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Article

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How to promote resilience in the supply chain in the context of COVID-19? An exploratory study using the Delphi method

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Abstract

Purpose – This paper is dedicated to elaborating, proposing and validating an action plan to enhance the mitigation of risks generated by the COVID-19 pandemic in the electric sector supply chain, aiming to promote a more resilient supply chain.

Design/methodology/approach – For this, a systematic review of the literature was carried out to prepare an action plan that was validated by a group of experts, through the Delphi methodology.

Findings – As a result, an action plan was obtained, with 18 actions subdivided into 13 resilience elements and related to 20 main risks arising from the pandemic. The actions oriented to the development of relationships among supply chain members, promotion of a culture oriented to learning and problem solving, contingency plan, safety stock and risk management were pointed as those capable of generating resilience in the chain analyzed in the moment of crisis.

Originality/value – The results achieved can contribute to the expansion of debates in the area of resilient supply chain management, as well as contribute to supply chain managers in their elaboration and definition of actions that aim to make the supply chain more resilient. It is noteworthy that no similar study was found in the literature considering the specificities of supply chain management in the Brazilian Amazon region.

Keywords Risk management, Supply chain, Resilience, COVID-19, Electric sector

Paper type Research paper

1. Introduction

The intensification of competition among companies and the acceleration of technological transformation are factors that demand better competitive strategies of companies and, in this scenario, supply chains should be constantly transformed to remain aligned with the market (Baştuğ and Yercan, 2021; Jafari *et al.*, 2021). These chains have become more complex and more difficult to control, since in addition to operating in more competitive markets,

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events such as political changes, economic crises and environmental disasters expose them even more to the risk of disruptions (Bui *et al.*, 2021).

Currently, the world is being impacted by the COVID-19 pandemic and, according to information from the Pan American Health Organization – PAHO, this disease causes serious respiratory problems and has a high transmission capacity (OPAS, 2020). The virus was first detected in December 2019 in China and classified by the World Health Organization (WHO) as a pandemic in March 2020. In Brazil, according to data from the National Council of Health Secretaries – Conass, the total number of deaths by COVID-19 until August 2021 was 579.010 (CONASS, 2021).

In addition to a large number of deaths, the pandemic caused social, cultural, political and economic impacts in the world, as the main measure suggested by the WHO to flatten the contagion curve was social isolation, an action that generated a stoppage in the productive market, affecting organizations around the world all (Silva, 2020).

As a consequence of these events, according to the Institute for Supply Management – ISM, in May 2020, 97% of the companies surveyed reported having been affected or believed that they would still suffer some impact due to disruptions in the supply chain, resulting from the COVID-19 pandemic. In Brazil, according to the Brazilian Institute of Geography and Statistics – IBGE, in August 2020, 33.5% of companies in operation indicated that the pandemic had negatively affected their activities (IBGE, 2020). The impacts also should be analyzed according to the sectors of the supply chains.

This work focused on the electricity sector in Brazil, as this sector suffered immediate consequences caused by the pandemic, mainly due to the reduction in electric consumption and the increase in default. Since, in March 2020, the National Electric Energy Agency – ANEEL approved Resolution number 878/2020, which guaranteed continuity in the distribution of electric energy and prohibited the suspension of supply due to the default of consumer units during the pandemic (Brasil, 2020). Thus, according to the National Association of Energy Consumers – ANACE, the delinquency of energy bills has increased, and, in a scenario of 50% delinquency of residential consumers and essential activities, the decrease in revenue reached almost 7 billion reais (around 1.358 billion dollars) monthly. The reduction in energy consumption, on the other hand, has the potential for a decrease in revenue of 1.7 billion in the month, in a scenario of a 30% reduction for non-residential consumption (ANACE, 2020).

Although measures were created to reduce the impacts of the pandemic on the electric sector, such as the July 2020 Covid-account, which enabled greater liquidity and reduced impacts on energy bills (ANEEL, 2021), the sector is still experiencing delays in investments, a decrease in maintenance activities and a demand reduction (FGV, 2020).

Considering the mentioned scenario, Supply Chain Risk Management (RMSC) can be a relevant ally, as it seeks to identify and control risks that can affect the performance of a supply chain (Matos *et al.*, 2017). In addition, according to Silva (2020), Risk Management proves to be a basic tool to make supply chains more flexible in the face of adverse events.

Without understanding the vulnerabilities that currently exist, it is not possible to make decisions to build resiliency in companies' supply chains, so they need to act now to discover the weaknesses that exist in their supply chains (Simchi-Levi and Simchi-Levi, 2020).

In this sense, this article aims to propose an action plan based on risk management and resilience in the supply chain, aiming to enhance the mitigation of risks arising from the COVID-19 pandemic, in an engineering company in the electric sector. For this, a systematic literature review was carried out to propose the action plan and later the Delphi method was used, in partnership with the company object of study, to validate it.

2. Theoretical background

2.1 Supply chain management

The Supply Chain (SC) is a set of companies involved in the manufacture of products for end consumers (Piovesan, 2020). Therefore, Supply Chain Management (SCM) is the way to connect suppliers, factories, warehouses and stores so that products arrive in the right quantity, at the right place and at the right time (Orenstein *et al.*, 2016).

The SC has become more complex, as uncertainty scenarios directly influence its performance (de Assunção *et al.*, 2020). In this way, the concept of Risk Management in the Supply Chain (RMSC) emerged from the concern with vulnerabilities and risks of disruptions in the SC, aiming to reduce the probability of these risks (Norrman and Jansson, 2004).

In addition, the RMSC is challenged to consider which impacts are related to risks and increased resilience in the SC (El Baz and Ruel, 2021). For this, according to Zsidisin and Ritchie (2009), the RMSC uses SCM and Risk Management (RM) concepts.

The RM is a set of activities to manage and control risks (ISO, 2018), with some models focused on RMSC, such as those proposed by Manuj and Mentzer (2008), Sinha *et al.* (2004) and Gaudenzi and Borghesi (2006) which include the survey of risks, evaluation and analysis, the proposal of action plans, the proposal of strategies to reduce the probability of risks or mitigation of risks and monitoring (Tanoue, 2016).

2.2 Resilience in the supply chain

Resilience can be understood as the ability of the entire SC to react to abrupt interruptions, thus, the use of resilience elements increases the robustness of companies (Martins *et al.*, 2021). Resilience must be built into companies' systems to help them quickly recover and adapt in this scenario (Linkov *et al.*, 2014).

