Supply Chain Challenges in the COVID-19 Pandemic World*

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Abstract

The constraints imposed by the pandemic COVID-19 had profound consequences on companies' supply chain, downstream and upstream. This study aims to evaluate the impact of a disruptive situation such as the pandemic in companies' supply chain, identifying the main constraints and suggesting solutions. To this end, a quantitative multiple case study methodology was used, and interviews were conducted with Portuguese companies. The results show that the companies that most suffered disruption in their supply chain were the most vulnerable and least resilient. With redundancies and strategic risk management, a more flexible supply chain can ensure that its supply chains are not threatened in case of disruptive events. This study has contributed to the literature on Complex Adaptive System theory and the consequences of the pandemic on supply chains. It is original because it is about analysing case studies of Portuguese companies.

Keywords: Logistics; Supply chain vulnerability; Resilience; COVID-19 pandemic; Supply chain disruptions; Operations management; Strategies.

Introduction

The pandemic of COVID-19 highlighted problems never before seen or imagined, no matter how much technology or knowledge there might be. No one was prepared to fight such a disaster, bringing economic, social and humanitarian problems. As we live in a global world where financial transactions, information or materials are just a click away, and in seconds, more vulnerabilities to the disruptions that resulted from the Covid-19 pandemic. In this context, companies faced numerous problems, including in the supply chain (Han *et al.*, 2021, Gomes *et al.*, 2021).

Also, due to globalisation, companies need to have increasingly extensive, complex, branched and interdependent supply chains. Supply chains are nothing more than a web of multiple and disparate actors that interact with each other incessantly, each with specific functions and where they all yearn for a common goal, namely the satisfaction of the final customer (Gaviolli and Laruccia, 2008).

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When any abnormal situation happens in any supply chain constituents, it will influence the others. Such situations are referred to as disruptions (Li *et al.*, 2017). Disruptions can be for various reasons, be it natural, economic, social crises, such as lack of raw material problems in transportation, among others (Hsu *et al.*, 2021, Han *et al.*, 2021).

The COVID-19 pandemic brought new challenges to businesses. Companies experienced disruptions in their supply chain that were unprecedented or comparable. However, with the disruptions in their supply chain, businesses learned to be more resilient. Being more resilient means anticipating obstacles or minimising damage of any kind, and after taking the most efficient measures, evolving and changing business behaviour. These are the assumptions stated and defended by the Complex Adaptive System theory (CAS) (Ferreira *et al.*, 2021). The CAS theory argues that resilience strategies are important and paramount to mitigate and improve the supply chain. These adopted strategies are the basis for systems evolution (Turner and Baker, 2019).

This study aims to analyse companies' supply chain during the pandemic of COVID-19, identifying potential problems and pointing out the respective solutions. To this end, a multiple case study was used, and interviews were conducted with companies located in the central region of Portugal.

Literature Review

CAS Theory

CAS theory advocates the existence of complex, dynamic, open, adaptive systems, i.e. systems capable of responding and adapting to change and non-linear. Therefore, a system that possesses the capacity to evolve (coevolution) into a new system (Shen and Gao, 2020). This system comprises internal elements (suppliers, distributors, customers, research centres, government, regulatory bodies, etc.) external elements that are in constant interaction. These actors react to disturbances in the supply chain, either by perturbations of the agents or by disturbances in the external environment, as they reorganise themselves, learn to solve adversities by recovering from a disturbing event, or even their ability to foresee a response (Turner and Baker, 2019, Lopes *et al.*, 2022).

Supply Chains

Supply chains are considered CAS (Zuo and Kajikawa, 2017). Supply chains are dynamic systems, consisting of various actors (from the supplier of raw materials to the companies producing products or services, to distributors until the sale of products to the final customer), which interact with each other and are interdependent. These are increasingly complex, and as such, these interactions cause disruptions. Therefore, companies need to increase the supply chain's resilience (Gaviolli and Laruccia, 2008).

As supply chains are complex, dynamic and unpredictable close coordination between all actors is required, and everyone's objectives must be aligned. The supply chain must achieve product delivery, at the right time, at the right place, with quality and at the lowest cost, and must minimise both costs and cycles and maximise customer satisfaction (Masoumi *et al.*, 2019). The supply chain should be managed holistically, and who influences the efficiency of the network is the purchasing capacity of the end consumer. The consumer, when buying, is the one who will influence along the supply chain the orders of the other actors. When the demand for a product increases, it triggers that demand in all its actors, the demand for raw materials by companies increases, production increases and, consequently, the transport of that product increases and it is delivered to the shops and finally to the final consumer. This chain management is directed towards the customer. It is important the partnerships between suppliers and customers in which suppliers sometimes work inside customers' factories, allowing the reduction of costs and processes, thus creating more efficiency in the chain (Venkatadri *et al.*, 2021).

