

## COVID- 19: outcomes for Global Supply Chains

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**Abstract.** *The COVID-19 crisis exposed the vulnerability and poor resilience of the global supply chains. The objective of this research is to reflect on the possible impacts of the Coronavirus crisis in the global supply chains and provide some recommendations to overcome the present situation, offering suggestions for future research: (1) What are the contingency factors affecting Supply Chains in the complex COVID-19 operating environment? (2) How do these factors affect post-COVID-19 operating performance? After a contextualization of the COVID-19 pandemic crisis and its impacts, theoretical background on Supply Chains and Supply Chain Management are presented, and a summary of the main scenarios for the post-COVID-19 crisis are discussed. The propositions regarding the contingency factors and their impact on the Supply Chain operating performance in post-COVID-19 suggest that successful companies will focus on creating a new kind of operational performance and minimize risks. To that end, companies will aim to improve their operations' resilience (ability to resist, hold on, and recover from shocks) and accelerate the end-to-end digital transformation. Consumers will have to adapt to the contact-free economy, less low-cost supply chains, and put additional emphasis on service levels. Governments will reinforce the focus in the health sector supply chain and increase spending in the health and social care sectors. Furthermore, the longer, the more concentrated, the less transparent, and the more price sensitivity is the supply chain, the more challenging the adaptation to the new pos pandemic realities. Suggestions for future research are also provided.*

**Keywords:** Supply Chain Management, Lean, Just in time, Performance, COVID-19, crisis, research propositions.

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### Introduction

The World Health Organization (WHO) declared a public health emergency of international concern over the global outbreak of the novel virus SARS-CoV-2 (COVID-19) with origin in Wuhan, China (30th January 2020). It escalated it to a global pandemic on 11th March 202. The COVID-19 pandemic has been progressing rapidly (Mckinsey a, 2020), as shown by the reported statistics (Worldometer, 2020), causing the present global crisis, with significant economic, social, and health negative impacts.

As the virus spread outside China, it affected countries worldwide. According to the International Monetary Fund (IMF, 2020), the world entered a crisis equal to or worse than the 2008-2009 financial crisis, affecting both demand and supply.

This research investigates the possible impacts of the Coronavirus crisis in the global supply chains and provides recommendations to overcome the present situation. A qualitative research approach was applied to build and develop a deeper understanding of the views, experiences, and perceptions of relevant individuals, groups, and institutions relating to the research scope. Information was gathered through a combination of various techniques and methods, such as literature review, document analysis, and interviews with experts, to gather a holistic understanding of the research phenomena.

To assess the impacts of COVID-19, namely on Global Supply Chains, and identify potential strategic responses, a critical, evidence-based assessment was performed. This exploratory study employs a critical contextual approach to collect information and support a critical reflection on the COVID-19 outcomes and responses. After reviewing scientific literature on Supply Chain Management and Crisis Management, data was collected and reviewed from online sources between April and May 2020, namely media and institutional sites and reports, to search for COVID-19 impacts on Supply Chain Management and potential responses to the crisis. Furthermore, an online brainstorming session (via Zoom) was held with four University Professors of Operations Management to ascertain what might be expected to Supply Chain Management in the post-COVID-19 crisis scenario?

Based on prior research, reasonable assumptions and the available evidence connecting Supply Chain Management and COVID-19, this research generated several propositions regarding SC operating performance in the post-COVID-19 operating environments. The propositions describe the cause-impact relationships between the identified factors ('what' question) and SC operating performance ('how' question). It is expected these propositions can spur further research that leads to measurable and testable hypotheses.

The questions to be answered are: (1) What are the contingency factors affecting Supply Chains in the complex COVID-19 operating environment? (2) How do these factors affect post-COVID-19 operating performance?

The rest of the paper is structured as follows. The paper begins with the theoretical background of Crisis management and Supply Chains. After the presentation of the main scenarios, propositions regarding the contingency factors and their impact on the SC operating performance in post-COVID-19 are developed. The last section concludes the paper and provides suggestions for further research.

