfigurable supply chain evaluation. The aim of this paper is to study the concepts addressed in the context of the evaluation of reconfigurable supply chains and to analyze the differences between them and to respond to the following question:

- *What are the criteria that can be considered to evaluate supply chain performance in the context of reconfiguration?*
- *How can the supply chain's ability to cope with disruptions be assessed?*

*Answering this question provides a way for managers and decision makers to have visibility into the ability of their supply chain to resist and cope with disruptions. Indeed, it requires an in-depth study of the performance indicators that can be used to better evaluate the performance of the supply chain in the context of reconfiguration. For this purpose, a bibliometric analysis has been conducted in order to gather the concepts used in the context of the above problematic and to identify the most relevant performance indicators that provide managers the possibility to evaluate and improve the performance of their supply chain in a context of disruption.*

The rest of the paper is organized as follows. In Section 2, we present a definition of the reconfigurability evaluation. The research methodology is described in Section 3. Section 4 presents the analysis and the obtained results of the bibliometric analysis. Section 5 concludes the paper.

## 2 Reconfigurability Evaluation

The evaluation of the ability of the supply chain to change its current configuration by reducing the effort of reconfiguration is called the “Reconfigurability Evaluation”. Reconfiguration can be a strategy for improving supply chain performance [6]. The concept of supply chain reconfiguration is defined as the structural and functional change of the supply chain. It concerns the change of supply chain configuration that is considered as a set of nodes and connections. The need for reconfiguration can be triggered by a disruptive event that forces decision makers to quickly react to ensure the functioning of the supply chain, or by a decision made by decision makers to ensure the continuous improvement of their supply chain. The need for reconfiguration is generally due to a hazard or disruptive event that causes a supply chain failure. Then the reconfiguration can be deployed within the innovation strategy to improve the operational and organizational performance of the supply chain without being affected by an external event. Reconfiguration is linked to several levels of application (network, system, plant and machine) [7, 8]. Indeed, each level of application has its own parameters and attributes allowing to judge their degree of reconfigurability and to choose the best configuration that changes its structure and functions easily and quickly. The reconfigurability characteristics (modularity, integrability, convertibility, diagnosability, scalability and customization) can be

relevant indicators for the evaluation of supply chain reconfigurability [5], thanks to their effective roles in reducing the reconfiguration effort [9, 10]. Several indicators have been used to measure the degree of reconfigurability in the different previously mentioned levels such as lead time, reconfiguration time and cost, reliability, productivity, etc. Several concepts can describe this ability, such as agility, flexibility, adaptability, alignment, etc. The performance of the supply chain is significantly dependent on the ability to adapt to the dynamic environment [11]. These can be indicators to measure the ability of the supply chain to cope with market disruptions.

### 3 Research Methodology

Bibliometric analysis is defined as a research collection technique that studies a specific research area quantitatively using mathematical and statistical methods [12–17]. Also, it is the quantification of bibliographic information for use in analysis [18]. It is used particularly in analyzing publications' content and network [19]. The bibliometric has advantages in predicting future trends of disciplines [20]. The Scopus database is used for our literature search. As indicated in [21], it is “the largest abstract and citation database of peer-reviewed literature: scientific journals, books and conference proceedings”. First, a set of keywords was used to determine the application domains of the reconfigurability concept and to select the words indicating the reconfigurability evaluation indicators. Secondly, this search was restricted by using the "title, abstract, keywords" search in Scopus database to determine the most important aspects related to the evaluation of the supply chain reconfigurability. The initial search yielded 2325 articles. The minimum number of occurrences of a keyword was set at 10. Only 88 of the 6500 keywords reached this threshold. The keywords "Reconfigurable", "Supply Chain", "Evaluation" and "Performance" were used to obtain a first list of articles using them. The second search was more precise and found 1149 papers using "Supply chain", "Reconfigurability" and "Criteria" as keywords. Only 101 keywords reached the 5 keyword threshold out of a total of 3324. The obtained results are summarized in Table 1. The VOSviewer software is used to visualize and explore maps based on network data obtained. The steps of the proposed approach are presented in Fig. 1.

