



Article

Supply Chain Response during the COVID-19 Pandemic: A Multiple-Case Study

Raúl Antonio Díaz Pacheco ^{1,*}  and Ernest Benedito ² 

¹ Social Sciences Department, Faculty of Engineering and Management, Universidad Nacional de Colombia, Carrera 32 # 12–00, Palmira 763533, Colombia

² Departament d'Organització d'empreses, Universitat Politècnica de Catalunya, Avda. Diagonal, 647, 08028 Barcelona, Spain; ernest.benedito@upc.edu

* Correspondence: radiazpa@unal.edu.co

Abstract: This study explores the responses of manufacturing and service provision companies in Santiago de Cali to stimuli during the COVID-19 pandemic. The responses included changes in demand, absenteeism, and the development of new products, which affected the supply chain (SC). The qualitative methodology of the multiple-case study was used. The evidence for the multiple-case studies was collected through semi-structured interviews, where the interviewees were SC experts from four manufacturing companies and one service company. The data analysis was performed in two phases. In phase one, the case study protocol was completed, and in phase two, thematic analysis was used to identify supply chain response (SCR) patterns. The results revealed two aspects of the SCR. First, to respond to a stimulus, SC adapted activities other than those of suppliers and manufacturers, such as product design and development, human resources, budgeting, and logistics. Second, the SCs used several alternatives to respond to the stimuli. This study contributes to two aspects of the SCR literature: (1) it documents the identification, detection, planning, and evaluation of SCR in response to a stimulus, and (2) it proposes the concept of the response alternatives. The response alternatives concept facilitates decision-making and resource management in SCR.

Keywords: supply chain response; COVID-19; response process; response path; multiple-case studies



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1. Introduction

According to Kritchanhai and MacCarthy [1] (p. 828), a stimulus is defined as “the factors, events, and issues that have or could have an impact on system activities and expected or desired goals. Stimuli are the major factors driving any firm to respond and hence provide the impetus to develop responsiveness capabilities”. Bak [2] described stimuli as the factors and reasons that affect the internal state of the company and cause the supply chain (SC) to transform. In the years 2020 and 2021, various stimuli that arose during the coronavirus disease 2019 (COVID-19) pandemic, such as the increase in demand for antiseptic alcohol, antibacterial gel, and face masks, the low availability of intensive care beds in hospitals, or the absence of personnel in companies, affected the execution of SC activities. Raj et al. [3] determined that companies in emerging economies responded to stimuli that occurred during the COVID-19 pandemic, including shortages of either labor or raw materials, supplier inconsistency, and delivery delays. Stephens et al. [4] investigated the different responses to the stimuli, such as the changes in the rate of operation of the organization’s processes and the frequency of product and service innovation generated in the pandemic. The supply chain response (SCR) to the effects caused by COVID-19 on SCs has been studied from various points of view. For example, Shokrani et al. [5] investigated the manufacturing response to increased demand for face shields during the COVID-19 pandemic. Lee et al. [6] showed how the response to the increased demand for masks in Korea involved the participation of members of the SC such as manufacturers,

logistics providers, the government, wholesalers, and retailers. Kahiluoto et al. [7] found that supplier response diversity improves SC resilience. Azyabi [8] concluded that information technologies and knowledge management improved the flexibility of processes and increased the response options of small and medium-sized companies to the crisis caused by the COVID-19 pandemic. Boehme et al. [9] confirmed that the COVID-19 crisis prompted additive manufacturing in Australia as an alternative response to the protective equipment supply crisis. According to Do et al. [10], the detection of opportunities or threats and the ability to modify tangible and intangible resources facilitated an agile response to disruptions in the food SC during the coronavirus crisis. Frederico et al. [11] stated that the planning, research, contracting, sourcing execution, and supplier relationship management phases improved supplier response from various industries during the pandemic. Margherita and Heikkilä [12] identified the response strategies implemented by 50 large companies to ensure business continuity during the pandemic. Mollenkopf et al. [13] demonstrated, using the dominant service logic, that service organizations responded to the challenges posed by the COVID-19 pandemic by making changes to work routines and authorizing both flexible hours and work at home. Wang et al. [14] described how monitoring customer response by integrating various technologies improved SC resilience. Giropoulos et al. [15] studied the response of small and medium-sized enterprises through the use of digital information to the disruptions caused by COVID-19 to the SC. Omoruyi et al. [16] stated that major food retailer investment in the SC, local supplier development, and technology facilitated the response to the effects of COVID-19 in South Africa. Meanwhile, Ramanathan et al. [17] proposed 15 strategies to food, sports, and fashion SC managers for facilitating the response before, during, and after the COVID-19 pandemic. Smith et al. [18] stated that fish merchants in the United States responded to the COVID-19 pandemic by developing strategies such as sharing and hiring new crew, donating fish to humanitarian organizations, and improving communication between fishermen and fish processors. Zhang et al. [19] reported how specific SC management strategies such as effective and reliable leadership, unity of purpose, integrated and strong digital infrastructure and capabilities, constant learning, and the development of resilience were essential in the response of the personal protective equipment company in British Columbia. Bhattacharya et al. [20] found that micro, medium, and small enterprises from India responded to SC disruptions based on management support for initiatives such as creating chain redundancy, expanding sourcing of supply, supporting the mental health of the workers, and using online channels to execute transactions for the companies. According to Locke et al. [21], retail and manufacturing companies responded to the COVID-19 crisis by ameliorating the execution of activities in unsafe conditions, while others sacrificed short-term profits to invest in the safety of workers whose activity was crucial during every stage of the pandemic. In the latter case, the companies increased wages, rest times, and training. Klöckner et al. [22] identified that some companies listed in the Standard and Poor's (S&P) 500 index used operational, digitization, financial, and management support strategies to respond to the effects of COVID-19.