The pandemic has exposed vulnerability in the global SC, which has made SC resilience even more important (Shi *et al.*, 2021). According to Tanoue (2016) One of the ways to achieve resilience in an organization is the RMSC, as it allows assessing the system's ability to deal with disruptions and acts in the adaptation to complex systems, since threats cannot always be predicted or controlled (Sikula *et al.*, 2015). In this way, when the risks involved in a situation are not identified, resilience must be created (Douglas and Wildavsky, 1983). Therefore, a SC presents resilience when it can withstand, adapt and recover from interruptions (Hosseini *et al.*, 2019).

Additionally, Liu *et al.* (2023) highlight that disruptive technologies result in new paradigms for supply chain risk management and, in addition, guarantee opportunities and bring challenges to a more resilient supply chain.

2.3 Elements of resilience in the supply chain

Sawyer and Harrison (2020) show 13 formative elements of resilience in SC. Below are defined concepts of the 13 elements of resilience (Collaboration, Flexibility, Redundancy, Agility, Decision making, Security, Culture, Robustness, Integration, Avoidance, Human resource management, Sustainability and Logistics capability).

Agility, which is the chain's ability to respond to unforeseen changes (Christopher and Peck, 2004; Ponomarov and Holcomb, 2009) and Anticipation, which is the ability to proactively plan and design the SC, to anticipate unexpected events (Ponis and Koronis, 2012).

Logistics capacity is related to the delivery speed, reliability, responsiveness and low-cost distribution of companies (Ponomarov and Holcomb, 2009). Transport was immediately affected by the pandemic, there was a significant reduction in labor in the logistics sector, which caused a significant reduction in transport capacity (Liu *et al.*, 2022). Collaboration refers to cooperation between SC participants to mitigate risk, increase resilience, and facilitate chain intelligence (Sawyer and Harrison, 2020).

Organizational culture is associated with learning-oriented culture, information sharing or reporting and risk management culture (Sawyer and Harrison, 2020). Flexibility lies in product, process, transport or service flexibility, or through supply flexibility through flexible suppliers, multiple sources of supply, and supplier diversification (Goyal *et al.*, 2018; Sawyer and Harrison, 2020).

Human resource management involves human resource development and knowledge management (Ali *et al.*, 2017; Pettit *et al.*, 2013). And Integration allows an environment focused on end-to-end interaction of orders, inventory, transportation and distribution (Ponomarev and Holcomb, 2009). The redundancy is tangible when it comes to capacity utilization and intangible when it comes to supplier relationships (Sawyer and Harrison, 2020). Robustness is the ability to maintain planned SC performance after an interruption (El Baz and Ruel, 2021). The Security element refers to protecting the SC from unexpected risks and events (Bandyopadhyay *et al.*, 2016).

Sustainability is the management of SC functions in line with the requirements of social, environmental and economic sustainability (Bui *et al.*, 2021; Khan *et al.*, 2021). And the Decision-Making element is the ability to decide on situations that impact the resilience of the SC (Jabbarzadeh *et al.*, 2016). With the COVID-19 pandemic, many risks threatened organizations and in current studies 20 main risks arising from the pandemic were identified. Table 1 presents the risks in SC resulting from the pandemic identified in the literature and which are relevant in the context of the electricity sector in Brazil.

Below are defined concepts of the 17 relevant risks found in the literature.

2.4 Risks in the supply chain

Delays in deliveries are mainly due to the determination of large-scale social restrictions and the implementation of health protocols during the pandemic (Praharsi *et al.*, 2021). This was one of the factors that caused price increases, forcing organizations to manage prices and costs together (Nascimento *et al.*, 2021).

The complexity of the chain was a risk that increased due to globalization and outsourcing along the SC, which make it less controllable and more sensitive to disruptions. In addition, this complexity limited the company's vision and ability to identify potential threats (Free and Hecimovic, 2021).

The delay in responding to the crisis caused a lack of resources and inventories, causing greater vulnerability for the company and exposure to various risks (Dellana *et al.*, 2019; Nandi *et al.*, 2021). Related to this risk is the delay in recovering from impacts and, therefore, it is necessary to provide an agile environment in the SC. In addition, changes in the market caused by disruptive events make it difficult to adapt (Do *et al.*, 2021).

The bullwhip effect is caused by the lack of information and demand variations, caused by uncertainties (Frederico *et al.*, 2021). The shortage of resources/stocks was considered one of the main disruptions of the pandemic (Chowdhury *et al.*, 2020) and a worrying risk, as in addition to the scarcity of stocks, labor resources, financial resources and raw materials, they generated bottlenecks in the process (Dohale *et al.*, 2022).

The risk of supplier bankruptcy is mainly caused by financial issues and can cause serious interruptions in the SC (Nascimento *et al.*, 2021). Reliability can be observed in the delivery and quality of the products, therefore, when there is no reliability, there is a lack of respect for deadlines and a reduction in the quality of products (Baştuğ and Yercan, 2021).

Crises, such as the one caused by the pandemic, as they are low-probability and high-impact events, tend to bring uncertainty to global SCs and the lack of preparation for these crises leads to a lack of supplies, lack of information, lack of human resources, financial constraints, operational restrictions etc. (Bui *et al.*, 2021).

