Guest editorial

Emerging technologies in emergency situations

1. The role of emerging technologies in emergency situations

The world is witnessing an unprecedented upheaval in global operations and supply chains (Azadegan and Dooley, 2021; Scholten *et al.*, 2020). Increasingly occurring natural disasters and the COVID-19 pandemic have plunged organisations into a state of emergency, with many fighting for their very survival (Ivanov, 2020; Queiroz *et al.*, 2020; Schleper *et al.*, 2021). Be they large or small, short-lived or sustaining for some time, emergency situations present a potential risk to an individual's health and livelihood, organisational and societal welfare and to the wider environment (van de Walle and Turoff, 2008; Sarkis, 2021). Emergency situations typically require urgent action to restore operations to the previous scenario or new strategies for survivability and adaptation to an entirely new context (Ivanov and Dolgui, 2020b; O'Flynn, 2020). Due to the scale and immediacy of these events, a range of actors is often involved, including governments, non-governmental organisations and businesses that need to work together to mitigate threats to life and property. To find a way out of today's emergency situations, managers urgently require guidance on how to rapidly redeploy operational resources and build resilience (Ivanov and Dolgui, 2021; Remko, 2020). Emerging technologies such as those related to Industry 4.0 are well-positioned to help organisations rebuild and reconfigure their resilience capabilities (Koh *et al.*, 2019; Spieske and Birkel, 2021).

Recent scholarly work on emerging technologies has deepened our understanding of Industry 4.0 in a supply-chain context, including research on blockchain (Wamba and Queiroz, 2020), artificial intelligence (AI) (Dwivedi *et al.*, 2019), big data analytics (Fosso Wamba and Akter, 2019; Kache and Seuring, 2017), the Internet of Things (IoT) (Schroeder *et al.*, 2020) and 3D printing (Kapletia *et al.*, 2019; Roscoe *et al.*, 2019). However, one area that has received limited scholarly attention is deploying emerging technologies in emergency situations. Technology has always been and continues to act as an enabler of enhanced performance. Despite the scarcity of research, it is clear that emerging technologies can act as a coordination mechanism and flexible manufacturing tool when responding to emergencies (Queiroz and Fosso Wamba, 2021), supporting localised manufacturing close to the point of need (Srai *et al.*, 2020). Recent advancements in digital technologies can enhance planning, mobilisation and management during emergency situations. For example, AI and business analytics can quickly identify populations in distress (Fosso Wamba *et al.*, 2021). Social media combined with big data analytics can coordinate the relief efforts of local volunteers during disasters (Dubey *et al.*, 2019;

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Sharma and Joshi, 2019). Distributed manufacturing technologies such as 3D printing offer organisations the potential for point-of-care manufacture of life-saving medicines, implants, equipment and devices within the vicinity of an outbreak or disaster (Srai *et al.*, 2020; Phillips *et al.*, 2020). Other recent cutting-edge technologies like Blockchain can improve information sharing during and after highly disruptive pandemic outbreaks and, consequently, enhance critical data visibility such as inventory levels throughout the supply network (Remko, 2020).

1.1 Aims of this special issue (SI)

While scholars have identified the coordination mechanisms needed to provide a synchronised response to emergency situations such as natural disasters (Holguín-Veras *et al.*, 2012; Oloruntoba and Gray, 2006; van Wassenhove, 2006), the processes required to deploy emerging technologies during such situations had received limited attention (Dubey *et al.*, 2020; Queiroz *et al.*, 2020; Remko, 2020). Moreover, while recent scholarly work has considered the importance of organisational and dynamic capabilities in developing Industry 4.0 technologies (Roscoe *et al.*, 2019; Xu *et al.*, 2018), the significance of fostering capabilities for the deployment of emerging technologies in emergency situations is under-researched (de Giovanni, 2019; Koh *et al.*, 2019; Sarkis, 2012). More specifically, the scale of disruption caused by COVID-19 has amplified the challenges presented by natural and man-made disasters, increasing the need for new strategies, capabilities and creativity in responding to emergency situations (Ivanov, 2020; Remko, 2020; Schleper *et al.*, 2021).

