Article

Not peer-reviewed version

The Role of Digitalization to Achieve Resiliency During Supply Chain Disruptions: Lessons from the Experiences of Family-Owned Austrian Firms During the Covid Pandemic

Deepak Khazanchi * and Reinhardt Bernsteiner

Posted Date: 25 October 2023

doi: 10.20944/preprints202310.1590.v1

Keywords: Digitalization; Supply Chain Disruptions; Digital Supply Chain; Resilience; Best Practices; sustainability

Article

The Role of Digitalization to Achieve Resiliency During Supply Chain Disruptions: Lessons from the Experiences of Family-Owned Austrian Firms During the Covid Pandemic

Deepak Khazanchi [1,*] and Reinhardt Bernsteiner [2]

[1] University of Nebraska at Omaha (UNO), USA; khazanchi@unomaha.edu
[2] Management Center Innsbruck (MCI), Austria; ReinhardChristian.Bernsteiner@mci.edu
* Correspondence: khazanchi@unomaha.edu

Abstract: The Covid-19 pandemic strained global supply chains, and companies faced numerous production, logistics, or material management problems. It is claimed that the digitalization of supply chains can have the potential to make supply chains more resilient to interruptions and disruptions. This article focuses on describing the experiences of three large Austrian family-owned business during the supply chain disruptions caused by the pandemic and the Ukraine war. This assessment is done from the perspective of the supply chain leaders in the organization. We provide insights on what worked and what did not for these firms and what we can take away from their experiences.

Keywords: digitalization; supply chain disruptions; digital supply chain; resilience; best practices

1. Introduction

"The supply chain mantra is changing from efficiency and low-cost country sourcing, to supply chain resilience and visibility to reduce complexity and uncertainty. The acceleration of digital transformation is key to that new way forward." Henry Brunekreef, Director, Operations Advisory and National Leader, Supply Chain Management, KPMG in Australia

The ILO (International Labor Organization) has defined "Global Supply Chains (GSCs)" as the cross-border organization of the activities required to produce goods or services and bringing them to consumers through inputs and various phases of development, production, and delivery. Global supply chains are complex, diverse, fragmented, dynamic, and evolving organizational structures with cross-border production and trade as a critical element (https://www.ilo.org/global/topics/dw4sd/themes/supply-chains/lang--en/index.htm#44).

Established in 2015 by the United Nations, the Sustainable Development Goals (SDGs) are a collection of 17 interlinked goals designed to be a "blueprint to achieve a better and more sustainable future for all". According to [1,2] the SDG's serve as guidelines for the attainment of sustainable business development and focus on cross-sector as well as cross-country partnerships and cooperation for sustainability. These authors assert that the "efforts to drive businesses towards SDGs are grounded in the equitable sharing of risks and benefits and require actions such as collaborative planning and product development, exchange of information and coordination at various levels among different actors within an GSC" [1,3]. According to the ILO and Pohlmann et al [4] to achieve a sustainable future, businesses will need to align their goals with the SDGs at the strategic as well as operational [1]. In fact, Golroudbary et al. [5] have shown in their research that an equal weighting of economic, environmental, and social elements is essential to developing, implementing, and executing sustainable policies and practices. These conclusions are also supported by a study by Haroon et al [6] who explored the perceived significance of sustainability indicators, specifically economic, environmental, and social, among supply chain practitioners in the implementation of sustainable supply chain practices. They discovered that these practitioners consider all three sustainability dimensions as equally important. The SDGs are also well connected with the three

 doi:10.20944/preprints202310.1590.v1

pillars of corporate sustainability, ecological, social, and economic, also called the Triple Bottom Line (TBL) [7]. The TBL is frequently employed to translate sustainable development into tangible and actionable decisions [8].