## **Theoretical Background**

### ***Global crisis and the response to COVID-19 pandemic***

In the dynamic and interconnected digital age, organizations need to monitor the internal and external context and the key issues that affect their ability to deliver quality products and satisfy their customers and key stakeholders. Moreover, they should consequently act effectively and timely to improve its sustainability and achieve enduring success (Fonseca & Domingues, 2017). Furthermore, research has emphasized the need for a more robust open organizational systems approach, considering the environment's influence and adopting a dynamic perspective to ensure the organizations survive and succeed (Fonseca, 2015).

In events such as crisis, with a high degree of ambiguity and potentially severe adverse outcomes, new approaches are needed to ensure its survival. A crisis can put an organizations' future at risk and demand urgent and compelling actions to respond to the new environmental challenges.

The world already faced crisis before, such as those originated from natural disasters (e.g., hurricanes and earthquakes, such as the 2011 Japanese earthquake and tsunami), health epidemics (such as Ebola in part of Africa in 2014-2015), and financial crises (such as the 2008-2009 subprime crisis). Research has shown that substantial and global coordinated actions (e.g., on the macroeconomic and financial imbalances) could have prevented the financial turmoil and the severe consequences of the 2008-2009 financial global crisis (Catte et al. 2001). During the present COVID-19 crisis, many major central banks have significantly pumped liquidity into the market banks are helping, in part, to fund the dramatic expansion in government spending taking place, especially in the United States, the Eurozone, and Japan (Bloomberg, 2020). At the business level, prior crisis management investigations emphasize risk assessment (e.g., Herbig, 2003) and the effect of the crisis on business profitability (e.g., Slintak, 2003).

A global crisis health crisis, such as the present coronavirus pandemic, is an unpredictable event with severe consequences, a so-called black swan (Bogle & Sullivan, 2009). Previous health-related crisis includes the Ebola (2014) and the SARS 2003. With approximately 29,000 reported infections, the Ebola epidemic on Liberia, Guinea, and Sierra Leone, had an estimated impact of \$2.8 billion (Mercy Corps, 2019). The 2003 SARS outbreak in 2003 that affected mainly China, Hong Kong, and Taiwan reported 8,000 infections worldwide (LeDuc & Barry, 2004) with a negative influence on production and assembly, sourcing of supplies, and quality (Day et al., 2004). Presently, more than 27,800,000 people have been infected with COVID-19 worldwide ([www.worldometers.info/coronavirus](http://www.worldometers.info/coronavirus)), meaning the COVID-19 global pandemic is much more aggressive than the previous Ebola and SARS regional ones, with a much higher potential for adverse outcomes.

The COVID-19 pandemic is the major health crisis since the influenza epidemic at the end of World War I, with implications on public health, economics, social stability, politics, and geopolitics. The US economy contracted (WSJ, 2020) at an annualized rate of 4.8 percent in the first quarter, which is the most substantial decline since the global financial crisis of 2007-2008. For the 19-member Eurozone, real GDP fell 3.8 percent, or at an annualized rate of 14.4 percent in the first quarter of 2020, which is three times more than the United States (which was down 4.8 percent annualized in Q1), reflecting an earlier effort to suppress social interaction to stifle the spread of the virus (WSJ, 2020). During times of great crisis, such as World War II, governments increased their control of the economy. Already, there has been a substantial economic intervention. As of April 10, governments worldwide had announced stimulus plans amounting to \$10.6 trillion (approximately eight Marshall Plans), emphasizing the support to citizens' basic needs, the preservation of jobs and businesses survival, and the reinforcement of the health and care sectors (Mckinsey b, 2020). Sectors that have been significantly impacted to the sharp decreases in demand and supply shortages include Transportation (Airlines, Cruise operators, Shipping companies), Tourism (Hotels, Restaurants, Hospitality), Oil, Gas, Mining, and Metals (with a decrease in demand and commodity prices), Manufacturers (e.g.,

those with complex supply chains such as Automotive and Technology) and Retailers (Deloitte, 2020).