Risks	References
Delivery delay	Baştuğ and Yercan (2021), Bhattacharya <i>et al.</i> (2021), Chowdhury <i>et al.</i> (2020), Dohale <i>et al.</i> (2022), Frederico <i>et al.</i> (2021), Nandi <i>et al.</i> (2021), Praharsi <i>et al.</i> (2021), Purvis <i>et al.</i> (2020)
Price increases	Nascimento <i>et al.</i> (2021)
Chain complexity	Baştuğ and Yercan (2021), Do <i>et al.</i> (2021), Free and Hecimovic (2021)
Delay in crisis response	Beilstein <i>et al.</i> (2021), Bhattacharya <i>et al.</i> (2021), Bui <i>et al.</i> (2021), Do <i>et al.</i> (2021), Iftikhar <i>et al.</i> (2021), Ivanov (2020), Nandi <i>et al.</i> (2021), Sharma <i>et al.</i> (2021)
Delay in crisis recovery	Do <i>et al.</i> (2021)
Difficulty of adapting	Beilstein <i>et al.</i> (2021), Do <i>et al.</i> (2021)
Bullwhip effect	Do <i>et al.</i> (2021), Frederico <i>et al.</i> (2021)
Shortage of resources/inventories	Chowdhury <i>et al.</i> (2020), Do <i>et al.</i> (2021), Dohale <i>et al.</i> (2022), Frederico <i>et al.</i> (2021), Kouvelis (2021), Nascimento <i>et al.</i> (2021)
Weak relationships in the chain	Barbanti <i>et al.</i> (2022), Bui <i>et al.</i> (2021), Iftikhar <i>et al.</i> (2021), Nandi <i>et al.</i> (2021), Purvis <i>et al.</i> (2020), Sharma <i>et al.</i> (2021), Silva <i>et al.</i> (2021)
Demand uncertainty	Bui <i>et al.</i> (2021), Do <i>et al.</i> (2021), Dohale <i>et al.</i> (2022), Kouvelis (2021), Kumari <i>et al.</i> (2021), Mithun Ali <i>et al.</i> (2021), Modgil <i>et al.</i> (2022)
Unavailability of employees	Do <i>et al.</i> (2021), Dohale <i>et al.</i> (2022), Kumari <i>et al.</i> (2021)
Interruption in supply	Baştuğ and Yercan (2021), Chowdhury <i>et al.</i> (2020), Frederico <i>et al.</i> (2021), Iftikhar <i>et al.</i> (2021), Mithun Ali <i>et al.</i> (2021)
Market changes	Bhattacharya <i>et al.</i> (2021), Bui <i>et al.</i> (2021), Do <i>et al.</i> (2021), Dohale <i>et al.</i> (2022), Kumari <i>et al.</i> (2021)
Stoppage of operations	Barbanti <i>et al.</i> (2022), Do <i>et al.</i> (2021), Nandi <i>et al.</i> (2021), Sharma <i>et al.</i> (2021)
Reduction in product quality	Bhattacharya <i>et al.</i> (2021), Frederico <i>et al.</i> (2021), Nascimento <i>et al.</i> (2021)
Chain restrictions	Bhattacharya <i>et al.</i> (2021), Bui <i>et al.</i> (2021), Kouvelis (2021), Kumari <i>et al.</i> (2021)
Stock out	Do <i>et al.</i> (2021), Free and Hecimovic (2021), Nascimento <i>et al.</i> (2021)
Source(s): Authors (2021)	

Table 1.
Pandemic risks in the supply chain

The weak relationship in the SC brings harm to its recovery in cases of interruptions, so sharing information and resources between members allows for better recovery (Bui *et al.*, 2021; Iftikhar *et al.*, 2021).

Due to frequent changes in real demand, SC was more exposed to situations of difficulties in forecasting demand (Bui *et al.*, 2021; Dohale *et al.*, 2022). The unavailability of employees occurred, as employees had to be absent, due to isolation restrictions imposed by the pandemic, such as social distancing or the contagion of the Coronavirus (Do *et al.*, 2021).

The interruption in supply can occur due to limitations or cancellation of trips, lack of transport, lack of manpower (Baştuğ and Yercan, 2021), product shortages, supplier payment interruption, and credit limitation (Chowdhury *et al.*, 2020), among others.

As the crisis caused by the pandemic caused an abrupt change in supply and demand (Do *et al.*, 2021), failures to identify potential opportunities in the market and low speed of response to market volatility occurred (Dohale *et al.*, 2022). Operations stoppages occurred due to a lack of raw material, labor or transport (Nandi *et al.*, 2021). The reduction in product quality was due to a loss of quality in the production or supply of raw materials, caused by resource limitations, and transport failures, among others. In this way, better monitoring of the quality of the products received is fundamental (Nascimento *et al.*, 2021).

Restrictions on SC may occur due to unavailability of manpower, logistical bottlenecks or resource restrictions (Kouvelis, 2021). Disruption stems from the lack of products in stock,

either due to supplier bankruptcy, low production level or interruption in production, due to a shortage of raw materials or high costs (Nascimento *et al.*, 2021).

Thus, for each risk mentioned, there are actions capable of promoting resilience in the SC and mitigating risks, also identified in the literature and presented in Table 2.

Below are defined concepts of the 18 actions found in the literature that are relevant to the context of the electricity sector in Brazil.

2.5 Actions to mitigate risks in the supply chain

The emergence of COVID-19 required SCs to respond quickly, however, this did not exist. This was a good warning for companies, as it demonstrated the need to be prepared for emergencies (Shi *et al.*, 2021). Thus, All parts changed and inserted into the text were highlighted in red as requested by the editor. Actions are necessary as a way to mitigate risks in SC.

There are actions capable of stimulating collaboration and integration during the pandemic involve a good relationship between SC members. That way, Dohale *et al.* (2022) mention the importance of sharing information and being transparent in the SC, to build trust and agility in responding to risks. Chowdhury *et al.* (2020) also highlight effective cooperation with suppliers, through information sharing, credit lines and prioritization in supply.

Iftikhar *et al.* (2021) also point out that the integration with customers helps to obtain insights, to develop solutions for their needs and the integration with suppliers ensures consistent supply. In addition, creating collaborative solutions and coordinated investments among participants is one of the ways to improve intelligence in SC (Kouvelis, 2021).

Actions	References
Favoring the Agile Supply Chain	Nandi <i>et al.</i> (2021), Purvis <i>et al.</i> (2020), Sharma <i>et al.</i> (2021)
Knowledge management	Queiroz <i>et al.</i> (2021)
Inventory balancing	Free and Hecimovic (2021), Iftikhar <i>et al.</i> (2021), Kouvelis (2021)
External collaboration and communication	Dohale <i>et al.</i> (2022), Iftikhar <i>et al.</i> (2021)
Supplier development	Chowdhury <i>et al.</i> (2021), Dohale <i>et al.</i> (2022), Kouvelis (2021)
Promoting a culture to support risk management	Kumari <i>et al.</i> (2021), Yu <i>et al.</i> (2021)
Use of multiple modes	Abdolazimi <i>et al.</i> (2021), Free and Hecimovic (2021)
Maintain short-term alternative sources of supply	Abdolazimi <i>et al.</i> (2021), Bhattacharya <i>et al.</i> (2021), Dohale <i>et al.</i> (2022), Nascimento <i>et al.</i> (2021)
Conduct ongoing training	Beilstein <i>et al.</i> (2021), Udofia <i>et al.</i> (2021)
Generate greater transparency in the Supply Chain	Chowdhury <i>et al.</i> (2021), Dohale <i>et al.</i> (2021), Iftikhar <i>et al.</i> (2021)
Use of multiple providers	Abdolazimi <i>et al.</i> (2021), Bhattacharya <i>et al.</i> (2021), Dohale <i>et al.</i> (2022), Nascimento <i>et al.</i> (2021)
Strategic Inventory	Chowdhury <i>et al.</i> (2020), Dohale <i>et al.</i> (2022), Free and Hecimovic (2021), Iftikhar <i>et al.</i> (2021)
Checking and avoiding risks	Dohale <i>et al.</i> (2022), Iftikhar <i>et al.</i> (2021)
Routine of auditing and inspecting	Barbanti <i>et al.</i> (2022), Nascimento <i>et al.</i> (2021)
Acquire insurance	Aldrighetti <i>et al.</i> (2021), Jaziri and Miralam (2021), Karmaker <i>et al.</i> (2021)
Engage the organization in risk management and crisis preparedness	Beilstein <i>et al.</i> (2021), Dohale <i>et al.</i> (2021)
Be adaptable to changes	Iftikhar <i>et al.</i> (2021), Yu <i>et al.</i> (2021)
Consider the risks involved in decision making	Anholon <i>et al.</i> (2021), Beilstein <i>et al.</i> (2021), Dohale <i>et al.</i> (2022), Ivanov (2022), Mithun Ali <i>et al.</i> (2021)