Caiado et al. [9] have investigated the integration of SDGs in global supply chain management and report that companies that align their operations and supply chain management activities with the SDGs can positively contribute to:

- ensure reliable and modern energy services, facilitating access to research and technology in clean energy, including renewables, energy efficiency, and advanced and cleaner fossil fuel technology (SDG#7).
- promote sustainable economic growth through the support of productive activities and the creation of decent jobs (SDG#8).
- encourage inclusive and sustainable industrialization by promoting innovation through improved resource-use efficiency and increased adoption of clean and environmentally sound technologies and industrial processes (SDG#9).
- diminish inequality by empowering and fostering the socioeconomic inclusion of everyone while ensuring equal opportunities (SDG#10).
- create more inclusive, safe, resilient, and sustainable cities by establishing accessible, sustainable, and intelligent transport systems (SDG#11).
- enhance technological capacity to transition towards more sustainable consumption and production patterns by minimizing waste generation through prevention, reduction, recycling, and reuse (SDG#12).
- Promote partnerships involving multiple stakeholders to mobilize and share knowledge, expertise, technology, and financial resources (SDG#17).

1.1. Supply Chain Disruptions

With the advent of modern digitalization in all its forms, speed, flexibility, scalability, just-in-time inventory, cost-effectiveness, eco-friendliness, or global connectivity are only a few of the many features linked to a global supply chain today. The Covid-19 pandemic and the Ukraine war caused supply chain interruptions and disruptions that demonstrated the vulnerability of an interconnected global economy. Formally, according to Macdonald et al. [10]**, supply chain disruptions** are defined as "unplanned and unanticipated events that disrupt the normal flow of goods and materials within a supply chain" ([11], 132). With Covid-19 [12], the Ukraine war [13], and the recent wildfires across the world [14], it is certain that unanticipated global events will continue to have a significant disruptive impact on global supply chains and, in fact, occur regardless of risk planning [15]. As a result, supply chain executives continue to face the critical challenge of recovering from disruptions while minimizing their impact.

The Covid-19 pandemic strained global supply chains, and companies faced numerous production, logistics, or material management problems. It is claimed that the digitalization of supply chains can have the potential to make supply chains more resilient to interruptions and disruptions. Some authors have conduced systematic analysis of the academic literature to theoretically discover themes, strategies, and challenges associated with global supply chain disruptions [15–18]; there have been no studies that describe lessons and insights from the perspective of large family-owned business and their experiences during the Covid-19 pandemic and beyond. To address this gap in our understanding, this paper focuses on describing the experiences of three large Austrian family-owned businesses during the Covid-19 pandemic from the perspective of the supply chain leaders in the organization. We report on the lessons learned and best practices from their experiences.

2. Research Approach

To develop insights into how family-owned firms handled the supply chain disruptions due to the Covid-19 pandemic and the Russia-Ukraine war, we conducted semi-structured interviews over Zoom of supply chain executives from three family-owned Austrian manufacturing firms in Spring 2022. Expert interviews aim to give further insights about a topic that literature cannot answer

 doi:10.20944/preprints202310.1590.v1

entirely [19]. The value of an expert interview is the individual's viewpoint and experience which can influence the researcher's investigation. Although methodological purists raise objections to expert interviews, of neither being a qualitative nor quantitative method but some hybrid is not representative [20,21]

The semi-structured interviews provided an ideal setting for the free conversational speech of the interviewee combined with guidance from the interviewer [22,23]. The interviews generally lasted 1-1.5 hours with a blend of closed- and open-ended questions, and some follow-up why and how questions as needed [22,23]. To minimize fatigue for both interviewer and respondent, according to [22,23], about one hour is considered a reasonable maximum length for semi-structured interviews.

After each interview, the content was transcribed and anonymized by the authors and coded according to Mayring's scheme of the qualitative content analysis [20]. The authors reviewed each transcript to develop ategories or themese from them that address the primary research question of what worked and did not work during the disruptions due to the pandemic and the Ukraine war and the lessons learnt thereof [20].

3. Results

In this section we provide a concise description of the data organized around thematic categories identified using interview evidence and prior research.

The three firms studied are characterized in Table 1.

Table 1. Attributes of Firms in this study.

Family businesses	Size	Primary Products
Company 1	Employees: 770 Turnover: of $730 million. Wholly owned subsidiary of a global company	Manufactures ground-based gardening tools, such as lawn mowers, robotic mowers, ride-on mowers, and garden shredders.
Company 2	Employees: 11,000 Turnover: $2 billion	Truck equipment manufacturer. Makes cranes, hook lifts, cable hoists, forklifts, liftgates, service bodies and platforms. Has 200 suppliers worldwide.
Company 3	Turnover: $1.67 billion Employees: 2,400 worldwide 14 plants; 8 branches in Europe & USA Products available in 100 countries	Business to business provider of beverages including fruit juice production, semi-manufactured products such as concentrates, and branded packaging for business customers.