The aim of this special issue (SI) is to understand how organisations, and their supply chain partners can build the capabilities and coordination mechanisms required to deploy and utilise emerging technologies in emergency situations. The SI intends to stimulate a debate amongst academic scholars, practitioners and government representatives on the latest advances in emerging technologies and their application in the context of natural and man-made disasters as well as disease outbreaks such as COVID-19.

2. The interplay between emerging technologies, emergency situations and operations management

Emerging technologies refer to a set of unproven or early-stage innovations with the potential for beneficial impact that can help remodel business and operations management dynamics (Dolgui and Ivanov, 2020). On the one hand, emerging technologies can bring different benefits for organisations and their supply chains. On the other hand, there are some potential risks and challenges associated with emerging technologies (Dolgui and Ivanov, 2020; Koh *et al.*, 2019). From the lens of benefits, emerging technologies such as AI, blockchain, big data analytics, 3D printing, IoT and digital twins can reshape operations and supply chain relationships, bringing more efficiency and minimising costs throughout an operation. Interaction and integration between emerging technologies can improve response times and visibility considerably in emergency situations, helping organisations mitigate and recover from a crisis (Dubey *et al.*, 2020; Ivanov, 2021; Queiroz and Fosso Wamba, 2021).

Furthermore, emerging technologies can play a decisive role in the highly disruptive emergency situation presented by COVID-19 in which supply chains cannot revert to early forms but need new strategies for survivability and adaptability (Ivanov and Dolgui, 2020b). However, emerging technologies can also be untested and have unintended consequences in certain circumstances. Therefore, their application should be carefully assessed with a system's perspective to understand better operational dependencies and how such technologies will change stakeholder behaviours. Table 1 highlights examples of disruptive emergency situations, the role of emerging technologies and the consequences to operations and supply chain management.

Table 1. Examples of the interplay between emerging technologies, emergency situations and operations management

Type of emergency situation	Emerging technologies applications	Implications to operations management	Related literature
Pandemic outbreaks	Blockchain for information transparency and visibility through the network	With blockchain applications, operations management can gain a considerable advantage in tracking the distribution of critical products. Information sharing through the network can be in real time to minimise supply chain disruptions	Lohmer *et al.* (2020), Remko (2020)
	Digital twins enable unprecedented real-time monitoring of the disruptions through the network	Digital twin technology can help build dynamic capabilities in operation by integrating different sources of information, making robust predictions and trend-spotting. Consequently, the operations manager can improve their decision accuracy and timeliness	Burgos and Ivanov (2021), Ivanov and Dolgui (2020a)
	Artificial intelligence techniques to support diagnostic processes and predictions, telemedicine and hospital operational procedures	Artificial intelligence can support lean hospital operations effectively by identifying critical demands of resources for patients' allocation. Also, it can help the operations manager during the patient journey by providing quick diagnosis, prediction and treatment	Luengo-Oroz *et al.* (2020), Queiroz and Fosso Wamba (2021)
Climate issues (i.e. wildfire, tornado, tsunami, flood, hurricane, earthquake, typhoon, etc.)	Social media combined with sophisticated algorithms/big data to support all stages of the crisis (i.e. preparedness, mitigation, response and recovery)	With social media, algorithms and big data approaches, operations and supply chain managers can be more efficient by gaining a deeper understanding and visibility of the necessary resources for critical regions. Thus, the distribution of water, food and medical supplies can be more responsive. Also, the prediction for the hospital care and treatment plans can be more effective	Sarker *et al.* (2020), Saroj and Pal (2020), Watson *et al.* (2017)

(*continued*)

Table 1.