Table 2.
Risk mitigation actions **Source(s):** Authors (2021)

Therefore, it is evident that better collaboration between members increases transparency and traceability, which are ways to mitigate risks throughout the SC during pandemic periods, such as COVID-19 (Nandi *et al.*, 2021; Paul and Chowdhury, 2020; Sharma *et al.*, 2021; Silva *et al.*, 2021).

As strategies for supply, there are: multiple sources of supply, flexible contracts, short-term alternative suppliers (Abdolazimi *et al.*, 2021; Bhattacharya *et al.*, 2021; Dohale *et al.*, 2022; Nascimento *et al.*, 2021), emergency supply (Paul and Chowdhury, 2020), greater regionalization of SC (Free and Hecimovic, 2021; Modgil *et al.*, 2022), local supplier development (Bhattacharya *et al.*, 2021; Sreedevi *et al.*, 2021), preservation of agile suppliers (Free and Hecimovic, 2021; Nandi *et al.*, 2021) and promotion of alternative channels (Abdolazimi *et al.*, 2021; Free and Hecimovic, 2021).

Another action highlighted in the literature is the strategic stock, because, with a greater risk of interruption in supply and delays in delivery, companies began to request extra quantities, to minimize the shortage of products (Chowdhury *et al.*, 2020). In this way, redundancy was generated with safety stocks, to meet the unforeseen or dammed demand (Dohale *et al.*, 2022). Therefore, having slack resources, such as strategic stock in the SC, to accommodate shock events, is a way to mitigate the initial impact of disruption (Free and Hecimovic, 2021; Iftikhar *et al.*, 2021).

Knowledge management enables learning from past disruptions, to develop predictions for future disruptions (Queiroz *et al.*, 2021). According to Kumari *et al.* (2021), an organizational culture that encourages collaboration, involvement and knowledge-sharing, generates greater interaction, understanding and innovation for the company. Therefore, the creation and innovation of knowledge are key resources (Yu *et al.*, 2021).

Agility can be achieved with the implementation of digital tools in SC (Nandi *et al.*, 2021; Sharma *et al.*, 2021), that is, through communication and digitalization technologies, the order point can be improved by increasing the frequency of receipt and reducing lead times along the SC, enabling the reduction of inventories (Purvis *et al.*, 2020), thus favoring an agile SC.

As for the anticipation strategy, it is recommended to create a team with different departments to identify and plan approaches to mitigate risks (Dohale *et al.*, 2022). Iftikhar *et al.* (2021) also indicate that monitoring the environment in which the SC is inserted is a way of anticipating threats.

In decision-making, risks must be recognized and correctly assessed through risk management tools, such as analysis of the most vulnerable touch points in the SC and simulation (Beilstein *et al.*, 2021; Ivanov, 2020; Mithun Ali *et al.*, 2021) and business continuity management (Anholon *et al.*, 2021). However, in addition to using risk management tools, a leader should seek help from experienced employees as needed (Beilstein *et al.*, 2021).

With the risk of rupture, measures in the financial area were also developed (Aldrighetti *et al.*, 2021), because there is a need to purchase insurance to cover economic losses (Jaziri and Miralam, 2021). Therefore, to help organizations survive, the government must encourage sustainable practices, such as funding for infrastructure, and access to sustainable and safe technologies (Karmaker *et al.*, 2021). In addition, it is necessary to carry out audits on suppliers, as a way of guaranteeing and monitoring the quality of the product (de Assunção *et al.*, 2020; Barbanti *et al.*, 2022).

In this period, an organization must also be ready for adaptation and continuous learning is a means of stimulating this. Therefore, leaders must support employees with feedback and a positive learning culture (Beilstein *et al.*, 2021). Another strategy for employee development is workforce flexibility, as it ensures multifunctional employees and can be achieved through training (Udofia *et al.*, 2021).

2.6 Resilience and risk in the supply chain

The previous sections discuss the concept of supply chain management and its growing complexity influenced by uncertainty scenarios. It introduces Risk Management in the Supply Chain (RMSC) as a response to vulnerabilities and disruptions, aiming to reduce the probability of risks. Risk in the supply chain refers to the potential for disruptions, events, or factors that can negatively impact the normal flow of goods and services. It can take various forms, such as operational and disruption (Choi *et al.*, 2019). Many risks intensified by the COVID-19 pandemic in the supply chain, such as delays in deliveries, chain complexity, resource shortages, the bullwhip effect, and the risk of supplier bankruptcy, emphasize the need for supply chain resilience.

The Supply Chain Resilience define the ability to react to abrupt interruptions, enhancing the robustness of companies. Resilience is crucial, especially in the context of the global supply chain vulnerability exposed by the pandemic. A resilient supply chain is one that can adapt to changes, absorb shocks, and recover promptly from unexpected events. These can include various disruptions such as natural disasters, economic fluctuations, geopolitical events, and even pandemics (e.g. Christopher and Peck, 2004; Chopra *et al.*, 2021; Wieland and Durach, 2021). Elements of resilience in the supply chain include agility, anticipation, collaboration, organizational culture, flexibility, human resource management, and sustainability, among others.

In summary, supply chain resilience and risk in the supply chain are interrelated, with resilience efforts serving as a proactive response to address or mitigate identified risks. Building resilience enables a supply chain to navigate challenges and uncertainties, ultimately ensuring its sustainability and success in a dynamic business environment.

