

The Role of Digitalization During Supply Chain Disruptions: Lessons from the Experiences of Family-Owned Austrian Firms During the COVID-19 Pandemic

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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 Russia-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 lessons we can take away from their experiences.

Keywords

Digitalization; Supply Chain Disruptions; Digital Supply Chain; Sustainability; Resilience; Best Practices.

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 (Chauhan et al., 2022; Gunasekaran et al., 2015) 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” (Chauhan et al., 2022; Mehdikhani & Valmohammadi, 2019). According to the ILO and Pohlmann et al (Pohlmann et al., 2020) to achieve a sustainable future, businesses will need to align their goals with the SDGs at the strategic as well as operational (Chauhan et al., 2022). In fact, Golroudbary et al. (Golroudbary et al., 2019)

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 (Haroon et al., 2021) 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 pillars of corporate sustainability, ecological, social, and economic, also called the Triple Bottom Line (TBL) (Calabrese et al., 2021). The TBL is frequently employed to translate sustainable development into tangible and actionable decisions (Singh & Rahman, 2021).

Caiado et al. (Caiado et al., 2022) 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).

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. Family-owned businesses that are innovative otherwise often struggle with modernization through digitalization (Baskins, 2023). The COVID-19 pandemic and the Russia-Ukraine war caused supply chain interruptions and disruptions that demonstrated the vulnerability of an interconnected global economy. Formally, according to Macdonald et al. (Macdonald & Corsi, 2013), supply chain disruptions are defined as “unplanned and unanticipated events that disrupt the normal flow of goods and materials within a supply chain” (Craighead et al., 2007), 132). With COVID-19 (Paul et al., 2021), the Russia-Ukraine war (Dyson et al., 2023), and the recent wildfires across the world (Galizia et al., 2021), 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 (Ivanov & Dolgui, 2021). 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 conducted systematic analysis of the academic literature to theoretically discover themes, strategies, and challenges associated with global supply chain disruptions (Hald & Coslugeanu, 2022; Ivanov & Dolgui, 2021; Katsaliaki et al., 2022; Moosaviet al., 2022); 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 other disruptions. There are several researchers who argue that family-owned businesses need to transform particularly during turbulent times (e.g., Davis, 2022), but very little is known about what has worked for them during the disruptions in the past couple of years.

To address the above gap in our understanding, *this paper addresses the following question: What was the impact of digitalization on family-owned businesses during crisis such as Covid-19 and the Ukraine war? This question is explored from the perspective of supply chain leaders in the organization via semi-structured interviews. A descriptive analysis of the interviews is used to elicit the **lessons learned** relating to the impact of digitalization during supply chain disruptions.*

The remaining paper is organized as follows. Section 2 provides an explanation of our research method followed by a detailed analysis of results in section 3 and a discussion of “lessons learnt” in section 4.

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 senior supply chain executives from three family-owned Austrian manufacturing firms in Spring 2022. The executives interviewed were the key leaders (SVP or VP level) of the supply chain for each firm and their digitalization efforts. The choice of firms was primarily due to the authors’ ability to gain convenient access to the firm and key executives responsible for the digitalization efforts in each firm’s supply chain. Although our sample size for this research is a limitation in terms of the generalizability of its conclusions, it is generally challenging, costly and time consuming to obtain access to senior leadership and firms for interviews of the kind reported in this research paper. Furthermore, we concluded that adequate data saturation was achieved with the three firms studied for the research goal of our study. Additional data collection would not produce any value-added insights with regard to the research goal of this research (Adams, 2015b; Saunders et al., 2018). The external validity and generalizability of our conclusions from this sample will of course be limited and applicable to firms that are like those studied. In this context, it is worth reiterating the argument made by Crouch and McKenzie (Crouch & McKenzie, 2006) about the “the logic of small samples...”: “in the social world, to discover what features there are in them and to account, however partially, for those features being as they are... a research project scrutinizes the dynamic qualities of a situation (rather than elucidating the proportionate relationships among its constituents), the issue of sample size - as well as representativeness - has little bearing on the project’s basic logic.”

Expert interviews aim to give further insights about a topic that literature cannot answer entirely (Mayring, 2015b). Although methodological purists raise objections to expert interviews to the expert interview¹ on grounds of it being a “dirty” *method*, the value of an expert interview is the individual’s viewpoint and experience which can influence the researcher’s investigation (Mayring, 2015a; Trinczek, 2009). The open ended semi-structured interviews provided an ideal setting for the free conversational speech of the interviewee combined with guidance from the interviewer (Adams, 2015a, 2015b). To minimize fatigue for both interviewer and respondent, according to (Adams, 2015a, 2015b), about one hour is considered a reasonable maximum length for semi-structured interviews. Our 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 (Adams, 2015a, 2015b).

