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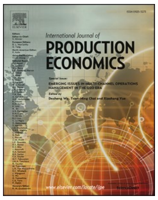

Editorial

Exploring supply chain structural dynamics: New disruptive technologies and disruption risks

ABSTRACT

We discuss recent developments in exploring supply chain structural dynamics. We focus on both positive (i.e., new disruptive technologies) and negative (i.e., disruption risks) triggers of the structural dynamics in complex supply chain networks. We discuss papers in the special issue which focus on supply chain structural dynamics using different methods, collating and presenting recent research in the field. In particular, the ripple effect, blockchain, network resilience, data analytics, and service platforms have been identified as the leading research directions.

Supply chains are complex, dynamic network systems that evolve over time and change their size, shape and configurations (Gross et al., 2018; MacCarthy et al., 2016). Supply chain structural dynamics theory studies changes in network design and topology and develops methods to manage and optimize the supply chain processes when experiencing structural changes (Ivanov et al., 2010). Supply chain structural dynamics can be considered in light of both positive and negative changes, such as new disruptive technologies (e.g., blockchain) or disruption risks (e.g., natural disasters and the ripple effect (Dolgui et al., 2018)), respectively. For example, Industry 4.0, service and manufacturing platforms, and additive manufacturing are driving changes in supply chain structural designs, i.e., the structures of supply chains are be adapted to new technology and innovations (MacCarthy et al., 2016; Sokolov et al., 2020; Fragapane et al., 2020; Frank et al., 2019; Tang and Veelenturf, 2019; Ivanov et al., 2020). Severe disruptions such as global pandemics (e.g., COVID-19 virus outbreak) or natural disasters may result in the temporary unavailability of some suppliers, or even of large supplier clusters (Boin et al., 2010; Tang and Musa, 2011; Dasaklis et al., 2012; Pournader et al., 2020; Ivanov 2020a; Queiroz et al., 2020). In such a case, the structural design of the supply chain is forced to change. In addition, sharing and circular economies are also changing value chain structures. Thus, both strategic structural transformations and operative, event-driven structural reconfigurations are being encountered more frequently.

The management and optimization of structural dynamics plays a crucial role in determining a firm's competitiveness in the markets. This research stream has also been extended by coining two new theoretical lens, i.e., supply chain viability (Ivanov 2020b; Ivanov and Dolgui, 2020) and supply chain reconfigurability (Dolgui et al., 2020). Moreover, the Covid-19 virus outbreaks and the global pandemic are likely to result in wide ranging structural changes to global supply networks, making the topic of this Special Issue very timely.This Special Issue has sought to attract new research in supply chain structural dynamics, considering disruptions in supply chains from both positive and negative perspectives. Examples of positive disruptive technologies and paradigms include:

- Blockchain and supply chain structural dynamics
- Industry 4.0 and supply chain structural dynamics
- Sharing and circular economy and supply chain structural dynamics
- Firm's organizational transformation (e.g., mergers&acquisitions, industrial symbioses) and supply chain structural dynamics
- Digital technology innovation (e.g., cloud manufacturing platforms or supply chain visibility) and supply chain structural dynamics
- Sustainability and supply chain structural dynamics.

However, disruption risks cause negative changes in supply chain structural dynamics:

- Capacity disruptions and supply chain structural dynamics
- Disruption propagation (i.e., the ripple effect) and supply chain structural dynamics
- Resilience and supply chain structural dynamics
- Recovery and supply chain structural dynamics
- Proactive control and supply chain structural dynamics.

A firm's competitive advantages strongly depends on the adoption of new disruptive technologies, such as Industry 4.0, Blockchain, Internet of Things, development of supply chain sustainability, and increasing resilience in light of more and more frequent and severe disruption risks. As such, new research is needed to advance our understanding of the place, role, and impacts of new technologies in the further development of digital and resilient supply chains with efficient and sustainable resource utilization (Dubey et al., 2019a,b, Ivanov et al., 2019, Ivanov and Dolgui, 2019, Babich and Hilary, 2020).