3. Methodological procedures

This research comprised the following steps: (1) Systematic review of the literature; (2) Elaboration of the action plan; (3) Delphi development to validate the action plan; (4) Content analysis of the experts' answers, according to the model of Elo and Kyngäs (2008), and (5) Establishment of results and conclusions.

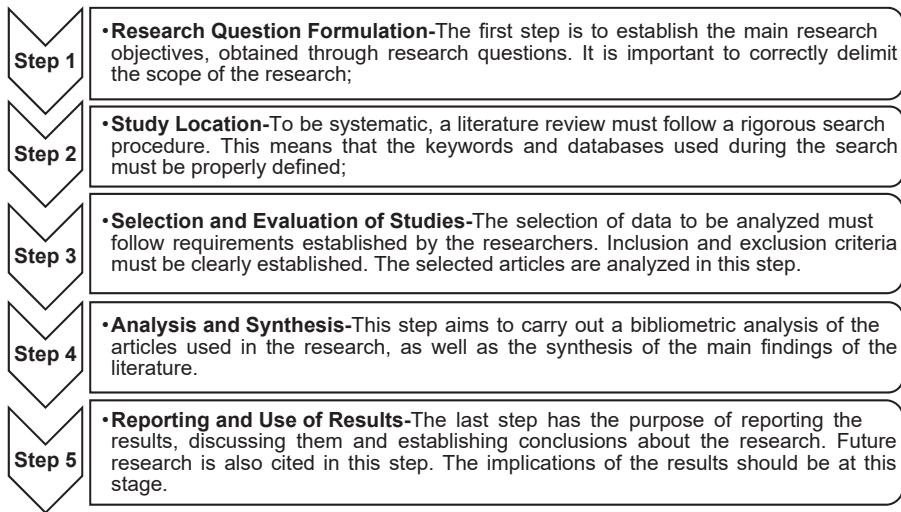
To carry out the systematic review of the literature, the steps suggested by Denyer and Tranfield (2009), as shown in Figure 1.

First, the guiding questions for the research were formulated: (Q1) What were the risks in the supply chain resulting from the COVID-19 pandemic? And (Q2) What actions are capable of stimulating the elements of resilience in the supply chain to mitigate these risks?

Then, the search keywords, "Risk Management", "Supply Chain", "Resilience", "COVID-19" and "Brazil", were defined for research in the scientific bases Emerald Insight and Science Direct. Thus, 98 files were obtained in the first result, however 63 were excluded, as they did not focus on the theme of this article, according to the summary of the selected articles, presented in Table 3.

It is noteworthy that the theoretical background presented in this paper was based on this methodology.

As a result of the analysis of the selected articles, 20 risks were identified in the literature, resulting from the pandemic and 18 actions relevant to the stimulation of elements of resilience and mitigation of these risks, both results presented in Section 2. Tanoue (2016), the action plan at RMSC often uses the 5W2H methodology, because, for each identified risk, actions are established, where they will be carried out, who will be responsible, what deadlines, what benefits, what strategies and how much will be the investment. Thus, an action plan was prepared in the 5W1H format for not having access to the cost information of the analyzed sector.



Source(s): Adapted from Martins *et al* (2019)

Figure 1.
Methodological
procedure of Denyer
and Tranfield (2009)

Search base	1st result	Exclusion	2nd result
Emerald Insight	57	35	22
Science Direct	41	28	13

Source(s): Authors (2021)

Table 3.
Summary of file
selection

To validate the proposed action plan, the Delphi method was used, in which a group of experts from the company object of study was selected, as shown in [Table 4](#). [Okoli and Pawlowski \(2004\)](#) recommend a minimum of 10 experts to ensure an effective dynamic, so 20 people involved in the company's SCM and with experience in the challenges and risks faced in the pandemic were selected.

It is noteworthy that the respondents participating in DELPHI are electricity sector managers who have considered the impacts of the COVID-19 pandemic on their processes and activities in their analyses.

Amount	Position	Motivator
1	Buyer	Explore the experience of the situation of suppliers and the market
5	Logistic coordinator	Regional view of the supply chain
1	Procurement Executive	Explore the experience of risks and decision making
1	Performance Executive	Explore the experience of customer and market situation
6	Contract manager	Regional view of the market, supply chain and decision making
1	Supply Chain Superintendent	Explore the holistic view of the supply chain and the enterprise
5	Warehouse Supervisor	Regional view of the operation, inventories and supply chain

Source(s): Authors (2021)

Table 4.
Experts and
motivators

How Delphi typically runs remotely, with questionnaires interspersed with expert feedback (Ahmad and Wong, 2019; Bélanger *et al.*, 2012), a Google form was used to obtain the experts' evaluation and, as a limit percentage of consensus for the answers, 80% was used, since Grisham (2009) argues that this is a good threshold.

The validators' responses were analyzed following the guidelines of Elo and Kyngäs (2008), and carried out in three phases. Therefore, the theme was defined as the research analysis unit: "Action plan to mitigate risks in the electric sector supply chain in a pandemic period". In the organizing data phase, this study was defined as inductive, as there are no previous studies on the phenomenon or knowledge is fragmented (Elo and Kyngäs, 2008).

In the open coding, all responses from validators are analyzed and categorized (Elo and Kyngäs, 2008). Categories related to 5W1H, risks, and actions were created in the synthesis of responses from the Delphi rounds. Because it is open coding, it was based on the guidelines of Elo and Kyngäs (2008), where all responses from validators are analyzed and categorized. To this end, the defined categories were related to 5W1H, risks and actions, such categories were defined based on the analysis of the DELPHI participants' responses and also based on the literature.

In the last stage of content analysis, reporting the analysis process and results, the results obtained in the research were compared with the information presented in the literature and conclusions were established (Elo and Kyngäs, 2008).

4. Results and discussions

The action plan (presented in Appendix 1) prepared based on the literature was proposed containing 18 actions distributed among the 13 resilience elements indicated by Sawyerr and Harrison (2020). Therefore, for each action found in the literature, the element of resilience and the risks associated with it were related. To validate the action plan, three rounds of Delphi were carried out and 18 respondents participated in the three rounds.