### ***Supply Chains***

#### *An overview of Supply Chain Management*

Supply Chain Management (SCM) incorporates the range of activities coordinated by an organization to procure and manage supplies (Oliver and Webber, 1982). SCM is an “umbrella construct” that incorporates supplier and network sourcing, and demand and value chain and integrated logistics management (Croom et al., 2000; Romano and Vinelli, 2001; Kotzab and Otto, 2004, Fonseca & Lima, 2015). A supply chain involves all parties that directly or indirectly fulfill a customer request (Chopra and Meindl, 2007).

The modern approaches to SCM focus on the interdependence of organizations working in a collaborative way to improve the efficiency of the global logistics channel (Shin et al., 2000; Narasimhan and Kim, 2002). This extended scope encourages synergy and cross-functional collaboration among all partners to achieve a more effective and efficient supply and integrate customers, suppliers, manufacturers, and other value chain actors through all the firm functions. Following these initial concepts, Chopra and Meindl (2007) stated that “A supply chain ...consists of all parties involved, directly or indirectly, in fulfilling a customer request”. The selection of suppliers should consider that a relationship between customers and suppliers does not depend only on costs but also on product quality, delivery, and flexibility (Fonseca & Lima, 2015). Low-cost supply chains are often unable to respond to unexpected changes in demand or supply or provide a higher amount of defective generating internal and external failures costs (Lee, 2004; Fonseca & Lim, 2015). Strategic supply management (SSM) should be regarded as strategic long-term planned effort to create a capable supplier base and leverage the benefit of supply management (Carr and Pearson, 1999; Shin et al., 2000; Chen et al., 2004).

Knowing the critical dimensions that affect performance is vital in a highly complex operations environment (Barbosa & Azevedo, 2019). Make-to-order (MTO) supply chains are vulnerable to demand uncertainty, disruptions in material supplies, long product lead times, and large order backlogs (Sahin, 2005). Managing inventories in MTO environments often encompasses keeping high inventory levels to minimize delays (Stavrulaki and Davis 2010). According to Barbosa and Azevedo (2019), the main performance determinants of Supply Chain (SC) performance are complexity, workload, design reuse, project type, outsourcing, and experience/knowledge of technology, while customers, manufacturers, and suppliers are the primary sources of uncertainty.

The COVID-19 crisis has revealed the fragility and exposed the global supply chains' vulnerability and low resilience. Moreover, the pandemic originated a problem that simultaneously affects supply and demand, making it more challenging to respond successfully. Firstly, there was a supply-side shock. Then there was a significant escalation on the demand side with the implementation of containment policies. The first concern of Governments was obviously to address the COVID-19 health issues by imposing social distance constraints on the population, ramping up hospital capacity, and gathering medical supplies, tests, and equipment (e.g., ventilators). However, selecting, and qualified new suppliers to make up for missing deliveries is not an easy task, especially in long global supply chains, that have proven to be the most vulnerable. As the distance and the number of players increase, so does the overall probability of disruption. One of the lessons that can

already be drawn from this crisis is the urgent need to design more robust, resilient, and more smart supply chains. In this development line, decentralization of capacity, multi-sourcing, and small batch production and digitization could be keen on building future supply-chains.

### ***Just in Time and Lean Supply Chain***

Lean principles, when applied among the several supply chain echelons effectively, will derive potential benefits for all concerned. Indeed, minimizing waste while making the right product available to the end customer at the right time and location, i.e., accordingly the just-in-time principles, can lead to unequivocal performance improvements. The overall aim is to optimize activities along the supply chain from the final customer's perspective. However, extending and spreading lean practices in all sourcing, transformation, and delivery chains can create operational conflict in very high variability resulting from unforeseen external events.. Supply chains are designed for nominal operations, not for once-in-a-lifetime disruption and recovery (Simchi-Levi, 2020). Therefore, it is of interest to pay attention to the main principles and concepts surrounding just-in-time and Lean Supply Chain.