The aforementioned studies deal with the SCR based on the adaptation of the strategies of the chain, the manufacturing processes, the supplier, and the information. However, research that focuses on aspects such as stimulus detection, planning, and evaluation of company responses to the effects of COVID-19 on the SC is lacking. Therefore, the current study answers the question: how did companies in Santiago de Cali respond to the stimuli that affected SCs during the COVID-19 pandemic? In trying to answer this question, we established four sub-questions targeting different aspects of SCR: (1) which stimuli affected SCs during the COVID-19 pandemic? (2) how did SC managers detect these stimuli? (3) how was the response to the stimuli planned? (4) how was this response assessed? Similar questions posed previously have been answered using research methods such as surveys, experiments, and case studies. According to Yin [23], surveys are used when the objective of the research is to describe the incidence of a phenomenon and identify the frequency of certain results. An experiment implies that the researcher controls the

development of the research in a precise and systematic way; however, when the aim is to study a contemporary event and when one wants to take advantage of the ease of obtaining evidence-based results through an interview or observation, a case study is more suitable.

Taking into consideration that the COVID-19 pandemic is a contemporary event, the current research questions go beyond determining the frequency of occurrence in the SCR and are not intended to control the development of the investigation, in addition to wanting to know directly how the SC responded in the COVID-19 crisis, which is why the case study was selected as the method used to carry out this research. Previously, the case study was used by Coelho et al. [24] to examine the impact on the logistic processes of the delivery of food rations to students in the state of Victoria, Brazil. Data for the case study were collected through semi-structured interviews. Data analysis was performed by applying thematic analysis. Thematic analysis has been successfully applied in several studies, such as the one carried out by Kaeo-Tad et al. [25] on manufacturing resilience during the COVID-19 pandemic and Vanany et al. [26], who used thematic analysis to study the resilience of SCs to mitigate disruptions caused by the pandemic.

A detailed examination of how companies responded to the stimuli that affected SCs during the pandemic can shed light on three aspects of SCR: (1) the strategies that SC managers used to respond effectively and on time, (2) the alternatives that the SC has to respond to a stimulus, and (3) facilitating the application of the response strategy in another company.

The rest of the manuscript is structured as follows: Section 2 presents the theoretical background of SCR. Section 3 explains the data collection and analysis methodology applied to the case studies. Section 4 reveals the results, followed by a discussion of the results in Section 5. Finally, Section 6 presents the conclusions, limitations, and potential for future research.

2. Theoretical Background

This section focuses on the foundations of approaching the concept of SCR, the responses of the SC to the COVID-19 crisis that have been identified in the literature, and the effects of the COVID-19 pandemic on the SC.

2.1. Supply Chain Response

SCR has been defined in various ways [27–30]. In this study, we define SCR as “the adaptation of the activities of an SC to the stimuli it receives, to simultaneously meet some objectives and those of the SC, evaluating the adaptation by the time elapsed between the occurrence of the stimulus and the fulfillment of the certain objective” [31] (p. 78).

This definition captures various aspects of SCR, including the stimuli to which the SC must respond, the adaptation of SC activities, the fulfillment of objectives (both relating to the SC and to those who receive the response), and the evaluation of the time taken to fulfill the objectives. The stimuli to which the SC responds are market signals, changes in demand and customer orders, disruptions and disturbances, and the identification of risks and opportunities. The SC activities that must be adapted include product design and development, supply, marketing, production, logistics, customer service, and SC management. The SC objectives intended to be met through the response are associated with cost control, increased profits, compliance with the service level, and the fulfillment of each SC process objective. As for the objectives relating to response recipients, these are associated both with the satisfaction of needs and expectations and also with the care and improvement of the environment. The evaluation of the response is based on various relevant indicators.