3.1. Qualititative Findings from Interview Data

3.1.1. Nature of Supply Chain Disruptions

The Covid pandemic, Ukraine war, the cascading impact of China's reaction to Covid, transportation bottlenecks, and general geopolitical factors severely impacted global supply chains and to some extent continue to disrupt them. The primary lessons learnt from these challenges to the supply chain are summarized below [16–18]. These findings combine the information gleaned from prior research and echoed by executives from the three firms studied in this research.

3.1.2. Logistics Disruptions

 doi:10.20944/preprints202310.1590.v1

The global logistics disruptions stemming from the COVID-19 pandemic impacted businesses and consumers as the flow of consumer goods into key markets such as North America and Europe, Southeast Asia and India was restricted by the continued shutdowns of major global ports and airports, largely in China, South Korea, and the USA. According to a supply chain disruptions survey reported by the magazine *Logistics Management*, as of December 2022, nearly 72% of respondents were still handling global supply chain disruptions and 54% expected this pressure on global supply chains to continue [24]. The companies we studied faced logistics disruptions relating to semi-conductors or chip bottlenecks from Taiwan. According to the Economist, Taiwan produces over 60% of the world's semiconductors and over 90% of the most advanced ones. This became a limiting factor that intensified competition for chip components in short supply and had a ripple effect on manufacturing during Covid and because of the ongoing the Russia-Ukraine war. All three subject firms faced disruptions due to the Ukraine war, particularly with respect to semi-conductors or chip bottlenecks impacting firms like Company 1. There was intense competition for chips between the large consumers such as BMW and others in Europe for chip supply). Additionally, the Russia-Ukraine war caused pressure on supply of raw materials such as Aluminum and Wooden Pallets which impacted "Company 1" in particular. Finally, all three subject firms faced transportation and logistics bottlenecks due to lack of shipping containers, time to transport form China/Taiwan to Europe of certain raw materials, and other similar constraints.

3.1.3. Production delays due to lack of components or materials

Production delays during COVID-19 become headline news. Manufactures were competing for limited supply of key commodities and logistical capacity, leading to consumers experiencing empty shelves and long purchase lead times. This capacity constraint has not completely been ameliorated in many critical sectors. In the technology industry for example, even in 2023, the COVID-19 pandemic, increased demand for consumer electronics, and supply chain disruptions have all contributed to the shortage, which is affecting production, innovation, and prices [25]. The ongoing Russia-Ukraine war has exacerbated the post-Covid recovery by disrupting global supply chains for some basic foods, fertilizers, chemicals, metals, and other minerals as well as oil and gas from Russia [13]. As the executive from Company 3 explained: "Out of stock situation are rarely seen in the food industry. However, if the supply chain is disrupted – we know that there are missing materials. Prices go up (supplies, financing, storage, and logistics/transportation) are significant cost factors. If we are out of stock due to bottlenecks – finished goods can be covered for a day or two, but it will ultimately impact production planning. This means we need to be agile while being economically. However, this continues to be a challenge to manage demand planning." For example, even materials that cost a few cents can have a major impact on delivery of materials. Company 3 had to stop production in their brewery plant due to lack of CO2 for one week; the cost is a few cents, but it is a critical component and was hard to predict that it would be in short supply. Similarly, Company 3 faced a water shortage due to high temperatures in Hungary being 40C or more; no one imagined such a shortage before. When the Ukraine war started, Company 3 had to stop receiving nails since steel was restricted from sanctioned countries such as Belarus. A very small item in terms of materials needed for the production line, but the intended impact was that palettes to ship goods could not be assembled and their cost tripled.

3.1.4. Over Reliance on limited and remote third parties causing supply chain disruptions

Covid-19 and the Russia-Ukraine war have demonstrated the inherent risk associated with focusing on one major trading partner(s) and/or cheaper remote vendors [[26]. Many businesses had strong relationships with one major supplier, one large customer and/or one major supply chain partner. Researchers have found that buyers face a tradeoff between the benefits of close relationships with their suppliers, the countries they are located in, and the risk of excessive concentration [27]. For example, according to one study [28], Austria had to sharply cut Russia's share of gas imports in the wake of the February 2022 invasion of Ukraine but has already returned to pre-war levels due to challenges associated with contracts, energy diversification, domestic politics and foreign policy. The

 doi:10.20944/preprints202310.1590.v1

dependence on China as a manufacturing hub for the world caused server disruptions in the global supply chain during the pandemic and continues to do so even now. In fact it has been reported that nearly 51,000 global companies had one or more tier-1 suppliers, and five million have one or more tier-2 suppliers in the Wuhan region ([29,30]).