Type of emergency situation	Emerging technologies applications	Implications to operations management	Related literature
Humanitarian crisis (derived from resources scarcity, conflicts, migration, etc.)	Drones/unmanned aerial vehicle (UAV) and the Internet of Things used to support search and rescue in humanitarian operations relief	Drones can perform a decisive role in humanitarian operations like medical supplies and food distribution in hard-to-reach regions. Drone technology can be combined with IoT applications for activities such as search and rescue	Ayamga *et al.* (2021), Bravo *et al.* (2019)
	3D printing/additive manufacturing for support scarcity of medical supplies and medical equipment and point-of-care production of medicines and therapies	By deploying 3D printing technologies, humanitarian operations enable a rapid response for the in-field manufacture of critical medical equipment/parts that often takes several weeks or months in a regular supply chain. For example, in conflict regions, there is often a recurrent need for the field ready 3D printing of prosthetics	Phillips *et al.* (2018), Corsini *et al.* (2020), Kovács and Falagara Sigala (2021)
		Rapid and improved recovery from traumatic injuries (tissue and organs) through the use of leading-edge regenerative medicines and bio-engineered blood products	Spear *et al.* (2018)
Terrorist attacks (humanitarian relief)	Smartphone platforms with communication apps (i.e. WhatsApp) to make available the necessary resources, track the victims, support evacuation strategies, etc.	Smartphone platforms can assist operational coordination during and after a terrorist attack by using different applications that enable more precise information about the location, conditions and demand for medical supplies and vehicles for victims transportation, etc.	Baytiyeh (2018)

3. Papers selected for the special issue – emerging technologies in emergency situations

In this SI, we invited scholars and practitioners to provide insights on the challenges facing operations and supply chain managers when adopting, implementing and diffusing emerging technologies in emergency situations. Based on this call, we received a significant number of manuscripts that were carefully handled by the guest editors, the editors-in-chief team and a fantastic team of reviewers. Accordingly, six high-quality papers were selected for the SI. The papers cover different types of emerging technologies in a range of emergency contexts. Table 2 summarises these papers by highlighting the main emerging technology explored, the emergency situation and the methodological approach.

The first paper in the SI "*Supply chain resilience in mindful humanitarian aid organizations: the role of big data analytics*" (Dennehy *et al.*, 2021) is focussed on

Title of the paper	Authors	Emerging technology	Emergency situations	Methodological approach
Supply chain resilience in mindful humanitarian aid organizations: the role of big data analytics	Dennehy, Denis; Oredo, John; Spanaki, Konstantina; Despoudi, Styliani; Fitzgibbon, Mike	Big data analytics	Humanitarian relief supply chains	Survey with Partial least squares structural equation modelling (PLS-SEM)
Managing emergency situations with lean and advanced manufacturing technologies: an empirical study on the Rumbia typhoon disaster	Chong, Alain; Pu, Xiaodie; Chen, Meng; Cai, Zhao; Tan, Kim Hua	Advanced manufacturing technologies (AMTs)	Typhoon disaster	Survey with archival data
Understanding analytics empowerment capability to tackle emergency situations	Akter, Shahriar; Bandara, Ruwan J.; Sajib, Shahriar	Big data analytics	Emergency service operations	Survey with partial least squares structural equation modelling (PLS-SEM)
The mitigating role of blockchain-enabled supply chains during the COVID-19 Pandemic	Lam, Hugo K. S.; Xiong, Yangchun; Kumar, Ajay; Ngai, Eric W.T.; Xiu, Chunyu; Wang, Xinyue	Blockchain	COVID-19	Event study
Exploring the application of blockchain to humanitarian supply chains: insights from Humanitarian Supply Blockchain project	Baharmand, Hossein; Maghsoudi, Amin; Coppi, Giulio	Blockchain	Humanitarian supply chain	Focus group, semi-structured interviews
Improving emergency response operations in maritime accidents using social media with big data analytics: the MV Wakashio disaster case study	Dominguez-Péry, Carine; Tassabehji, Rana; Vuddaraju, Lakshmi Narasimaha Raju; Duffour, VIkhram	Big data analytics with social media	Maritime accidents	Secondary data

