CONSEQUENCES OF THE PANDEMIC CONSTRAINTS ON THE SUPPLY CHAIN OF COMPANIES: AN EXPLORATORY APPROACH

Gomes S., Lopes J.M.*

Abstract: The disruption in the supply chain imposed by the COVID-19 pandemic has posed important challenges for companies. This study explores the consequences of the pandemic on the supply chain of companies, identifying the main problems and proposing solutions for future disruptive situations. The qualitative study presented is based on the study of multiple cases obtained through interviews with Portuguese companies. Exploring the multiple cases of companies revealed that companies with less resilient and more vulnerable supply chains, both upstream and downstream, were most affected by the pandemic. The supply chain that includes redundancies and adopting appropriate risk management tools by companies guarantees greater flexibility for supply chains to adapt more quickly to disruptive situations. This exploratory study contributes to the approach of the Complex Adaptive System theory and brings new insights into the consequences of the pandemic on supply chains.

Keywords: Logistics; Supply chain vulnerability; Resilience; COVID-19 pandemic; Supply chain disruptions

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. 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 resulting from the Covid-19 pandemic. In this context, companies face numerous problems, including in the supply chain (Gomes et al., 2021; Han et al., 2021).
Also, due to globalisation, companies must have increasingly extensive, complex, branched and interdependent supply chains. Supply chains are nothing more than a web of multiple and disparate actors that interact incessantly, each with specific

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functions and where they all yearn for a common goal, namely the satisfaction of the final customer (Gaviolli and Laruccia, 2008).

When any abnormal situation happens in any supply chain constituents, it will influence others. Such situations are disruptions (Li et al., 2017). Disruptions can be for various reasons, be it natural, economic, or social crises, such as lack of raw material problems in transportation (Han et al., 2021; Hsu 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 assumptions are stated and defended by the Complex Adaptive System theory (CAS) (Ferreira et al., 2021). The CAS theory argues that resilience strategies are paramount to mitigating and improving the supply chain. These adopted strategies are the basis for systems evolution (Turner and Baker, 2019). 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 with 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.) and 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 (Lopes et al., 2022; Turner and Baker, 2019).

This study aims to analyse companies' supply chains during the pandemic of COVID-19, identifying potential problems and pointing out 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

Supply chains are extensive, complex, and mostly unpredictable. 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. Thus, supply chains are considered CAS (Zuo and Kajikawa, 2017). The longer supply chains are, the more complex they become and the more difficult and time-consuming it becomes to respond to disruptions. In the literature, interruptions can be defined as unplanned or anticipated circumstances that alter the normal flow of the supply chain (Bode and Wagner, 2015). This type of interruptions, which are difficult to predict, can be caused by changes in demand, supply, the legal system, supporting infrastructure, or in catastrophes or

unpredictable phenomena such as earthquakes, for example (Bode and Wagner, 2015; Fartaj et al., 2020; Kondo, 2018).

Consequently, according to Zhu et al. (2021), these interruptions can affect product demand, supply and distribution. The COVID-19 pandemic was a never-before-experienced event, which affected supply chains in a transversal way downstream and upstream. Organisations quickly realised that they had to restructure their businesses and internal and external organisations (Ferreira et al., 2021; Oliveira et al., 2021a; Oliveira et al., 2021b). One of the consequences was to look for shorter and more simplistic supply chains, circumventing the confinement measures imposed by the pandemic. The pandemic has demonstrated that complex supply chains, composed of extensive and interdependent networks, are more susceptible to vulnerabilities (Ferreira et al., 2021). This type of supply chain requires more accurate risk measurement instruments (technological, organisational and logistical) that allow managers to detect early sources of vulnerability that can affect the normal flow of supply chains, namely in terms of internal assets, supply, and external geographic factors (Benedito et al., 2020). In this context, the researchers formulate the following hypothesis:

H1: Interruptions in supply chains result in more negative consequences when there is no instrument to measure their vulnerability risk.

In addition to the negative consequences imposed by the pandemic on supply chains, opportunities were also identified for organisations to improve their supply processes. The orientation towards change depends on the resilience of organisations (Alonso-Muñoz et al., 2021). Resilience in the supply chain is how they respond or anticipate any disruption to any setback or interruption. Resilience is also synonymous with overcoming problems and is necessary for long-term sustainability (Arsovski et al., 2015). 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). Therefore, companies must increase the supply chain's resilience (Gaviolli and Laruccia, 2008).

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; Sharma et al., 2020). Thus, it is necessary to implement a more resilient supply chain with fewer vulnerabilities and more sustainability (Hsu et al., 2021). Thus, it formulates the following hypothesis:

H2: Disruptions in supply chains result in more negative consequences when organisations are less resilient.