To compensate for the supply chain disruptions brought on by the pandemic and the Ukraine war, many companies have been moving their manufacturing and/or sourcing closer to home. According to the Logistics Management survey cited previously [24], more than half (52.3%) of respondents have attempted to nearshoring and/or reshoring approach over the last two years while 36.4% have not.

In the case of Company 1 and 2 in our study, the reliance on Taiwan for wafers during Covid-19 was a massive limiting factor – demand for chips was high and transportation/logistics bottlenecks were endemic causing delays in production. Furthermore, both were trying to bring some manufacturing of components back to the Eastern Europe where labor was still a bit cheaper. Company 1 was also exploring alternative suppliers for their critical components by trying to just understand which components are critical so that they can move to demand planning better with global standards for suppliers in the value chain. This was driven by worries about not having adequate data transparency for the whole supply chain.

Company 3 being in the food sector had the challenge of understanding the quantity and type of goods that are needed and whether raw materials would be available, particularly since lead time was critical for perishable goods in the food industry. Additionally, dependence on 1000+ farm-based suppliers in Europe was particularly challenging for this organization since many of the farmers have no computers – contracts are manual and individually customized and vary from country to country even within the EU. However, interestingly, billing is electronic while farmers get paper payments.

3.1.5. Technology, Digitalization and Supply Chain Disruptions

The need to improve the resiliency of supply chains has become even more critical post-pandemic. Digital transformation in supply chain management could enable organizational flexibility, business process automation, cost-effectiveness, visibility, and accelerate innovation in supply chain management itself ([31–33]). Using digital transformation to this end is a laudable goal but requires financial investment and strategic planning. Absence of planning and collaboration, wrong demand forecast, lack of inventory sharing, incorrect assumptions, lack of knowledge, agility, and flexibility, high volatility, over-reliance on the suppliers, and lack of integration between digital and non-digital management are some reasons why digital transformation of supply chain may fail ([31,33]). Additionally, there is some argument that digitalization is not a panacea for achieving resilience of global supply chains; the degree and sophistication of the digitalization needed may vary depending upon the nature of the business, size, and concentration of suppliers ([34–37]). In fact, Shashi et al. [22] found that "…technology appears as a necessary but not-sufficient enabling factor for ASC ("agile supply chain") deployment."

All the three firms in our study reported varying degrees of success with digitalization before and after Covid-19 and throughout the disruptions caused by Covid-19 and the ongoing Ukraine war. At the time of our interview, Company 1 was in the early stages of digital transformation since they had very little plant level automation and used manual processes to handle raw material supplies. They were in the process of implementation of SAP HANA at the plant level with varying adoption across its plants globally. Even though production planning was automated. Bottleneck handling was mostly annual (prior to Covid-19 through post-Covid timeframe). This was because of lack of data visibility across the supply chain, and it was difficult to get a "clear picture across multiple suppliers." In the words of our interview subject at Company 1, digitalization did not provide any immediate advantage to overcome disruptions, particularly of chips. In fact, Company 1 worked manually first to address manufacturing based on supply of materials – that is adjust what would be manufactured based on what is available from suppliers. They were making decisions about which products to manufacture, for example based on which ones would provide the highest revenue. Limited quantity of certain components can impact how to distribute them to the right

 doi:10.20944/preprints202310.1590.v1

products in plants. Needed digitalization at the plant level to have all the information relevant for a decision in place, in time and fast.

Company 2 was also in the early stages of digital transformation and was strategically thinking about ways to approach it for its whole supply chain. Their supply chain had different digitalization maturity levels with some plants being the most advanced in terms of VMI, supply relationship management software that connected 200+ suppliers across the globe that also included integration with loading planning and transportation tools. According to our interview subject, Company 1 managed some disruptions in supplies of materials better by using supply relationship management software to get a holistic view of the supply chain. They also used VMI to plan better for inventory. Company 2 also used SAP HANA but for limited functions and was in the process of implementing it across the supply chain.