Just in Time (JIT) aims to eliminate non-valuable added activities, helping companies to reduce costs and improve operational performance, and was presented in works by Clutterbuck (1978), Schonberger (1982), and Shingo (1989), amongst others. JIT dimensions and practices are summarized in table 1:

*Table 1. JIT dimensions and practices*

<b>JIT Dimensions</b>	<b>JIT practices</b>
Management commitment	<ul style="list-style-type: none"> <li>• Management education</li> <li>• Formal means for listening and investigation of suggestions</li> <li>• Authority to stop lines (Jidoka) and use of quality circles</li> </ul>
JIT Production strategy	<ul style="list-style-type: none"> <li>• Product design simplicity</li> <li>• Single minute exchange dies (SMED) setup time reduction</li> <li>• In-house lot sizes</li> <li>• Pull production system and Kanbans</li> <li>• Cell production layouts</li> <li>• Cross-training and multifunction workers</li> <li>• Total Preventive Maintenance (TPM)</li> <li>• Visual management</li> <li>• MRP adaptation to JIT and accounting adaptation to JIT</li> </ul>
JIT supplier strategy	<ul style="list-style-type: none"> <li>• Small lot sizes and frequent delivery</li> <li>• Sole preferred sourcing</li> <li>• Supplier quality level</li> <li>• Supplier lead time and flexibility to respond</li> </ul>
JIT education strategy	<ul style="list-style-type: none"> <li>• Quality certification of suppliers</li> <li>• Employees training</li> <li>• Pilot project</li> <li>• JIT team, consultants, and JIT champion.</li> </ul>

Source: Adapted from Mehra and Inman (1992) and Sakakibara et al. [1993].

Lean production or lean thinking (Womack et al., 1990; Womack and Jones, 1996) is based on the concept of achieving improvements in the most economical ways with an

emphasis on “Muda” (waste) elimination. It is in line with Ohno’s Toyota Production System and the Just in Time methodology. Lean intends to combine the flexibility of craftsmanship with the low cost of mass production and tries to achieve more with the existing resources, to achieve the intended outcome with fewer resources (Fonseca & Domingues, 2018). Lean is supported on five principles (Womack and Jones, 1996, p. 10):

- specify the value by specific product.
- identify the value stream for each product.
- make the value flow without interruptions.
- let the customer pull value from the produce, and
- pursue perfection.

Top management should support teamwork and focus on Lean tools and techniques to identify problems and their causes, rather than searching and punishing the responsible. Lean focuses on flexibility, waste elimination, and people involvement, with the support of tools and techniques such as the value stream mapping to design the flow of value of a product (Rother and Shook, 2003).

The lean supply chain has a principle of inventory optimization. Optimal inventory levels are those that will allow for operational efficient and effective fulfilling of current customer demand patterns. However, lean global supply chains are one of the main reasons for supply shortages during the COVID-19 crisis. With globalization, supply chains have extended to low-cost regions to reduce costs, and just-in-time methodologies were adopted to reduce waste, resulting in lower inventory levels throughout the supply chain. After all, if to make a car 10.000 parts are needed, one missing part is enough to prevent the car delivery.

#### *The return of Just in Case?*

Instead of focusing on eliminating all inefficiencies and waste through the overall supply chain, companies are more concerned about ensuring operational continuity. In this context, some companies might consider moving from just-in-time to a just-in-case methodology and keep enough inventories to reduce to face supply and demand uncertainties and focus on balancing efficiency with flexibility, resilience, and reliability on the overall supply chain. However, just in case would require more “safety stocks” to address possible delivery delays, which represents additional costs and is not in line with the Lean/ JIT methodology. In a just in case approach, companies will emphasize compromise between efficiency with resilience. They will prepare contingency plans, accept higher possible higher procurement costs and longer delivery times, and focus more on reliable than cheap suppliers, and ensure high visibility and supply chain process improvements and technology over the supply chain.

Nevertheless, it is not possible to have the best of both worlds at the same time. Just-in-case robustness and resilience to backorders and satisfy customer demands brings an additional cost of tying up capital in inventory, and someone will have to pay for it., or either by increasing prices, or reducing profitability, or maybe a balance of the two.

#### *Supply Chain Performance*

Supply chain performance (SCP) seeks to measure the efficiency (maximize the output with the minimum input, e.g., by reducing waste and cost) and effectiveness (achieving the desired outcome, e.g., improving quality and increasing customer satisfaction) of the supply

chain processes (Li et al., 2006; Balocco et al., 2011; Fonseca and Lima, 2015; Maestrini et al., 2018).