Table 2.
Summary of the accepted papers for this SI

humanitarian relief supply chains. Using empirical survey data and archival information collected from NGOs, government development agencies and consultancy think tanks focussed on humanitarian relief, the authors develop a model to capture the interplay between collective mindfulness and big data analytics. By employing partial least squares structural equation modelling (PLS-SEM), the paper offers empirical evidence that organisational mindfulness plays an essential role in enabling resilient humanitarian relief supply chains as opposed to simply facilitating big data analytics in a humanitarian context.

The paper by Chong *et al.* (2021) "Managing emergency situations with lean and advanced manufacturing technologies: an empirical study on the Rumbia typhoon disaster" investigates the impact of lean manufacturing techniques on the financial performance of companies negatively affected by emergency situations. It subsequently explores the role of advanced manufacturing technologies in complementing lean manufacturing to enhance financial performance in emergency and non-emergency scenarios. The paper shows interesting results that include an inverted U-shaped relationship between lean manufacturing and financial performance. More importantly, they identify the interactive effects of advanced and lean manufacturing technologies in influencing financial performance in emergency and non-emergency situations.

The third paper, entitled "Understanding analytics empowerment capability to tackle emergency situations" (Akter *et al.*, 2021), analyses the interplay between an analytics empowerment capability and its effect on strategic emergency service agility and emergency service adaptation. Using PLS-SEM, the results unveil that an analytics empowerment capability is framed by analytics culture, technology, tools, information access, decision-making, knowledge and skills, as well as training and development. The findings highlight the partial mediator effect of strategic emergency service agility in the relationship between analytics empowerment capability and emergency service adaptation.

The fourth paper by Lam *et al.* (2021) explores the mitigating role of blockchain-enabled supply chains during the COVID-19 pandemic. The authors use an event study approach to identify the financial impacts of COVID-19 between those organisations that adopted blockchain and those that did not. The paper presents evidence that blockchain-enabled supply chains play a decisive role in mitigating the negative outcomes of COVID-19, particularly for those with lean and complex supply chains.

The paper by Baharmand *et al.* (2021) "Exploring the application of blockchain to humanitarian supply chains: insights from Humanitarian Supply Blockchain project," also concentrates on blockchain technology. The authors investigate the key drivers and barriers to the adoption of blockchain technology in humanitarian supply chains. They collect data using a focus group and semi-structured interviews and identify visibility, collaboration, accountability, traceability, trust, time efficiency and cross-sector partnerships as the main drivers to the adoption of blockchain technology. The main barriers to adoption include the lack of technical skills and training, privacy concerns, regulatory problems, lack of resources, pilot scalability issues and governance challenges. Finally, they highlight that blockchain can improve visibility and traceability, consequently adding value and transparency for humanitarian supply chains.

The final paper by Dominguez-Péry *et al.* (2021) "Improving emergency response operations in maritime accidents using social media with big data analytics: the MV Wakashio disaster case study" investigates the contribution of big data analytics integrated with social media in order to improve the emergency response operations before and in the course of maritime accidents. The authors used BDA approaches in a real-time dataset from Twitter, considering the MV Wakashio maritime disaster. Their findings indicate that ship's organisation, official institutions and the wider community play a fundamental role in the operations response success. Also, they highlight that the integration of social media with big data analytics techniques can add value contributing to a collective sense-making in this type of emergency situation.

4. Implications and research opportunities for the fields of production and operations management: uncertainties are the only certainties

Considering the complexity of the emergency situations highlighted in this SI, it is clear that emerging technologies will continue to play decisive role in future emergency situations. As we noted earlier, the frequency and severity of emergency situations seem to be ever-increasing, requiring further technological advances and managerial knowledge of how to adopt and deploy emerging technologies during crises. While this SI takes a first step along the path of discovery, we feel it prudent to outline several promising future research areas for academics and practitioners.