Company 3 was a contrast to the other two firms since they are in the food services industry and had rarely faced out-of-stock situations until the pandemic. They had implemented EDI (Electronic Data Interchange) with most of their major suppliers. However, they also have 1000+ farmers as fresh commodity suppliers from around Europe who did not have any automation. They had some visibility because of EDI and used demand planning and maintained safety stick when possible. Their mantra was to "be agile while being economical" in what is provided as finished goods. However, demand planning continued to be a challenge. Our interview commented that we because of the way economies are highly interconnected globally, they must use "agile JIT" and not focus on 100% availability of items, which is not always possible as illustrated by the supply chain disruptions during the pandemic and the ongoing Ukraine conflict. They also considered the notion of having more buffers in all parts of the supply chain with reasonable demand planning.

3.1.6. Workforce Issues

Uncertainties in workforce due to shortages of skilled labor and the impact of technology causes challenges for digital transformation of supply chains. To cope with a progressively digitalized and automated supply chain, workers must acquire fresh skills, and advancements in technology will significantly transform their current roles. A considerable portion of employees' routine tasks will be automated, necessitating greater emphasis on innovation, creativity, collaboration, and leadership in their jobs ([38–40]). None of the subject companies had workforce concerns at the time of interviews. However, the partners in the supply chain of these firms were globally dispersed and workforce concerns were different in each part of the world. As suggested earlier about the implication of the SDGs on GSCs, there was limited consideration given for the workforce located at supply chain partners in terms of their economic uncertainty created by the pandemic and the impact on the sustainability of their viability. However, Company 3 was particularly concerned about the economic and social impact of the pandemic on the 100s of individual farmers who were their suppliers.

3.1.7. Lack of Transparency/Visibility

Supply chain end-to-end visibility can potentially mitigate the risks of supply chain disruptions [12,41,42]. Lack of visibility of the supply chain occurs due to inaccurate data, inability to track supplier performance, late updates, and incomplete information. Lack of visibility and transparency can also make decision making challenging in terms of which products and how much to schedule for manufacturing. Company 1 was in the early stages of digital transformation across the supply chain and lacked an integrated and holistic view of the whole supply chain from sales forecasting to component demand to production planning. In contrast Company 2 used its supply relationship management platform with its 200+ suppliers to gain visibility on information flows and used that to optimize the supplier network particularly during the Covid pandemic Finally, Company 3 was severely challenged with demand planning due to the lack of visibility of the smaller players in their supply chain and due to the unpredictable delays in transportation via containers.

4. Discussion and Lessons Learned

 doi:10.20944/preprints202310.1590.v1

Based on our analysis of the supply chain disruptions faced by the subject firms and their approaches to addressing them, the following lessons/strategies, and implications for sustainability can be gleaned.