In the first round, the form contained the research objective, the action plan and a field for recording suggestions in the action plan and, of the 20 submissions, 18 responses were obtained. The group of experts selected belongs to both the head office and the company's branches, that is, the opinions of people distributed in 10 cities, in three states of Brazil, namely Pará, Bahia and Pernambuco. As a characteristic of this group, 39% of respondents have more than 10 years of experience in the area, 39% have between 5 and 10 years and 22% have less than 5 years of experience. Regarding the training of these professionals, 39% are in the administration area, 33% in engineering, 22% in logistics and 6% in economics.

In the first round, 27 interventions were identified in the action plan, but seven interventions were already contemplated in the plan. For content analysis, eight categories were used to identify necessary improvements, the consensus among the professionals' notes and to support the redefinition of the proposed action plan: (1) Responsible (Who); (2) Locations (Where); (3) Moments (When); (4) Modus Operandi (How); (5) Risks; (6) Shares; (7) Structure of the action plan; and, (8) General considerations.

Regarding the Responsible category, the experts pointed out that action number 6 focused on the company's board and that it should be extended to the subsidiaries. In addition, in the category associated with the location, it was suggested that actions 16 and 17 also encompass subsidiaries.

Regarding the "when", it was recommended that the deadlines used were short, if not immediate. In the Modus Operandi category, training for all those involved in the SC was added to the "how" of action 9 and it was specified to the "how" of action 1 that the adjustment of the order point would be for items with higher inventory turnover.

Regarding the actions, for action 2, an approach for failure in the purchase was suggested, as well as the creation of a catalog for materials inspection. For action 5, reverse logistics of

post-consumer materials were suggested and, for action 7, better transport was highlighted and the reduction of delivery time. In addition, the direct shipping of supplies was scored, however, it was observed that the use of multiple modes would allow this shipping and the use of local suppliers would bring greater agility to the process, in cases of urgency. In action 9, systems training was highlighted.

For action 14, it was suggested to cover knowledge about products, however, it was found that this would be better allocated in action 9, where training on products was specified. Also regarding action 14, the reduction of costs with exchanges and internal reprocessing, as well as the inspection during the return of used products, was highlighted. The non-applicability of action 15, contracting insurance, in the context of the company under study was pointed out, however, it was highlighted that the action plan aims to provide a macro service, considering different organizational contexts and, therefore, this action remained in the case it can be applicable for another organization.

In the Risks category, the lack of understanding of the risk of unavailability of employees stood out. Therefore, turnover was included in this risk, to improve the nomenclature and the relationship between risk and action was explained, since knowledge management avoids the loss of experience and as at the time of the pandemic there were many shortages of employees, reports and procedures are effective for continuity of processes. The lack of understanding about the relationship between the risk of interruption in supply and knowledge management action was also indicated. Therefore, it was clarified that knowledge management helps to respond and prevent an interruption in supply, as it points out previous errors. Finally, it was suggested to include the risk of lack of information in action 9.

As for the structure of the action plan, the specialists requested the organization of the plan by risks, for better understanding. However, instead, in the redefinition of the plan for the second round, the elements of resilience were inserted, since the referred plan was elaborated according to them.

Finally, the General considerations category comprised comments that explained the impacts, experiences and actions taken during the pandemic. Regarding the impacts experienced, it was highlighted the increase in the time of production and receipt of materials, transport difficulties, fluctuation in the consumption of materials, cost containment, renegotiation of market conditions, financial difficulties and service restrictions.

Regarding the strategies used, the validators focused on the relationship with essential suppliers, to ensure the frequency of service and better commercial conditions, in addition to the acquisition of higher output materials and essential for the continuity of the service. The importance of procedures, communication and partnerships was emphasized.

Based on the experts' comments, the action plan was redefined and a new form was sent to the respondents of the first round. This form contained a summary of the responses from the first round and the redefined action plan. Based on this, the experts answered whether their suggestions were considered or not and, if not considered, satisfactorily justified.

From the synthesis of the responses of the first round, the second round was conducted and there were additional points to be adjusted. Thus, the content was analyzed and the necessary adjustments were performed.

Concerning the Responsible category, the inclusion of subsidiaries in action 5 was requested. In this way, those responsible for this action were expanded to members of the SC. In addition, the inclusion of subsidiaries in the "where" of this same action was pointed out, since it encompasses the reverse logistics of post-consumer materials and it will be in the regional ones that the treatment and handling process will take place. Therefore, the "location" of action 5 was expanded to companies, considering that it will be carried out both in the company object of study and other companies throughout the SC.

Considering these adjustments in the action plan, the third round was performed. Similar to the previous round, the questionnaire of this round presented a summary of the responses from the second round and the redefined action plan, and the experts needed to answer whether the action plan, in this new phase, fulfilled its objective, that is, the enhancement of the mitigation of risks, arising from the COVID-19 pandemic, in the company's SC.

After sending and receiving the form, it was found that, of the 18 responses obtained in this round, 100% of the experts stated that the action plan achieved its objective. Thus, we arrived at the final version of the action plan, presented in [Appendix 2](#).

The analysis of the organizational culture becomes important to enhance the development of actions established in the action plan.

After the elaboration and validation of the action plan, it is highlighted that actions related to the development of an organizational culture that helps the RMSC, allow better integration between the members of the SC and better adaptation to an environment of uncertainties. An organizational culture aligned with the proposed objectives tends to guarantee positive results. As it is associated with information sharing, continuous learning and risk management culture ([Sawyer and Harrison, 2020](#)). Therefore, working on actions that improve the means of communication and information management throughout the SC is of paramount importance, as the strengthening of collaborative partnerships for the development and transparency of relationships between SC members brings benefits to their recovery, in cases of interruptions and crises ([Bui et al., 2021](#)).

5. Conclusions

Based on the results presented, it is concluded that the objective of the study was achieved, that is, the action plan to enhance the mitigation of risks arising from the COVID-19 pandemic in the supply chain of the company object of study. In this way, it was possible to verify the importance of planning actions to mitigate and manage risks in times of crisis, to generate resilience. Therefore, as practical implications, the results of this research contribute to more efficient decision-making considering the uncertainties, enable better SC management and can preserve or increase the organization's value, by minimizing the impacts of unexpected events and improving the perception of stakeholders about the level of organizational risk.

From a theoretical point of view, the results of this study can serve as a basis for researchers in the area of risk management and resilience in SC, since the relevance that the topic currently has was verified. As a limitation of this study, it is noteworthy that the action plan was validated by specialists from an engineering company in the electric sector and was not applied to analyze the efficiency of the recommended actions. Therefore, it is suggested for future studies the validation of the action plan, as well as the use of other methods for validation and implementation in the context of the companies in the electricity sector, to verify its robustness.