Notably, supply chain structural dynamics is encountered in multiple structures such organizational, functional, information, financial, technical and product structures, i.e., it can be looked at from different perspectives and studied by methods covered in different disciplines. In other words, we encounter multi-structural supply chain dynamics

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(Ivanov et al., 2010). Besides, structural dynamics appears at strategic, tactical and operative decision-making levels. We summarize different dimensions of supply chain multi-structural dynamics in Table 1.

At the strategic level, supply chain structural dynamics is triggered by long-term disruptions which may be both positive (i.e., new technological developments) and negative (i.e., long-term market disruption due to a political or financial crisis). Examples include re-design of facilities and supply networks in the organizational structure (Silbermayr and Minner, 2014; Yildiz et al., 2016; Yu et al., 2019), re-allocation of functions in the functional structure (e.g., a logistics company takes over some retail activities), information infrastructure re-design (e.g., formation of cloud manufacturing platform in the supply chain) (Liu et al., 2019; Rossit et al., 2019; Sokolov et al., 2020), re-design of supply chain financial flows, product re-design, and re-design of technical equipment (e.g., introduction of autonomous mobile robots).

At the tactical level, supply chain structural dynamics is triggered by medium-term disruptions, e.g., as a reaction to a natural disaster or a cyber-attack. Examples include resilience and Ripple effect analysis in the organizational structure (Ivanov et al., 2014; Ambulkar et al., 2015; Garvey et al., 2015; Hosseini et al., 2019; Li et al., 2019; Tan et al., 2019; Xu et al., 2020), supply chain plan reconfiguration in the functional structure (Elluru et al., 2019; Pavlov et al., 2019; Sawik, 2020), information system reconfiguration, adjustment of payment and contracting mechanisms (Shen et al., 2019), product postponement and some modernization of technical equipment. Unlike the strategic structural dynamics, which result in long-term, irreversible changes in the supply chain, structural dynamics at the tactical level changes the supply chain for some period of time to overcome a medium-term disruption (Ivanov et al., 2019). After the recovery, the supply chain structures may return to normal ones.

At the operative level, supply chain structural dynamics is triggered by some operational oscillations. This kind of structural dynamics is less obvious than at the strategic and tactical levels. Most of the operative oscillations can be recovered without any significant structural changes (Paul and Rahman, 2018; Lücker et al., 2019). However, some operative recovery actions can involve structural dynamics also. For example, the use of a backup supplier can help to mitigate some temporary material shortages, which results in changes in the supply structures, even if for a short period of time (Sawik, 2013). Within the functional structure, stability analysis and Bullwhip-effect control may be used to understand the impact of and react to some inventory and lead-time oscillations (Wang and Disney, 2012; Spiegler and Naim, 2017; Demirel et al., 2019). Product substitution and some temporary re-assignments of production lines (Zennaro et al., 2019, Battaïa et al., 2020), e.g., as a reaction to demand fluctuations might be used in the product and technical structures, respectively (Lu et al., 2011; Gupta et al., 2020). Unlike the strategic and tactical structural dynamics, the structural dynamics at the operative level changes the supply chain for a shorter period of time to overcome some short-term oscillations. After recovery, the supply chain structures will typically return to a previous state.

Notably, there are many situations when structural dynamics analysis involves the interconnection of different decision-making levels. For example, strategic decisions on supply chain re-design may be driven by the tactical and operative dynamics across the structures (Klibi and Martel, 2012; Brintrup et al., 2015; Wamba et al., 2015; Altay et al., 2018; Bier et al., 2019). Moreover, dynamics can be dispersed across different structures. Examples of such mutual interrelations include, but are not limited to, integrated dynamics at the interfaces of organizational and financial structures (Wang and Yu, 2020; Gupta et al., 2020), organizational and product structures (Lu et al., 2011), technical and information structures (Ivanov et al., 2019), and functional and organizational structures (Sawik, 2017).