Research Methodology

In this study, a qualitative approach was used 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 (Lopes et al., 2018; Njie and Asimiran, 2014; Rodrigues et al., 2021). 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 companies responsible for supply chains (see Table 1). These companies are located in the central region of Portugal, and the interviews were carried out in March and April 2021, with an average duration of 60 minutes. The choice of companies was made for convenience, given their geographical proximity. The criteria for selecting the companies were the existence of a formally established supply chain and the size (large and medium-sized companies).

After the interviews, the data were transcribed and analysed based on thematic analysis, a correlation of the accounts, and a 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 ten 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 in 2020 (€)	Type of Company	Date of foundation of the company
Company 1	Made-to-measure mass-produced garments	Purchasing and sub-contracting department	25 years	6 million	Large Company	1961
Company 2	Manufacture of other outerwear in series	Commercial Department	32 years	11 million	Large Company	1984
Company 3	Manufacture of helmets	Financial Director	13 years	14 million	Medium-sized Companies	2000
Company 4	Multinational food company	Team leader in the commercial area	28 years	480 million	Large Company	1923 in Portugal

Research Results

Given that this study aims to analyse companies' supply chains 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 is assessing supply chain vulnerabilities, 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 customer deliveries. 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 during the pandemic season due to selling basic goods. The companies have metrics that allow them to identify alarm situations. These computer systems warn when stocks are minimal and when there are customers to whom goods have not yet been delivered. These metrics make it possible to immediately assess situations disrupting their upstream and downstream supply chain. Thus, the results suggest that H1 is confirmed. Concerning 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. 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 of "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

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unavailable, sales and production departments receive this 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 group's companies. 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 and 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 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. Thus, the results suggest that H2 is confirmed.

Discussion and Conclusion

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 unprepared for an event that disrupted their supply chain, as evidenced in Magableh's (2021) study. Consequently, they experienced downstream and upstream delays in their supply chains. Immediate awareness of disruption and 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 (Christopher and Holweg, 2011; Golan et al., 2020).

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 case study and 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 directions, the authors propose to enrich the sample in terms of the number and diversity of activity sectors of companies to obtain more robust results. They 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.

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KONSEKWENCJE OGRANICZEŃ PANDEMICZNYCH DLA ŁAŃCUCHA DOSTAW PRZEDSIĘBIORSTW: PODEJŚCIE EKSPLORACYJNE

Streszczenie: Zakłócenia w łańcuchu dostaw narzucone przez pandemię COVID-19 spowodowały istotne wyzwania dla firm. W niniejszym opracowaniu zbadano konsekwencje pandemii dla łańcucha dostaw firm, identyfikując główne problemy i proponując rozwiązania dla przyszłych sytuacji zakłócających. Przedstawione badanie jakościowe opiera się na badaniu wielokrotnych przypadków uzyskanych dzięki wywiadom z portugalskimi firmami. Badanie wielu przypadków przedsiębiorstw ujawniło, że firmy o mniej odpornych i bardziej wrażliwych łańcuchach dostaw, zarówno w górę, jak i w dół łańcucha, zostały najbardziej dotknięte przez pandemię. Łańcuch dostaw obejmujący redundancje i przyjęcie przez firmy odpowiednich narzędzi zarządzania ryzykiem gwarantuje większą elastyczność łańcuchów dostaw w celu szybszego dostosowania się do sytuacji zakłócających. To badanie

eksploracyjne wnosi wkład do podejścia teorii Complex Adaptive System i przynosi nowe spojrzenie na konsekwencje pandemii dla łańcuchów dostaw.

Słowa kluczowe: Logistyka; Podatność łańcucha dostaw; Odporność; Pandemia COVID-19; Zakłócenia w łańcuchu dostaw

大流行病对公司供应链的制约后果 一个探索性的方法

摘要：COVID-19**大流行病**对供应链造成的破坏给企业带来了重要的挑战。本研究探讨了该大流行病对公司供应链的影响，确定了主要问题并为未来的破坏性情况提出了解决方案。所提出的定性研究是基于对通过采访葡萄牙公司获得的多个案例的研究。对公司的多个案例进行探讨后发现，无论是上游还是下游的供应链，其弹性较差，比较脆弱的公司受大流行病的影响最大。包括冗余和公司采用适当的风险管理工具的供应链，保证了供应链有更大的灵活性，可以更快适应破坏性的情况。这项探索性研究为复杂适应系统理论的方法做出了贡献，并为大**流行病**对供应链的后果带来了新的见解

关键词·物流；供应链的脆弱性；复原力；COVID-19**大流行病**；**供**应链中断