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Table A1.
Version 1 of the
stock plan

Appendix

Related risks	Mitigation action	What?	Where?	Who?	When?	Why?	How?
* Delivery delay	Action 1: Favor the Agile Supply Chain	Increase receiving frequency and reduce lead times along the supply chain	Logistics Sector	Matrix – Corporate	Short term	* Increase product availability	Adjusting the order point
* Uncertainty of demand						* Reduce risks associated with maintaining high levels of inventories	
* Resource reduction						* Portrait the realistic view of the processes	
* Unavailability of employees	Action 2: Knowledge management	Record and manage information from past disruption events, such as which processes/products are most likely to experience disruptions, how these disruptions might occur, and which disruptions have already occurred	Purchasing Sector	Matrix – Corporate	Mid-term	* Harvest lessons from past failures	Preparing reports and procedures for failures and risks in the processes
* Supply interruption						* Be prepared for future failures	
* Lack of preparedness for crises						* Maintain process knowledge in the company	

(continued)

Related risks	Mitigation action	What?	Where?	Who?	When?	Why?	How?
* Delivery delay	Action 3: Inventory balancing	Develop an integrated inventory system so that one warehouse can supply the other if needed	Logistics Sector	Matrix and Regionals	Immediate	* Ensure availability in case of supply disruption	Developing an integrated inventory system to exchange information between warehouses
* Supply interruption							
* Uncertainty of demand							
* Price increase	Action 4: Collaboration and external communication	Maintain continuous contact with suppliers and customers, sharing information among supply chain members, such as behavior and demand characteristics	Supply Management	Matrix – Corporate	Immediate	* Improve supply chain intelligence * Increase supplier monitoring	Sharing information across the chain through reporting and constant contact
* Bullwhip effect							
* Supplier bankruptcy*Uncertainty of demand							
* Supply interruption							
* Reduction of resources	Action 5: Supplier development	Initiate and strengthen collaborative partnerships to develop relationships and supply chain members	Supply Management	Matrix – Corporate	Mid-term	* Improve supply chain intelligence * Increase trust among chain members * Strengthen the relationship between chain members	Close agreements and close flexible supply contracts
* Out of stock							

(continued)

Table A1.

Table A1.

Related risks	Mitigation action	What?	Where?	Who?	When?	Why?	How?
* Difficulty adapting	Action 6: Promote a culture that helps manage risk in the supply chain	Encourage a culture oriented towards learning and sharing information/knowledge	Company Board	Matrix – Corporate Managements – Regional	Long term	* Readiness to deal with change	Create events with dynamic problem solving and knowledge sharing
* Delay in crisis response							
* Lack of preparedness for crises						* Improve the chance of survival	
* Delivery delay	Action 7: Use multiple modals	Diversify the modes of transport used	Purchasing Sector	Matrix – Corporate	Immediate	* Prevent risk of transport breakage	Diversifying transport contracting
* Supply interruption							
* Resource reduction						* Decrease the dependency relationship with companies	
* Chain restrictions	Action 8: Maintain short-term alternative sources of supply	Having local suppliers as a contingency plan	Purchasing Sector	Matrix – Corporate and Regional	Immediate	* Ensure availability in case of supply disruption	Mapping new regional suppliers
* Lack of preparedness for crises							
* Unavailability of employees						* Develop cross-functional teams	
						* Improve employee flexibility	

(continued)

Related risks	Mitigation action	What?	Where?	Who?	When?	Why?	How?
* Delivery delay	Action 10: Generate greater transparency in the Supply Chain	Provide greater interaction between chain members	Chain members	Companies	Long term	* Bring greater transparency and information	Through an integrated environment of information about order status, demand and distribution
* Supplier bankruptcy*Uncertainty of demand							
* Supply interruption	Action 11: Use multiple providers Action 12: Strategic Inventory	Maintain alternate sources of supply for critical items	Purchasing Sector	Matrix – Corporate	Short term	* Ensure availability in case of supply disruption	Mapping new suppliers
* Out of stock							
* Delivery delay		Review current safety stock level policy for critical products that have high inventory turns	Logistics Sector	Matrix – Corporate	Short term	* Ensure availability in case of supply disruption	Adjusting the safety stock
* Supplier bankruptcy							
* Uncertainty of demand	Action 13: Check for risks and deal with them before they occur	Form a specialized team to identify and manage risks	Company Board	Matrix – Corporate	Mid-term	* Maintain planned performance despite supply chain disruptions	Using a risk identification and mapping committee
* Supply interruption							
* Out of stock							
* Lack of preparedness for crises							
* Market changes							
* Uncertainty of demand							
* Stop operations							

(continued)

Table A1.

Related risks	Mitigation action	What?	Where?	Who?	When?	Why?	How?
* Lack of reliability	Action 14: Have a routine to audit and inspect	Inspect the quality of products upon receipt	Warehouse team	Regionals	Immediate	* Ensure the safety of operation	Through inspections upon receiving the material
* Lack of preparedness for crises						* Ensure reliability with suppliers	
* Reduction in product quality	Action 15: Take out insurance	Have insurance for unexpected events	Company Board	Matrix – Corporate	Immediate	* Share risks	By hiring insurance companies
* Delay in crisis recovery	Action 16: Engage the organization in risk management and crisis preparedness	Train and engage employees in resolving challenges and crises	Company Board	Matrix – Corporate	Long term	* Increase the possibility of a faster and more efficient recovery	Training and familiarizing the company with negative incident contexts
* Difficulty adapting	Action 17: Be adaptable to change	Encourage creative thinking and problem solving in the organization	Company Board	Matrix – Corporate	Long term	* Create solutions for crises and unforeseen events	Fostering employee participation and collaboration in problem solving
* Lack of preparedness for crises							
* Delay in crisis response	Action 18: Consider the risks involved in decision making	Analyze risks and consult chain information for decision making	Company Board	Matrix – Corporate	Mid-term	* Build strategic resilience in the company	Using Risk Management Practices
* Weak relationship in jail							

Source(s): Authors' own creation

Appendix 2.