This Special Issue has sought to focus on supply chain structural dynamics from a multi-methodological perspective, collating and presenting recent research in the field. We received 39 submissions and selected 10 papers for publication subject to a rigorous peer-review process. Papers in this Special Issue represent a variety of methodologies and research paradigms, including mainstream supply chain and operations management research, network theory, graph theory, control, dynamical systems theory, game theory, optimization and simulation, surveys, and case-studies.

1. Ripple effect and network resilience

The paper "*Exploring Supply Chain Network Resilience in the Presence of the Ripple Effect*" by Li and Zobel (2020) elaborates on the ripple effect, i.e., disruption propagation and the subsequent structural network dynamics in the context of multi-dimensional quantitative resilience assessment. The authors present a comprehensive analysis of how network structure and node risk capacity influence different aspects of supply chain network resilience. In particular, the results show that the influence of network type on resilience tends to be more significant in the short-term than it is in the longer-term, given the ripple effect. Moreover, resilience can be improved more effectively by enhancing node risk capacity than by adjusting network structure.

2. Resilience and structural dynamics

Dixit et al. (2020) present a paper "*Assessment of pre and post-disaster supply chain resilience based on network structural parameters with CVaR as a risk measure*" that analyses dependencies of supply chain resilience on structural parameters and their dynamics. Using an empirically-grounded dataset, the authors compute resilience as a compounding function of density, centrality, connectivity, and network size. Using a conditional-value at risk (CVaR) approach, the authors show that firms with the lowest supply network density and centrality and the highest connectivity and network size exhibit the highest resilience.

3. Inventory control and ripple effect

Garvey and Carnovale (2020) analyse inventory control under

Table 1
Matrix of supply chain multi-structural dynamics.

Decision-making levels	Supply chain structures					
	Organizational	Functional	Information	Financial	Product	Technical
Strategic (triggered by long-term disruptions and tactical-operative dynamics)	Re-design of facility and supplier networks in the supply chain	Re-allocation of functions in the supply chain	Re-design of supply chain information infrastructure	Re-design of supply chain financial flows	Product re-design	Re-design of technical supply chain equipment
Tactical (triggered by medium-term disruptions)	Supply chain resilience analysis and Ripple effect control	Supply chain re-planning and reconfiguration	Information system reconfiguration	Payment schemes and contract adjustments	Product postponement	Modernization of technical equipment
Operational (triggered by short-term oscillations)	Dual sourcing and backup suppliers	Supply chain stability analysis and Bullwhip effect control	Information coordination adjustments	Cash-flow re-directions	Product substitution	Operative re-allocation of production lines

conditions of the ripple effect and structural dynamics in their paper "*The Rippled Newsvendor: A New Inventory Framework for Modelling Supply Chain Risk Severity In The Presence of Risk Propagation*". The authors propose a new version of the single-period newsvendor model – the "Rippled Newsvendor" – with supply chain severity as the primary objective while taking into account network structure dynamics due to disruption propagations. They utilize a Bayesian Network approach whereby the conditional probability distributions are functions of the inventory ordering decisions. The results help to show the behavior of the objective function as well as to gain insight into the potential optimal ordering policies of this new model.

4. Data analytics

Dubey et al. (2020) focus their paper "*Big data analytics and artificial intelligence pathway to operational performance under the effects of entrepreneurial orientation and environmental dynamism: A study of manufacturing organisations*" on the role of entrepreneurial orientation on the adoption of big data analytics powered by artificial intelligence and operational performance. The authors use the dynamic capabilities view of firms and contingency theory to develop and test their model. The results provide novel insights on the dynamic use of firm capabilities utilizing new disruptive technologies.