Furthermore, the competitive advantages of supply chains are influenced by the use of technologies. Thus, since the transfer of information, data and money are fast, reliable, and with reduced costs, more easily companies respond to customer needs in real time. In this way, technology provides and accelerates the cooperation of the various actors (Santos *et al.*, 2012).

Vulnerabilities, Resilience and Supply Chain Disruptions

Supply chains are extensive, complex, and mostly unpredictable. Managers must have the chain mapped and predict disruptive events, have methods and tools to manage risks as quickly as possible and understand weaknesses dependencies (Blackhurst *et al.*, 2018).

The word resilience derives from the Latin word *"resiliere",* which means to recover. Thus, there are several factors such as the supply strategy to be taken into consideration, whether there are few or many suppliers, the supply chain's arrangement, and the strategy of each company in case of rupture. These factors must be aligned to save the company from huge losses or even prevent bankruptcy itself. Resilience is also synonymous with overcoming problems and is necessary for long-term sustainability (Arsovski *et al.*, 2015).

That said, resilience in the supply chain is how they respond or anticipate any disruptive event to any setback some interruption. In the face of this, strategies are adopted to settle any losses. The goal is to return to the state of equilibrium, or even more advantageous, making the company more competitive (Lopes *et al.*, 2022). On the other hand, vulnerabilities are impacts of disturbances in the supply chain. Vulnerability and resilience are concepts that appear in the literature often related because, in any supply chain, there are disturbances that we cannot avoid, control or eliminate (Gomes *et al.*, 2021). Thus, it is necessary to implement a more resilient supply chain with fewer vulnerabilities and more sustainability (Hsu *et al.*, 2021).

Methodology

In this study, we used a qualitative approach through direct observation. The case study methodology, through a multiple case study, is the most suitable for this study, as it allows observation in natural environments, as well as providing research and interpretation of specific phenomena, such as the functioning of supply chains during the COVID-19 pandemic, understanding the adopted processes of the companies under study (Njie and Asimiran, 2014, Rodrigues *et al.*, 2021, Lopes *et al.*, 2018).

The interviews followed a previously defined script. The semi-structured script was adapted from Yaroson *et al.* (2021), Gomes *et al.* (2021), and Ferreira *et al.* (2021) and is composed of thirty-one open questions. Four interviews were carried out with large companies located in the central region of Portugal, in March and April 2021, with an average duration of 60 minutes each.

After the interviews, the data were transcribed analysed based on thematic analysis and a correlation of the accounts and comparison between related themes presented in the next section.

Table 1 shows the characterisation of the sample. The heads of the interviewed companies have more than 10 years of experience, and the companies' fields of activity are diversified (textile, accessories and food). In terms of size, three of the companies are large companies, and one of the companies is medium-sized. The companies were all founded more than 20 years ago.

Table 1: Characterisation of the sample

Company	Type of company	Respondent's area of responsibility	Years of experience of the interviewee	Invoicing volume	Type of Company	Date of foundation of the company
Company 1	Made-to-measure mass-produced garments	Purchasing and sub-contracting department	25 years	Year 2020 - 6 million	Large Company	1961
Company 2	Manufacture of other outerwear in series	Commercial Department	32 years	Year 2020 - 11 million	Large Company	1984
Company 3	Manufacture of helmets	Financial Director	13 years	Year 2020 14 million	Medium-sized Companies	2000
Company 4	Multinational food company	Team leader in the commercial area	28 years	Year 2020 480 million	Large Company	1923 in Portugal

Results

Given that this study aims to analyse companies' supply chain during the pandemic of COVID-19, identifying potential problems and suggesting recommendations to solve these problems, three groups of results are presented in this section. The first is regarding supply chain disruptions during the pandemic; the second in which supply chain vulnerabilities are assessed, and the third is regarding the resilience of supply chains.

Disturbances in the supply chain

During the pandemic, supply chains suffered various constraints. The two textile companies and the accessories company experienced delays in the supply of raw materials and, as such, delays in deliveries to customers. These disruptions were identified soon after the onset of the pandemic with mandatory containment. The food company, during the pandemic, never experienced delays in the supply of raw materials, nor was it late in delivering the products to its customers due to the type of activity it performs. Food businesses experienced increased momentum in the pandemic season due to the sale of basic goods. The companies have metrics that allow them to identify alarm situations, namely computer systems that warn when stocks are minimal and when there are customers to whom goods have not yet been delivered. In this way, these metrics make it possible to immediately assess situations disrupting their upstream and downstream supply chain. With regard to the evaluation of supply chain efficiency, the companies carry out analyses at different intervals (in the textile companies, the analysis is daily and weekly; in the accessories company, it is daily, and in the food company, it is hourly). In terms of barriers encountered in the interruption of the supply chain, the textile companies identified the shortage of raw materials and the accessories and food companies said they had not identified barriers because they have a diversified portfolio of suppliers that prevents them from situations of downtime in the event of events affecting their supply chain.