- **Digitalization must be strategically fit(ted)** and it is not a panacea for poor processes or strategic vision. This includes assessing the state of the global supply chain partners in terms of maturity level of digitalization. Strategic digital transformation of GSCs will need huge technology investments and commitment from top management. The implication here is that in terms of sustainability as described in SDG#12 and SDG#8, digitalization across the GSC will involve support for partners to upgrade their infrastructure, train employees, and integrate systems across the supply chain network. For example, Company 1 described the need to responsibly make sure perishable goods are protected and to allow for longer lead times by keeping greater buffer such as an extra truck of supplies. This would need more real-time supply chain optimization.
- Digitalization can result in benefits if the **supply chain automation** includes much **more than just eliminating manual tasks through automation**. It involves process and payment automation, improving resource efficiency, delivering valuable insights, and integrating transportation logistics across the GSC. To reap outstanding rewards, companies need to apply supply chain technology directly within the operations including plant automation and across its whole global supply chain**.** This insight aligns well with SDG#9 which encourages inclusive and sustainable industrialization by promoting innovation through improved resource-use efficiency and increased adoption of clean and environmentally sound technologies and industrial processes. Company 2 is a great example of how this was taking shape: they had implemented tactical network optimization process and system along with network optimization across their network. They used simulations of their network to conduct scenario analysis. The interview subject commented that "Simulating the network was game changing; the technology was a big advantage." This firm also used their supplier relationship management digital platform to be more resilient by providing clear information flows and had implemented a relationship management software for all its 200 suppliers across globe and were also integrating transportation in the SRM process.
- Digitalization must address the issue of **supply chain transparency and visibility** head on. This not only means clear information flows but also clarification of processes, roles, and responsibilities. This will help with resiliency and adaptability and be in line with SDG#17. The implication of SDG#17 is that true collaboration including sharing of knowledge and information with global supply chain partners is critical for sustainability. We need to work in collaboration with suppliers. As the executive from "Company 2" in our study commented: "*… (we) need to change – collaboration with the whole supply chain is essential…. including the internal supply chain – supply chain collaboration in engineering, suppliers, is now needed in the future to be successful*".
- Consider **reconfiguring supply chains to avoid disruption** so that there is less dependence on just a few sources of raw materials and/or locations. Need to explore the idea of bringing some critical component manufacturing closer to plant operations. In doing so, the economic and social impact on supply chain partners across the globe in terms of sustainable practices will need to be addressed per SDG#8 and SDG#17.
- **Adaptability (agility/responsiveness)** of the supply chain through backward integration is essential with digitalization. The idea is that truly resilient companies need to continue processes and make decisions by quickly reacting to dealers, partners, and customers. This means using tools and processes for better demand planning and agility to respond or react to changing demand in collaboration with supply chain partners (SDG#17; SDG#9).
- **Supply chain collaborations** are even more critical for sustainability and resiliency during disruptions (SDG#17; SDG#9). This is particularly important that this happens between large and small suppliers and buyers – VMI by itself cannot address this challenge.
- Don't forget the **human component**; Transparency also means educating the workforce for the next generation of digitalization and process transformations. It also implies that working conditions and decent work practices be adopted and supported across the GSC network (SDG#8).

Funding: This research received no external funding.

Informed Consent: Interviews were conducted with organizational executives who explicitly agreed to participate in them.

Data Availability Statement: The interview data summarized and presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy needs of the participating organizations.