First, we call on researchers to investigate how traditional operations management approaches such as lean thinking, just-in-time and just-in-case can be enabled by emerging technologies during and after emergency situations. Some technologies can enhance the efficiency of firm operations. Others can enhance the firm's ability to ward off or mitigate emergencies. An assessment of how emerging technologies affect the relationship between operations management approaches and performance (i.e. as moderating or mediating factors) can be a valuable contribution to the literature.

Second, we call on researchers to consider how novel yet less applied management theories that can shed light on how to integrate disparate emerging technologies within emergency response networks. One example of such theories is resource orchestration theory (Sirmon *et al.*, 2011). This theory considers the role of managers in structuring resources and bundling them into capabilities. Resource orchestration theory can help explain how emerging technologies can be used in tandem to mitigate the effects of emergency situations. Another useful theory is that of organisational information processing theory (Premkumar *et al.*, 2005). Organisational information processing theory explains how firm performance is improved when the information needs of an organisation align with information processing capabilities. By enhancing the information processing of the firm, emerging technologies can help buffer uncertainty and thereby improve performance. The behavioural theory of the firm (Cyert and March, 1963) is another less applied but useful theory in this domain of inquiry. The behavioural theory of the firm explains how firms make decisions based on a coalition of groups, functions and departments. Decisions to be made may be different based on the information available to each group. By allowing for better sharing of information, emerging technologies can help create consensus amongst the groups. Perhaps even more interestingly, the theory suggests that some groups, functions or departments may not be interested in an optimal solution to organisational challenges. Instead, they may look for "good enough" solutions to face such challenges. By offering better awareness, how emerging technologies can improve decisions such that they move beyond satisficing (Simon, 1955) and towards optimal ones, particularly in facing emergency situations, can be very interesting. A final noteworthy theory is that of Simons' levers of control (Simons, 1995). Simons suggests that managers use different control mechanisms to direct and nurture performance. Amongst others, controls include diagnostic and interactive control systems. Whereas diagnostic controls are one-way directives, interactive controls offer means for feedback from different functions back to managers. Whether and how different emerging technologies can be categorised as control systems and how their application can improve performance is certainly a viable approach to the use of this theory.

Third, we see potential in identifying the cultural and behavioural factors that inhibit and enable the deployment of emerging technologies by multiple emergency response actors. For instance, it is well-established that certain government agencies, national NGOs and local NGOs show different behaviour during humanitarian disasters (see Shaheen *et al.*, 2021, for example). Of particular interest is how emerging technologies such as blockchain, AI and big data can act as coordination mechanisms between networks of emergency response organisations. Next, we call on researchers to develop managerial frameworks and

taxonomies that explain how and when to deploy emerging technologies to support resilience, adaptability and survivability in large-scale and prolonged emergency situations, such as pandemic outbreaks. Further, we see an opportunity for future researchers to determine how emerging technologies can support supply chain redesign during large-scale emergencies, including offshoring, nearshoring, onshoring and distributed approaches. Finally, we call on future researchers to explore the role of emerging technologies in supporting a circular economy approach to minimising waste and stock-outs during emergency situations.

5. Concluding remarks

The interplay between emerging technologies, emergency situations and operations management is a nascent area of research. The rapid spread of COVID-19 around the globe has reinforced the urgency to understand how technologies such as AI, additive manufacturing and blockchain can help organisations build more effective methods of responding to emergency events. Each paper in this SI offers valuable insights for academics and practitioners on the adoption and use of different emerging technologies in a variety of emergency contexts. Researchers have been presented with many fruitful areas of inquiry to build on this nascent area of scholarship. The only certainty in today's disruptive world is uncertainty, and these new challenges require new technological solutions and previously untapped capabilities.

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