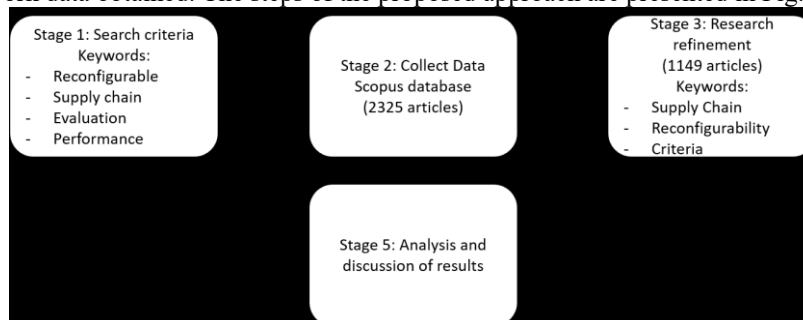
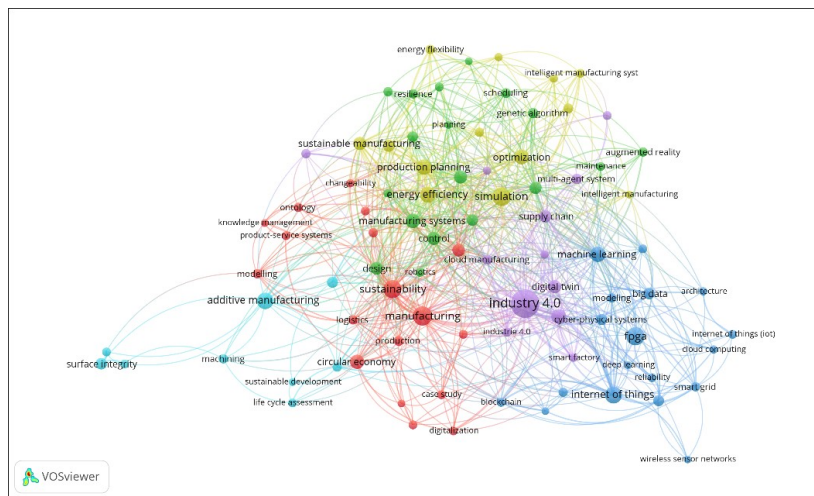


Fig. 1. Research methodology

## 4 Results and Analysis

### 4.1 The Obtained Results

The first research aims to identify the concepts used in the literature in the context of supply chain performance evaluation. This analysis allowed to identify 6 clusters that indicate the 5 aspects referring to the ability of the supply chain to resist and cope with disruptions. Then, by including the keyword "criteria", our first search was consistent with the results of the second search, which allowed to identify 5 relevant indicators to evaluate the performance of the supply chain in the context of reconfiguration. The first search results generated six clusters as shown in Fig. 2. This clustering groups all the selected keywords into clusters that designate mainly the domain of application and the aspects related to reconfigurability. The clusters in red and light blue concern the first aspect called "changeability" which is related to product development and sustainability. The second aspect called "Resilience & Robustness" relates to the cluster in green. The cluster in blue represents the third aspect called "Reliability". The fourth aspect is deduced from the yellow cluster and is called "Flexibility". The last cluster in purple is the fifth aspect called "Agility".



**Fig. 2.** Co-occurrences of keywords of evaluated papers from the first search

#### The changeability

The Changeability aspect is related to the product development at the level of the manufacturing system. Indeed, production is an important enabler to ensure a changeable supply chain. The implementation of a changeable supply chain requires the coordination of production capacities [22]. The dynamism of the production leads to the necessity of a changeable organization and the differentiation of the products to

ensure the sustainability [23]. The implementation of a changeable system provides flexibility and reconfigurability [24]. In fact, the changeability allows to evaluate the ability to change the production capacity to quickly and economically adjust to the new requirements.

### **The Resilience & Robustness**

The Resilience & Robustness aspect designates the ability of the supply chain to resist and avoid change and succeed after failure. [25] consider that resilience and avoidance are the two dimensions that allow to judge the degree of robustness of the supply chain. The ability of the supply chain to succeed after a failure refers to resilience [26], which means that the supply chain is able to change and reconfigure its structure and resources to achieve the expected functions [27]. Resilience & Robustness can be created to mitigate threats to organizational performance caused by market disruptions [28]. From a reconfiguration perspective, Resilience and Robustness are important indicators because they allow judging the ability of the supply chain to withstand or avoid failures (before the failure occurs) or to return to its normal state with minimal delay (after a failure occurs).

### **The reliability**

The Reliability aspect refers to the ability of the supply chain to meet the needs of customers within the required conditions. Reliability is a key indicator for quantifying risks and uncertainties in the supply chain [29]. It unifies the fuzzy and random meaning in a dynamic environment [30]. [31] consider reliability as a key indicator in the performance evaluation of reconfigurable systems as it has a positive impact on responsiveness. In the process of evaluating the reconfigurability of supply chains, reliability increases the visibility of the supply chain as well as the quality of service with customers. The implementation of new technologies, especially those of digitalization, allows to improve the reliability of the supply chain, especially the reliability related to the information flows.