Supply chain management aims to use resources and capabilities in an effective way to improved performance (Maestrini et al., 2018). Lee et al. (2007) and Liao et al. (2010) proposed reliability, cost-containment, customer-oriented, and supplier-oriented, as dimensions to measure performance, while Baofeng (2012) emphasized supplier and customer-oriented performance. Table 2 presents a summary of the SCP measures:

*Table 2. SCP measures*

SCP measure	Authors
Supplier performance (quality, flexibility, delivery, price)	Li et al. (2006); Boafeng, (2012); Fonseca and Lima (2015)
Supply chain response time (time between the receipt of customer order and delivering of finished goods)	Lee et al. (2007)
Capacity utilization (affects the speed of response to customer demand)	Gunasekaran et al. (2004)
Reliability performance (order fulfilling rates, inventory turnover rates, the value of product guarantee claims)	Lee et al. (2007); Liao et al. (2010)
Supply chain and logistics cost	Gunasekaran et al. (2004)
Cost associated with assets and return on investment	Gunasekaran et al. (2004)
Sales growth	Gunasekaran et al. (2004), Fonseca and Lima (2015)

## **Possible scenarios for Supply Chain Management in a post-COVID-19 world**

It would be very dared to make confident predictions of what will happen after the COVID - 19 crisis and how the world economic order will look in the next years or even months. With globalization, companies can move production wherever it is most efficient, people can travel anywhere, and money can flow freely. However, countries are already assessing how much they are dependent from other countries and assessing which critical technologies, critical resources, and manufacturing capacity they want to retain. The Trump administration embraced this movement, and other countries are following the path, e.g., "France's finance minister directed French companies to re-evaluate their supply chains to become less dependent on China and other Asian nations" (Irwin, 2020). Governments might shift toward regional trade blocs, and there will be greater emphasis on having companies increase supply chain resilience and redundancy. In the economic field, entrepreneurship, innovation, knowledge economy, development sustainable intellectual capital, and digitalization, should remain the main variables for enhancing competitiveness and development (Păunescu, 2013; Anagnoste, 2017, Bratianu, 2018; Bratianu et al., 2020; Dinca et al., 2019).

The COVID-19 crisis has revealed severe Supply chain shortcomings, namely on pharma and medical supplies industries, such as lack of personal protective equipment for health workers and ventilators in hospitals, which led Governments to emphasize the domestic production of medical supplies.

The COVID-19 pandemic has dramatically changed the demand and the supply of products and services worldwide. The weakness and lack of resilience of global supply

chains and service networks have been exposed. However, at the same time, some companies managed to adapt to the pandemic environment and improve their agility and productivity, connecting to end-consumers and maintaining their liquidity, e.g., by resorting to e-commerce and moving from Business to Business (B2B) to Business to Consumer (B2C). An example of this is how leading retailers', with physical stores closed, by focusing on their sense of purpose and improving speed, reinforced the e-commerce capabilities, resorting to online and direct-to-customer sales and delivering food to customers confined in their homes (Mckinsey a, 2020).