5. Service platform operations

Choi et al. (2020) propose in their paper "*Information Disclosure Structure in Supply Chains with Rental Service Platforms in the Blockchain Technology Era*" a stylized duopoly model to analyse the product-information-disclosure Nash game between two rental service platforms whose products-to-rent are substitutable. The authors derive the equilibrium level of product information disclosure and identify conditions under which the platforms choose to disclose or not to disclose information. The results show that for products with higher profit margin, both platforms are more likely to disclose information. The findings also indicate that there exists a critical threshold on the information-sensitive consumers, which helps each platform decide whether or not to disclose product information. The impacts of product information disclosure on the consumer surplus and seller benefits are explored, and the roles played by the blockchain technology are discussed.

6. Blockchain and supply chain performance

Fosso Wamba et al. (2020) analyse technology adoption and supply chain performance in the context of blockchain in their paper "*Dynamics Between Blockchain Adoption Determinants and Supply Chain Performance: An Empirical Investigation*". The authors indicate numerous directions in how blockchain can disrupt the existing supply chain practices. Their findings reveal that knowledge sharing and trading partner pressure play an important role in blockchain adoption. Moreover, the authors show that supply chain performance is significantly influenced by blockchain transparency.

7. Blockchain and resilience

Lohmer et al. (2020) present a study entitled "*Analysis of Resilience Strategies and Ripple Effect in Blockchain-Coordinated Supply Chains: An Agent-based Simulation Study*". The authors utilize an agent-based simulation methodology to examine the potential of blockchain technology to build resilient supply chains. They identify possible risk-related applications of blockchain-coordinated supply chains and examine their impacts on different resilience strategies. The experiments conducted under a range of scenarios demonstrate that the propagation of disruptions (i.e., the ripple effect), network recovery time and total costs can be substantially reduced due to time-efficient collaboration.

8. Blockchain and smart contracts

Giovanni De (2020) analyses a supply chain managed through either a traditional online platform or a blockchain in his paper "*Blockchain and Smart Contracts in Supply Chain Management: A Game Theoretic model*". In the case of an online platform, the firms face business risks due to delivery and service and also pay high transaction costs. In a blockchain platform, firms can avoid risks and save the transaction costs. However, the blockchain requires initial implementation investments and variable costs can increase. The author identifies the conditions and the stochastic cases in which the blockchain is not worth implementing. Further, he investigates the suitability of a smart wholesale price contract and a smart revenue sharing contract to better coordinate firms' relationships and negotiations. The results show that the use of smart contracts makes blockchain applications more operationally convenient and economically appealing.

9. Resilience analysis and recovery

Fattahi et al. (2020) propose a new measure to quantify supply chain resilience by using stochastic programming in their paper "*Stochastic optimization of disruption-driven supply chain network design with a new resilience metric*". The specific feature of this new measure is the expected value of supply chain cost increase due to a possible disruption during the recovery period. The new resilience measure combines recovery time and costs.

10. Supply-demand reallocation

Harpreet and Prakash Singh (2020) consider a novel problem setting when supplier selection and order allocation should take into account both potential disruption risks and disruptive technologies in their paper "*Multi-Stage Hybrid Model for Supplier Selection and Order Allocation Considering Disruption Risks and Disruptive Technologies*". In their model, suppliers are evaluated based on a set of criteria suitable in an Industry 4.0 environment using Data Envelopment Analysis (DEA) and are further prioritized using the Fuzzy Analytical Hierarchical Process and Technique for Order of Preference by Similarity to Ideal Solution (FAHP-TOPSIS). The risk associated with each supplier is computed. For optimization purposes, the authors develop a mixed integer programme (MIP) to optimize multi-period, multi-item order allocation so that costs and risk of disruption are minimized simultaneously.

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Alexandre Dolgui[a], Dmitry Ivanov[b,*]
[a] *IMT Atlantique, LS2N - CNRS, La Chantrerie, 4 Rue Alfred Kastler, 44307, Nantes, France*

[b] *Berlin School of Economics and Law Supply Chain and Operations Management, 10825, Berlin, Germany*

[*] Corresponding author.

E-mail addresses: alexandre.dolgui@imt-atlantique.fr (A. Dolgui), divanov@hwr-berlin.de (D. Ivanov).