### **The Flexibility**

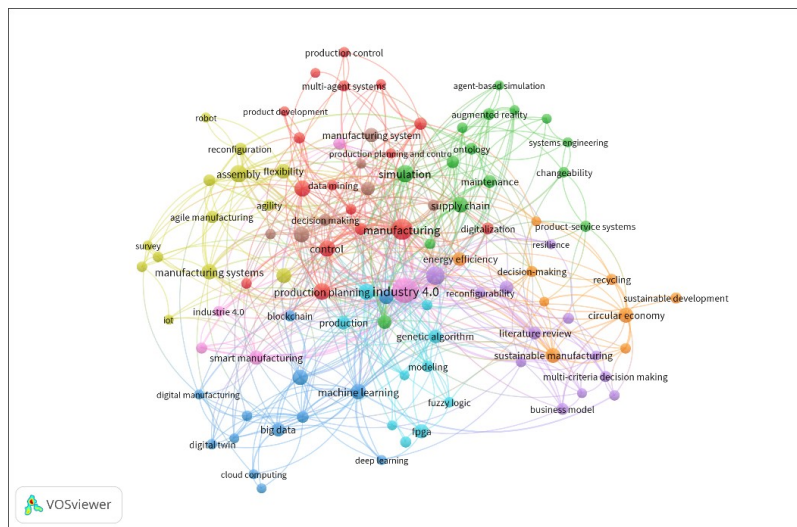
The flexibility aspect designates the ability of the supply chain to quickly respond to changing customer requirements. It is considered as an advantage of reconfigurable supply chain [3]. Flexibility allows to deal with market uncertainty [32]. The flexible supply chain is defined as the ability to correctly and quickly react to changes by restructuring the chain cost-effectively to cope with market disruptions and uncertainties [33–35]. In reconfigurable supply chains, as flexibility can be considered as an advantage of reconfigurability, it is necessary to measure the ability of the supply chain to respond to new customer requirements in an uncertain environment to improve reconfigurability.

## The agility

The agility aspect is closely related to the flexibility aspect. This aspect is defined as the ability to quickly react to short-term changes in demand or supply [36]. Responding quickly to new requirements requires the integration and sharing of information within collaboration strategies between all actors in the supply chain [37–39]. Agility is seen as a benefit of the reconfigurable supply chain through new technologies that allow engagement with innovative supply chain partners [3]. [37] consider that without flexibility, the supply chain cannot be agile. As part of reconfiguration, the measurement of agility allows to assess the ability of the supply chain to survive with new challenges and engage in new market opportunities.

## 4.2 Discussion

Evaluating the performance of a reconfigurable supply chain essentially requires measuring its degree of reconfigurability. This measurement consists of assessing the ability of the supply chain to change its structure and functions to cope with market disruptions and meet new customer requirements. The results of the bibliometric analysis showed several elaborated concepts that designate the supply chain's ability to adapt to new market needs (Changeability, Resilience & Robustness, Reliability, Flexibility and Agility). Furthermore, a more precise research was developed to verify the concepts related to the evaluation of the reconfigurability of supply chains as explained in the previous section as shown in Fig 3.



**Fig. 3.** Co-occurrences of keywords of evaluated papers from the restricted search

The results of this research gave the same concepts found in the first research. This shows the importance of the aspects previously mentioned in the evaluation process

of the reconfigurable supply chain by integrating the different levels such as the manufacturing system, the machine, the product, etc. In the last few years, these concepts have been addressed in the context of new technologies such as industry 4.0, digitalization, cyber physical systems, machine learning, artificial intelligence. The 5 aspects found also showed the importance of sustainability in improving the reconfigurability of supply chains.

The assessment of the supply chain's ability to cope with disruptions and change its configuration to adapt to new changes requires the consideration of indicators to judge this ability. The main changes are related to the implementation of new technologies. Although our analysis shows the relevance of the 5 aspects found, it will be interesting to study how these aspects can be ensured and improved by integrating Industry 4.0 technologies. Indeed, the parameters for evaluating the supply chain's ability to change must include the characteristics of Industry 4.0 and digitalization, namely the reduction of truck time, the time between the need for reconfiguration and its realization, the increase in visibility of information, promoting adaptation with new changes, etc. On the other hand, it is recommended to integrate the concept of sustainability and its aspects in the parameters of performance evaluation of the supply chain under disruption. Indeed, the improvement of changeability, resilience & robustness, reliability, flexibility and agility must include other aspects, in this case the aspects of Industry 4.0 and its positive impact on sustainability while promoting the possibility of easy reconfiguration.

## 5 Conclusion

In this article, a study of the aspects and concepts treated within the context of the evaluation of reconfigurable supply chains was elaborated. Based on a bibliometric study, an analysis has been carried out through two searches of papers dealing with the evaluation of reconfigurable supply chains.

The first study gave the results of five essential aspects related to the evaluation of reconfigurability (Changeability, Resilience & Robustness, Reliability, Flexibility and Agility). These aspects allow an effective assessment of the supply chain's ability to cope with disruptions and meet new market requirements. The second, more precise research validated the five aspects identified above. This study showed the crucial role and the high dependence between these aspects and Industry 4.0 technologies in the supply chain reconfiguration strategy, as it is the most common keyword found in the researches elaborated. Thus, the latter must integrate the concept of sustainability to meet its requirements. Thus, the guarantee of the six characteristics of reconfigurability (modularity, convertibility, integrability, diagnosability, scalability and customization) provides a reconfigurable supply chain and has a crucial role in ensuring changeability, resilience & robustness, reliability, flexibility and agility.

The proposed approach has two main limitations. First, the lack of detail on the parameters and metrics allowing to quantitatively measure the five aspects previously mentioned. Secondly, it is recommended to consider the interrelationships between



these five aspects in order to better optimize the model of evaluation and improvement of the supply chain's ability to cope with disruptions.

As a perspective, we propose to study the evaluation of reconfigurable supply chains in the area of Industry 4.0.

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