After each interview, the content was transcribed and anonymized by the authors and coded according to Mayring’s scheme for qualitative content analysis (Mayring, 2015a). The authors reviewed each transcript to develop categories or themes from them that address the primary research question of what worked and did not work during the disruptions due to the COVID-19 pandemic and the Russia-Ukraine war and the lessons learnt thereof (Mayring, 2015a).

Table 1: Open ended Semi-Structured Interview Guiding Questions

Q1. Please describe your role and your firm.
Q2. How much digitalization and/or automation exists with respect to the firm’s supply chain?
Q3. In the context of the Covid-19 pandemic and the Russia-Ukraine war, how is digitalization and/or digital transformation allowing companies to overcome supply chain disruptions and/or become more resilient?
Q4. What have been the challenges relating to supply chain disruptions in your firm? How is digital transformation helping (“helped”)? What are the risks of digitalization?
Q5. How do you (and your firm) think about the resiliency of your global supply chain? What does the future look like for you?

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 2.

Table 2. Attributes of Firms in this study

Family businesses	Size	Primary Products
Company 1	Employees: 770 Turnover: \$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.

Qualitative Findings from Interview Data

Nature of Supply Chain Disruptions

The COVID-19 pandemic, Russia-Ukraine war, the cascading impact of China's reaction to COVID-19, 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 (Hald & Coslugeanu, 2022; Katsaliaki et al., 2022; Moosavi et al., 2022). These findings combine the information gleaned from prior research and echoed by executives from the three firms studied in this research.

Logistics Disruptions

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 (Bridget McCrea, 2022). 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-19 and because of the ongoing the Russia-Ukraine war. All three subject firms faced disruptions due to the Russia-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 from China/Taiwan to Europe of certain raw materials, and other similar constraints.

Production delays due to lack of components or materials

Production delays during COVID-19 become headline news. Manufacturers 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 (Versa Electronics, 2023). 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 (Dyson et al., 2023). As the executive from Company 3 explained: “Out of stock situations 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 economical. 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 Russia-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 pallets to ship goods could not be assembled and their cost tripled.

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 [(Allam et al., 2022). 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 (Polyviou et al., 2023). For example, according to one study (Oxford Analytica, 2023), 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 dependence on China as a manufacturing hub for the world caused severe 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 ((Ivanov, 2020); (Jim Kilpatrick, 2020)).

To compensate for the supply chain disruptions brought on by the pandemic and the Russia-Ukraine war, many companies have been moving their manufacturing and/or sourcing closer to home. According to the Logistics Management survey cited previously (Bridget McCrea, 2022), 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.

Technology and Digitalization

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 ((Baryannis et al., 2019), (Hamidu et al., 2023), (Nasiri et al., 2020)). 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 ((Baryannis et al., 2019), (Nasiri et al., 2020)). 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 ((Zavala-Alcívar et al., 2020), (Yin & Ran, 2022), (Shashi et al., 2020), (Casalino et al., 2019)). 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 Russia-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 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 stock 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 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.

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 ((Berg et al., 2020), (Foroughi, 2021), (Wahab et al., 2021)). 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.

Lack of Transparency/Visibility

Supply chain end-to-end visibility can potentially mitigate the risks of supply chain disruptions (Brandon-Jones et al., 2015; Paul et al., 2021; Roy et al., 2019). 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-19 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.

DISCUSSION and LESSONS LEARNED

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).

Limitations and Implications for Future Research

This research has inherent limitations due to the nature of the qualitative research method and narrow sample of firms participating in the interviews. However, in addition to the lessons learned described previously, there are interesting issues that could be further explored using mixed research or survey research designs. For example, research is needed to address the relationship between the extent of digital transformation in a global supply chain and its impact on reducing supply chain disruptions – this could mean also looking at opportunity costs of not fully digitalizing a supply chain. Additionally, there is still research that needs to be done on how supply chains can be optimally reconfigured to become more resilient through digitalization during disruptions. One of the issues raised by our interviewees was adaptability of the supply chain to disruptions – how can we intentionally design adaptability and responsiveness? Another facet of GSCs that came out in our research that needs further study has to do with engendering effective collaboration across the network due to the large investments needed for a coherent and effective digital transformation strategy. How can firms accomplish this with a shared vision, smart financial investment, governance, and appropriate policies? Finally, a research issue that is often ignored in global supply chains is the study of challenges and best practices of applying decent work principles to labor across the GSC network.

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