Supply chain vulnerabilities

According to Wagner and Bode (2006), the vulnerability of supply chains can be defined as their susceptibility to disruptive events that may occur. The greater the complexity of the supply network, the greater the number of interfaces and, as such, the greater its vulnerability (Peck, 2005).

According to the heads of the interviewed companies, the characteristics of the products they market do not extend disruptive activities. The supply chain of the two textile industries and the accessories company are similar, using the guiding principle "just in time": they produce according to orders. When a customer order is received, that order generates a requirements sheet in the sales department, which is forwarded to the purchasing department. All items with no absolute or partial availability are ordered from the suppliers in sequential order and sent by email, requesting confirmation of delivery deadlines, prices, and history of previously established conditions. On receipt of the goods, the order is transformed into a goods receipt document with the quantities sent by the suppliers. In the event of discrepancies, the purchasing department is informed. If the raw material is not available, the sales department and the production department receive this availability information to adjust the start of production. The warehouses register the production outputs of the quantities sent and return the goods that the different production departments did not use during production. Subsequently, the order is delivered to the customer. In the case of the food company, it buys raw materials from various suppliers worldwide, which are then processed in one of the companies of the group, and then the products are distributed directly to customers.

Suppliers play an important role in the case of disruptive events such as the pandemic, providing alternatives and solutions to the problems that arise in the supply chains. This reinforces the need to have a diversified supplier portfolio. When there is a disruption in the supply chain, all the companies mention that the suppliers warn them, and the company managers hold meetings with the various departments involved.

Supply chain resilience

The supply chain's resilience is the ability to recover from situations that alter its normal functioning (Christopher and Peck, 2004). The heads of the textile and accessories companies mentioned that, in case of disruption in the supply chain, the company's strategy is to change the products to be produced. These strategies prevent the collapse of the supply chain and ensure that one can continue to supply the customers. In the case of the food company, this question does not arise because they have had no interruptions. The sharing of information between departments a stable financial situation that makes it possible to reallocate investment in alternative machines and buy more expensive raw materials or bear higher logistics costs are some of the resources that make it easier for companies to recover in the event of a supply chain disruption. Companies maintain regular contact with their stakeholders such as suppliers and share information about their supply chains at trade fairs and exhibitions. They also mentioned again that having a diversified supplier portfolio in various geographical locations allows them to have suppliers available at all times, reducing the impact of obstacles such as lack of raw materials and higher

transport costs. A disruptive situation such as the pandemic allowed companies to learn and correct errors in supply chains, reinforcing the need to have alert tools in case changes are detected.

Discussion of Results and Conclusions

This study aims to analyse the supply chain behaviour of companies during the pandemic of COVID-19, identifying potential problems and their solutions.

The interviews show that the companies, except the food company, were not prepared for an event that disrupted their supply chain, as evidenced in Magableh (2021) study. Consequently, they experienced downstream and upstream delays in their supply chains. Immediate awareness of disruption and the use of alert metrics enabled companies to quickly detect barriers and assess supply chain efficiency. The central role of a diverse and geographically dispersed supplier portfolio in reducing vulnerability, the likelihood of disruption and increasing supply chain resilience is highlighted (Birkie and Trucco, 2020). If the supply chain is more flexible, i.e. with the ability to adapt to business changes and if redundancies are created through the creation of safety stocks, the supply chain also becomes more resilient (Golan *et al.*, 2020, Christopher and Holweg, 2011).

In this context, it becomes important to anticipate disruptions that may affect supply chains by creating a risk management strategy (Ferreira *et al.*, 2021, Gomes *et al.*, 2021). This strategy should identify known and unknown risks. Known risks are those that are measurable and possible to manage over time. In the case of unknown risks, where they cannot be predicted, the vulnerabilities of supply chains need to be reduced, and their resilience strengthened (Magableh, 2021). Thus, four practices are suggested that companies should follow to reduce the probability of disruption in their supply chain: (1) continuously identify, assess and document the risks at each point in the upstream and downstream supply chain; (2) develop a contingency plan for risk management that addresses the consequences if the disruptive event occurs, the materialisation of the threat and the organisation's preparedness to face this risk; (3) monitor risk using digital tools that collect risk indicators and bet on predictive tools and (4) at the governance level, create a mechanism that allows for periodic review of supply chain risks.

This study is original because it is based on a multiple case study, and it contributed to the CAS theory literature and literature on the pandemic's consequences on supply chains. It presents some limitations due to the small number of firms involved in the sample and their heterogeneity in terms of characteristics. Each activity sector has its particularities at the level of supply chains, and the results cannot be generalised. For future lines, we propose to enrich the sample in terms of the number and diversity of activity sectors of companies to obtain more robust results. We also propose to compare the disruption caused by the pandemic with the disruption caused by the scarcity and high prices of raw materials currently experienced.

Acknowledgements

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