Furthermore, what might be expected in the post-COVID-19 crisis scenario? According to McKinsey Global Institute (McKinsey Global Institute, 2020), 93% of the surveyed supply chain executives, representing diverse worldwide value chains, reported that they plan to make their supply chains more resilient. The measures include building in redundancy across suppliers (e.g., dual sourcing of raw materials), increasing inventory of critical products, nearshoring and expanding the supplier base, reducing the number of unique parts, and regionalizing their supply chains. An online brainstorming session (via Zoom) was held with four University Professors of Operations Management to gather additional insights on post-COVID-19 Supply Chain scenarios. This session's outcomes emphasize that it seems unlikely that companies try to resort back to the "old normal", Concerning supply chain management, it is likely that successful companies will focus on creating a new kind of operational performance and minimize risks. To that end, they will improve their operations resilience and accelerate the end-to-end digital transformation, aiming for a sustainable operation competitive advantage. Historically, suppliers are selected based on price, quality, and delivery capability and performance. However, there are two new relevant key process indicator (KPI) that should be addressed: time to recovery (TTR) that is "the time it would take for a particular node — a supplier facility, a distribution center, or a transportation hub — to be restored to full functionality after a disruption"; and the Time to Survive (TTS), which is "the maximum duration that the supply chain can match supply with demand after a supplier or node disruption" (Simchi-Levi, 2015). If TTS is greater than TTR, the disrupted site does not represent a risk since, while it is recovering, the company can still match supply with demand. However, if TTS is smaller than TTR, there will be a disruption in the supply chain with operational and financial problems to the company. Moreover, while a just-in-time company usually outperforms another one running a just-in-case inventory management system (Mackelprang & Nair, 2010), it is up to each specific company to choose the system that works best for them. Companies can decide to keep just-in-case inventory on its most critical items in a post-crisis world while relying on just-in-time inventory to fulfill the customer requests that occur less often. Furthermore, to help companies in that regard, some apps are already available to assess the COVID-19 Impact for Supply Chain Management (e.g., <https://www.camelot-itlab.com/en/covid-19-impact-analyzer-for-supply-chain-management/>).

Building on the previous considerations, a summary of the contingency factors and their possible effect on post-COVID-19 SC performance, are proposed in table 3:



Table 3. COVID-19 contingency factors and effects on SC performance

<b>COVID 19 contingency factor performance</b>	<b>Effect on SC management performance</b>	<b>Effects on SC performance (quality, flexibility, delivery, cost/price)</b>
Contraction of major world economies	Decrease in demand, excess capacity	Fewer revenues and price increases, low utilization rates
Stimulus plans, increased government control of the economy, emphasis on jobs preservation and business survival	Emphasis on basic needs fulfillment, reinforcement of the health and care sectors Focus on national and regional suppliers	Changes in SC networks configurations
Relevance of contingency plans	Supply chain partnerships to establish a coordinated crisis-support system and contingency plans	Improved flexibility and delivery reliability
Focus on delivery reliability acceptance	Emphasize delivery reliability versus price Focus on value rather than price Lees single-source components	Higher procurement costs
Improve visibility through the SC, understand supply chain risks, build safety stocks for critical items, improve operations resilience, and emphasize delivery reliability	Assessing global environmental risks (e.g., PESTEL analysis), such as natural disasters, economic shocks, terrorism, or cybersecurity risks. Evaluate the supplier networks, e.g., the transportation and logistics systems, and the suppliers organizational and financial strengths (identify fragile suppliers) Identify and test alternative suppliers and logistics routes, to maintain the flexibility to reposition inventory across the overall SC. Increase visibility into tier 2 and tier 3 suppliers that, although relatively small, can quickly and significantly disrupt production.	Improved flexibility and delivery reliability Increased safety stocks Higher responsiveness Increase ramp-up capability Higher procurement costs
Accelerate end-to-end digital transformation	Build transparency through analytics to identify weaknesses and do benchmarking. Internet of things, artificial intelligence, big data, and related technologies transform supply chain networks into new supply	Improved quality, flexibility, delivery, cost/price

	chain intelligent workflows, improving overall performance and supporting quick scenario planning and decision making.	
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When the COVID-19 crisis is gone, some companies will hope that such a crisis will not happen again and try to resort to business as usual practices.

Barbosa and Azevedo (2019) identified SC complexity, workload, design reuse, project type, outsourcing, and experience/knowledge of technology, as the primary performance determinants of SC performance. Based on this analysis, three additional dimensions for SC management are proposed: (1) Length (tier levels and number of suppliers); (2) Concentration (dependence on a few vital suppliers, low level of substitutability); (3) Transparency and accountability (performance management systems and Key process indicators).

Furthermore, there will be other companies that would have learned the lessons from the crisis and ensure they can react fast and adopt solutions in case of a crisis, as suggested in table 4.