Acknowledgments: The corresponding author's research time in Austria was made possible by international travel support from a 2022 Fulbright Scholar Award to Austria.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Chauhan, C.; Kaur, P.; Arrawatia, R.; Ractham, P.; Dhir, A. Supply chain collaboration and sustainable development goals (SDGs). Teamwork makes achieving SDGs dream work. *Journal of Business Research* **2022**, *147*, 290–307, doi:10.1016/j.jbusres.2022.03.044.
2. Gunasekaran, A.; Subramanian, N.; Rahman, S. Green supply chain collaboration and incentives: Current trends and future directions. *Transportation Research Part E: Logistics and Transportation Review* **2015**, *74*, 1–10, doi:10.1016/j.tre.2015.01.002.
3. Mehdikhani, R.; Valmohammadi, C. Strategic collaboration and sustainable supply chain management. *Journal of Enterprise Information Management* **2019**, *32*, 778–806, doi:10.1108/JEIM-07-2018-0166.
4. Pohlmann, C.R.; Scavarda, A.J.; Alves, M.B.; Korzenowski, A.L. The role of the focal company in sustainable development goals: A Brazilian food poultry supply chain case study. *Journal of Cleaner Production* **2020**, *245*, 118798, doi:10.1016/j.jclepro.2019.118798.
5. Golroudbary, S.R.; Zahraee, S.M.; Awan, U.; Kraslawski, A. Sustainable Operations Management in Logistics Using Simulations and Modelling: A Framework for Decision Making in Delivery Management. *Procedia Manufacturing* **2019**, *30*, 627–634, doi:10.1016/j.promfg.2019.02.088.
6. Haroon, S.; Wasif, M.; Khalid, R.; Khalidi, S. Supply Chain Practitioners' Perception on Sustainability: An Empirical Study. *Sustainability* **2021**, *13*, 9872, doi:10.3390/su13179872.
7. Calabrese, A.; Costa, R.; Gastaldi, M.; Levialdi Ghiron, N.; Villazon Montalvan, R.A. Implications for Sustainable Development Goals: A framework to assess company disclosure in sustainability reporting. *Journal of Cleaner Production* **2021**, *319*, 128624, doi:10.1016/j.jclepro.2021.128624.
8. Singh, A.P.; Rahman, Z. Integrating corporate sustainability and sustainable development goals: towards a multi-stakeholder framework. *Cogent Business & Management* **2021**, *8*, doi:10.1080/23311975.2021.1985686.
9. Caiado, R.G.G.; Scavarda, L.F.; Azevedo, B.D.; Mattos Nascimento, D.L. de; Quelhas, O.L.G. Challenges and Benefits of Sustainable Industry 4.0 for Operations and Supply Chain Management—A Framework Headed toward the 2030 Agenda. *Sustainability* **2022**, *14*, 830, doi:10.3390/su14020830.
10. Macdonald, J.R.; Corsi, T.M. Supply Chain Disruption Management: Severe Events, Recovery, and Performance. *J Bus Logist* **2013**, *34*, 270–288, doi:10.1111/jbl.12026.
11. Craighead, C.W.; Blackhurst, J.; Rungtusanatham, M.J.; Handfield, R.B. The severity of supply chain disruptions: design characteristics and mitigation capabilities. *Decision sciences* **2007**, *38*, 131–156.
12. Paul, S.K.; Chowdhury, P.; Moktadir, M.A.; Lau, K.H. Supply chain recovery challenges in the wake of COVID-19 pandemic. *Journal of Business Research* **2021**, *136*, 316–329, doi:10.1016/j.jbusres.2021.07.056.
13. Dyson, E.; Helbig, R.; Avermaete, T.; Halliwell, K.; Calder, P.C.; Brown, L.R.; Ingram, J.; Popping, B.; Verhagen, H.; Boobis, A.R.; et al. Impacts of the Ukraine–Russia Conflict on the Global Food Supply Chain and Building Future Resilience. *EuroChoices* **2023**, *22*, 14–19, doi:10.1111/1746-692X.12380.
14. Galizia, L.F.; Alcasena, F.; Prata, G.; Rodrigues, M. Assessing expected economic losses from wildfires in eucalypt plantations of western Brazil. *Forest Policy and Economics* **2021**, *125*, 102405.
15. Ivanov, D.; Dolgui, A. A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0. *Production Planning & Control* **2021**, *32*, 775–788, doi:10.1080/09537287.2020.1768450.
16. Moosavi, J.; Fathollahi-Fard, A.M.; Dulebenets, M.A. Supply chain disruption during the COVID-19 pandemic: Recognizing potential disruption management strategies. *International Journal of Disaster Risk Reduction* **2022**, *75*, 102983, doi:10.1016/j.ijdrr.2022.102983.