Resilience element	Related risks	Mitigation action	What?	Where?	Who?	When?	Why?	How?
E1: Agility	* Delivery delay	Action 1: Favor the Agile Supply Chain	Increase receiving frequency and reduce lead times along the supply chain	Logistics Sector	Matrix – Corporate	Short term	* Increase product availability	Adjusting the reorder point for items with higher inventory turnover
	* Uncertainty of demand							
	* Reduction of financial resources and products in stock						* Reduce risks associated with maintaining high levels of inventories	
E2: Anticipation	* Unavailability/ Employee turnover	Action 2: Knowledge management	Record and manage information from past disruption events, such as which processes/products are most likely to experience disruptions, how these disruptions might occur, and which disruptions have already occurred. As well as creating a specification catalog on the materials	Purchasing Sector	Matrix – Corporate	Immediate	* Optimize structures to reduce operating costs	Preparing reports, failure procedures, process risks and creating catalogs with product specifications
	* Supply interruption						* Portrait the realistic view of the processes	
	* Lack of preparedness for crises						* Harvest lessons from past failures	
E3: Logistics capacity	* Delivery delay	Action 3: Inventory balancing	Develop an integrated inventory system so that one warehouse can supply the other if needed	Logistics Sector	Matriz and Regionals	Immediate	* Be prepared for future failures	Developing an integrated inventory and information exchange system between warehouses
	* Supply interruption						* Maintain process knowledge in the company	
	* Uncertainty of demand						* Avoid errors in the purchasing process	

(continued)

Table A2.
Version final of the stock plan

Table A2.

Resilience element	Related risks	Mitigation action	What?	Where?	Who?	When?	Why?	How?
E4: Collaboration	*	Action 4: Collaboration and external communication	Maintain continuous contact with suppliers and customers, sharing information among supply chain members, such as behavior and demand characteristics	Supply Management	Matrix – Corporate	Immediate	* *	Sharing information across the chain through reporting and constant contact
	*							
	*							
	*	Action 5: Supplier development	Initiate and strengthen collaborative partnerships to develop relationships and supply chain members	Chain members	Companies	Immediate	* *	Tightening agreements, closing flexible supply contracts and considering the reverse logistics of post-consumer materials
	*							
	*							
E5: Organizational culture	*	Action 6: Promote a culture that helps manage risk in the supply chain	Encourage a culture oriented towards learning and sharing information/ knowledge	Company Board Regional Managers	Matrix – Corporate and Regional	Mid-term	* *	Improving supply chain intelligence Increase supplier monitoring Improving supply chain intelligence Increase trust among chain members Strengthen the relationship between chain members Creating events with problem solving and knowledge sharing dynamics
	*							
	*							

(continued)

Resilience element	Related risks	Mitigation action	What?	Where?	Who?	When?	Why?	How?
E6: Flexibilidad	* Delivery delay	Action 7: Use multiple modals	Diversify the modes of transport used	Purchasing Sector	Matrix – Corporate	Immediate	* Prevent risk of transport breakage * Decrease the dependency relationship with companies * Streamline the delivery process	Diversifying transport contracting and reducing delivery time
	* Supply interruption							
	* Reduction of financial resources and products in stock							
	* Chain restrictions							
E7: Human resource Management	* Lack of preparedness for crises	Action 8: Maintain short-term alternative sources of supply	Having local suppliers as a contingency plan	Purchasing Sector	Matrix – Corporate and Regional Companies	Immediate	* Ensure availability in case of supply disruption	Mapping new regional suppliers
	* Unavailability of employees	Action 9: Conduct ongoing training	Conduct cross-training for employees on processes, system and products	Chain members	Chain members	Immediate	* Develop cross-functional teams * Improve employee flexibility	Training the warehouse team and other employees involved in the chain
	* Lack of information						* Streamline warehouse processes	
	* Delivery delay	Action 10: Generate greater transparency in the Supply Chain	Provide greater interaction between chain members	Chain members	Companies	Mid-term	* Bring greater transparency and information	Through an integrated environment of information about order status, demand and distribution
E8: Integration	* Supplier bankruptcy							
	* Uncertainty of demand							
	* Supply interruption							
	* Out of stock							

(continued)

Table A2.

Resilience element	Related risks	Mitigation action	What?	Where?	Who?	When?	Why?	How?
E9: Redundancy	* Delivery delay	Action 11: Use multiple providers	Maintain alternate sources of supply for critical items	Purchasing Sector	Matrix – Corporate	Immediate	* Ensure availability in case of supply disruption	Mapping new suppliers
	* Supplier bankruptcy							
	* Uncertainty of demand	Action 12: Strategic Inventory	Review current safety stock level policy for critical products that have high inventory turns	Logistics Sector	Matrix – Corporate	Immediate	* Ensure availability in case of supply disruption	Adjusting the safety stock
	* Supply interruption							
	* Out of stock							
E10: Robustness	* Lack of preparedness for crises	Action 13: Check for risks and deal with them before they occur	Form a specialized team to identify and manage risks	Company Board	Matrix – Corporate	Short term	* Maintain planned performance despite supply chain disruptions	Using a risk identification and mapping committee
	* Market changes							
	* Uncertainty of demand							
E11: Security	* Stop operations	Action 14: Have a routine to audit and inspect	Inspect the quality of products upon receipt from the supplier and upon return from the electrician	Warehouse team	Regionals	Immediate	* Ensure the safety of the operation	Through inspections when receiving material from the supplier and electrician
	* Lack of reliability						* Ensure reliability with suppliers	
	* Lack of preparedness for crises						* Reduce costs with exchanges and internal reprocesses	
	* Reduction in product quality	Action 15: Take out insurance (if feasible)	Have insurance for unexpected events	Company Board	Matrix – Corporate	Immediate	* Share risks * Guarantee credit	By hiring insurance companies

Resilience element	Related risks	Mitigation action	What?	Where?	Who?	When?	Why?	How?
E12: Sustainability	* Delay in crisis recovery	Action 16: Engage the organization in risk management and crisis preparedness Action 17: Be adaptable to change	Train and engage employees in resolving challenges and crises Encourage creative thinking and problem solving in the organization	Company Board	Matrix – Corporate and Regional Matrix – Corporate and Regional	Short term Immediate	*	Training and familiarizing the company with negative incident contexts Fostering employee participation and collaboration in problem solving Using Risk Management Practices
	* Difficulty adapting							
	* Lack of preparedness for crises							
E13: Decision making	* Delay in crisis response	Action 18: Consider the risks involved in decision making	Analyze risks and consult chain information for decision making	Company Board	Corporate	Immediate	*	Build strategic resilience in the company
	* Weak relationship in jail							

Note(s): Immediately, these are actions to be developed as quickly as possible; short term, are actions to be developed in up to one month, and; medium term are actions that can be planned and developed in six months

Source(s): Authors' own creation

Table A2.