*Table 4. Post COVID-19 Supply Chain Management actions*

Supply	<ul style="list-style-type: none"> <li>• Ongoing assessment of the supply chain to continue production and supply</li> <li>• Engagement with critical suppliers and evaluating their ability to maintain the continuity of supply</li> <li>• Preparation of contingency plans for alternative suppliers</li> <li>• Improve the resilience of the supply chain (e.g., suppliers with more robust organizational and financial capabilities)</li> <li>• Multi-level sourcing</li> <li>• Increase visibility</li> <li>• Improve redundancy, especially for critical suppliers and parts, components, and products</li> <li>• Increase stock levels for critical parts, components, and products (note: it should be acknowledged that this represent a cost increase, and someone will have to pay for it)</li> <li>• Perform supply chain stress tests</li> <li>• Engaged in the digital transformation and e-commerce</li> <li>• Develop the B2C to complement B2C</li> <li>• More business analytics and big data</li> </ul>
Demand	<ul style="list-style-type: none"> <li>• Increase visibility</li> <li>• continuously engaging with customers to manage expectations</li> <li>• redefinition of the communication channels (more RRSS, online, influencers, community groups)</li> <li>• Online SEO /SEM platforms</li> </ul>

Source: Authors' own research.

The health sector supply chain will be most surely be reinforced, and Governments will increase spending in the health and social care sectors. Moreover, we should not forget that a supply chain exists to satisfy the demand so that the future demand patterns will have a significant influence in that regard. The longer the supply chain, the more difficult it would have to adapt to the new pos pandemic realities. Additionally, those that have high price sensibility will also face more difficulties. Consumers will probably have to adapt to the contact-free economy and less low-cost supply chains and put additional emphasis on service levels.



Proposition 7: The demand for more robust and resilient Supply Chains will lead to an acceleration of end-to-end digital transformation.

Proposition 8: In the Post COVID-19 world, there will be an improvement in SC delivery reliability acceptance.

Proposition 9: In the Post COVID-19 world, there will be an increase in the overall SC cost.

Proposition 10: In the Post COVID-19 world, there will be a decrease in the profitability of low-cost suppliers.

Proposition 11: In the Post COVID-19 world, there will be an increase in the profitability of the value cost suppliers.

## **Conclusions and suggestions for further research**

This paper has identified and analyzed the possible impacts of the Coronavirus crisis in the global supply chains. From the various lessons learned, it is recognized that companies and supply chains need to improve their resilience by adopting new organizational and management policies and practices and technologies for digitizing their inter-related processes to have greater visibility up and downstream. Therefore, several recommendations are posited to overcome the present situation. Suggestions for future investigations are presented, namely, on the contingency factors affecting Supply Chains in the complex COVID-19 operating environment and how these factors affect the post-COVID-19 operating performance.

The first research question was ‘What are the contingency factors affecting Supply Chains in the complex COVID-19 operating environment?’ This investigation suggests that the COVID-19 contingency factors will significantly impact Supply Chain management and performance. Successful companies will focus on creating a new kind of sustainable operational performance with shorter and more resilient supply chains and risk management and business continuity plans.

The acceleration of the end-to-end digital transformation, both on the demand and the supply side, means that consumers will have to adapt to the contact-free economy, less low-cost supply chains, and put additional emphasis on service levels. Moreover, Governments will reinforce the focus in the health sector supply chain and will increase spending in the health and social care sectors. The second research question was, ‘How do these factors affect the post-COVID-19 operating performance?’ Eleven research propositions are presented to assess the possible influence of the COVID-19 pandemic on SC operating performance.

In a nutshell, the longer, more concentrated, less transparent, and more price-sensitive supply chain, the more challenging the adaptation to the new post-pandemic realities. Therefore, it is suggested that these propositions should be analyzed, discussed, and eventually validated by future research, contributing to novel SC knowledge and literature. One possible path would be to develop a multi-sectoral study (traditional and non-traditional sectors) and segmented by different dimensions, for example, type of product (complexity, level of consumption, level of customization), type of market (local, regional, national, global), degree of technological sophistication (maturity and availability of the processes used).

This exploratory research contains an inherent limitation, since the propositions link concepts without testing hypotheses, and there is no empirically quantitative data to support the above recommendations, which is suggested for future research. However, in the face of the novelty of the COVID-19 pandemic, it is useful to map the territory, and this paper contributes to that end.

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