17. Katsaliaki, K.; Galetsi, P.; Kumar, S. Supply chain disruptions and resilience: a major review and future research agenda. *Annals of Operations Research* **2022**, *319*, 965–1002, doi:10.1007/s10479-020-03912-1.
18. Hald, K.S.; Coslugeanu, P. The preliminary supply chain lessons of the COVID-19 disruption—What is the role of digital technologies? *Operations Management Research* **2022**, *15*, 282–297, doi:10.1007/s12063-021-00207-x.
19. Mayring, P. *Qualitative Inhaltsanalyse*: *Grundlagen und Techniken*, 12., überarb. Aufl.; Beltz: Weinheim, 2015, ISBN 3407293933.
20. Mayring, P. Qualitative content analysis: Theoretical background and procedures. *Approaches to qualitative research in mathematics education: Examples of methodology and methods* **2015**, 365–380.
21. Trinczek, R. How to interview managers? Methodical and methodological aspects of expert interviews as a qualitative method in empirical social research. In *Interviewing experts*; Bogner, A., Littig, B.L., Menz, W., Eds.; Palgrave Macmillan: London, 2009; pp 203–216.
22. Adams, W.C. Conducting Semi-Structured Interviews. *Handbook of Practical Program Evaluation*, 2015; pp 492–505, ISBN 9781119171386.
23. Adams, W.C. Conducting Semi-Structured Interviews. In *Handbook of Practical Program Evaluation*; Newcomer, K.E., Hatry, H.P., Wholey, J.S., Eds.; Jossey-Bass: San Francisco, 2015.
24. Bridget McCrea. 2022 Supply Chain Disruptions Study. Available online: https://www.logisticsmgmt.com/article/2022_supply_chain_disruptions_study (accessed on 26 July 2023).
25. Versa Electronics. Electronic Component Shortage – An Update for 2023. Available online: https://versae.com/electronic-component-shortage-2023-update/ (accessed on 26 July 2023).
26. Allam, Z.; Bibri, S.E.; Sharpe, S.A. The rising impacts of the COVID-19 pandemic and the Russia-Ukraine war: energy transition, climate justice, global inequality, and supply chain disruption. *Resources* **2022**, *11*, 99.
27. Polyviou, M.; Wiedmer, R.; Chae, S.; Rogers, Z.S.; Mena, C. To concentrate or to diversify the supply base? Implications from the US apparel supply chain during the COVID-19 pandemic. *J Bus Logist* **2023**.
28. Oxford Analytica. Austrian exit from Russian gas is far from assured. *Emerald Expert Briefings* **2023**.
29. Ivanov, D. Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case. *Transportation Research Part E: Logistics and Transportation Review* **2020**, *136*, 101922.
30. Jim Kilpatrick. Managing supply chain risk and disruption. Available online: https://www.deloitte.com/global/en/services/risk-advisory/analysis/covid-19-managing-supply-chain-risk-and-disruption.html (accessed on 26 July 2023).
31. Baryannis, G.; Validi, S.; Dani, S.; Antoniou, G. Supply chain risk management and artificial intelligence: state of the art and future research directions. *International Journal of Production Research* **2019**, *57*, 2179–2202, doi:10.1080/00207543.2018.1530476.
32. Hamidu, Z.; Mensah, B.D.; Issau, K.; Asafo-Adjei, E. Does technological innovation matter in the nexus between supply chain resilience and performance of manufacturing firms in a developing economy? *Journal of Manufacturing Technology Management* **2023**.
33. Nasiri, M.; Ukko, J.; Saunila, M.; Rantala, T. Managing the digital supply chain: The role of smart technologies. *Technovation* **2020**, *96-97*, 102121, doi:10.1016/j.technovation.2020.102121.
34. Zavala-Alcívar, A.; Verdecho, M.-J.; Alfaro-Saiz, J.-J. A conceptual framework to manage resilience and increase sustainability in the supply chain. *Sustainability* **2020**, *12*, 6300.
35. Yin, W.; Ran, W. Supply chain diversification, digital transformation, and supply chain resilience: Configuration analysis based on FSQCA. *Sustainability* **2022**, *14*, 7690.
36. Shashi; Piera Centobelli; Roberto Cerchione; Myriam Ertz. Agile supply chain management: where did it come from and where will it go in the era of digital transformation? *Industrial Marketing Management* **2020**, *90*, 324–345, doi:10.1016/j.indmarman.2020.07.011.
37. Casalino, N.; Żuchowski, I.; Labrinos, N.; Munoz Nieto, Á.L.; Martín, J.A. Digital Strategies and Organizational Performances of SMEs in the Age of Coronavirus: Balancing Digital Transformation with An Effective Business Resilience. *SSRN Journal* **2019**, doi:10.2139/ssrn.3563426.
38. Berg, L.; Farbenblum, B.; Kintominas, A. Addressing Exploitation in Supply Chains: Is technology a game changer for worker voice? *ATR* **2020**, 47–66, doi:10.14197/atr.201220144.
39. Foroughi, A. Supply chain workforce training: addressing the digital skills gap. *HESWBL* **2021**, *11*, 683–696, doi:10.1108/HESWBL-07-2020-0159.

 doi:10.20944/preprints202310.1590.v1

40. Wahab, S.N.; Rajendran, S.D.; Yeap, S.P. Upskilling and reskilling requirement in logistics and supply chain industry for the fourth industrial revolution. *Logforum* **2021**, *17*, 399–410, doi:10.17270/J.LOG.2021.606.
41. Roy, A.; Gilbert, S.M.; Lai, G. The implications of visibility on the use of strategic inventory in a supply chain. *Management Science* **2019**, *65*, 1752–1767.
42. Brandon-Jones, E.; Squire, B.; van Rossenberg, Y.G.T. The impact of supply base complexity on disruptions and performance: the moderating effects of slack and visibility. *International Journal of Production Research* **2015**, *53*, 6903–6918.