2.2. Responses Implemented in the COVID-19 Pandemic

Companies have responded to the effects of COVID-19 by executing various types of responses. Regarding strategic responses, Wenzel et al. [32] affirmed that companies use retrenchment, perseverance, innovation, and exit to respond to a crisis. Setyoko et al. [33]

identified that strategies such as market development, product diversification, operating expense control, and smart financial management were used in the auto parts industry in response to the COVID-19 crisis. Sharma et al. [34] concluded that companies use reactive and proactive strategies in response to rare events. Reactive responses are positively influenced by the government, while proactive ones are influenced by healthcare infrastructure and lessons learned from past pandemics. Wang et al. [35] classified the responses of Chinese companies into two dimensions. The first is the motivation for innovation, and the second is the level of collaborative innovation. The combination of these dimensions facilitates four types of responses: reactive responses, proactive responses, collaborative responses, and association responses. According to Hohenstein [36], agility, robustness, and learning from experience were the response strategies that facilitated risk management in the SC in times of crisis. Related to operational responses, Saïah et al. [37] concluded that responses focused on eliminating non-essential tasks, exploiting internal and external bottlenecks, and reallocating process priorities increased responsiveness in modularity-based processes. According to Hossain et al. [38], small and medium-sized businesses responded in time to the effects of COVID-19 by using digital platforms to buy and sell products. Based on the thinking of workers at a meat packing plant, Ramos et al. [39] identified that the rapid response of the company to prevent the spread of the virus should include changes such as a reduction of working hours, additional salary, payment of sick leave, and a restructuring of shifts. Kang et al. [40] proposed that the response strategies from the marketing area are based on the expansion of product lines, supplier management, and customer relationship management. Belhadi et al. [41] stated that in the automotive industry's response to the COVID-19 crisis, supplier location decisions were made and information technologies were used, while in the aeronautical industry, response efforts focused on maintaining business continuity both at airports and on flights. In the framework proposed by Xu et al. [42], they highlight that the increase in online business, social responsibility, and the union of companies to form industrial conglomerates were the strategies that improved the SC response. For Snowdon and Saunders [43], the response strategies used by Nova Scotia during the pandemic were the integration of the SC, strategic and local sourcing, and the restricted use of raw materials.

2.3. Impacts of the COVID-19 Pandemic on SCs around the World

The World Bank (2020) [44] stated that due to the COVID-19 pandemic, the baseline forecast calls for a 5.2 percent contraction in global gross domestic product in 2020. The World Trade Organization (WTO) (2020) [45] estimates that the volume of world merchandise trade in 2020 will fall by somewhere between an optimistic 13 percent and a pessimistic 32 percent. According to Mańkowski et al. (2022) [46], the world had never faced an impact of such magnitude as that caused by the COVID-19 pandemic on the SC. In this sense, Kumar et al. (2021) [47] stated that the negative impact occurred in sectors such as business, agriculture, the entertainment industry, tourism, and the service sector. Regarding the companies, Karuppiyah et al. (2022) [48] identified negative impacts on product supply and demand, demand forecasting, skilled labor shortages, and reduced cash inflows. Eldem et al. (2022) [49] stated that aspects of companies such as raw materials, transportation, labor, and the payment of work disabilities were impacted by the COVID-19 crisis. Sombultawee et al. (2022) [50] highlighted that the impact of COVID-19 on economic performance was throughout the SC and not just on individual companies. Ogunnusi et al. (2021) [51] noted that the impacts of COVID-19 on the construction SC were both positive and negative. The aspects that were positively impacted were the reduction of general expenses, remote work, and the prioritization of worker health and safety, while the negatively impacted aspects include low trade turnover, delays in payments and delivery of goods, the difficulty of doing work at home, and job loss. Regarding the end customer of the SC for Brandtner et al. (2021) [52], the impact depends on aspects such as the distribution of the retailer's plant, space available to the customer, equipment available to make the purchase, interaction with the staff, problem-solving, and the

price of the product. Kwon (2020) [53] concluded that a production disruption in SCs caused by COVID-19 has a ripple effect on other chains, both global and local. However, Castañeda-Navarrete et al. (2021) [54] stated that impacts differ between regions and industries. According to Pinzón et al. (2020) [55], the impact of the COVID-19 pandemic was reflected in the decrease in household consumption and the deepening of problems in the logistics processes of companies.

2.4. Effects of the COVID-19 Pandemic on SCs

According to Aday and Aday [56], COVID-19 affected all processes in the food SC, from sowing seeds to delivering the final product to the consumer. COVID-19 affected how products were acquired as well as the processes of supplying, manufacturing, and distributing them. To reduce the spread of the virus, governments in various countries issued orders restricting people's mobility and modes of transport, among other things. In addition, conditions were imposed on the manufacturing, distribution, and sale of products that affected the operation, costs, and profits of SCs. Fonseca and Azevedo [57] stated that the pandemic caused simultaneous supply and demand problems for both products and services. Similarly, Kumar et al. [58] asserted that the availability and production of essential items such as food, groceries, and pharmaceutical products were drastically reduced during the COVID-19 pandemic and that there was a mismatch between production and demand. Trautrimis et al. [59] stated that the pandemic influenced how products and services were acquired and consumed. The disruptions to SCs caused by COVID-19 had various consequences, such as the nonfulfillment of demand, the obsolescence of inventory, and the abuse of power by both the buyer and the supplier. Remko [60] stated that the SC plans to deal with the disruptions caused by COVID-19 were inadequate in the response preparation phase; therefore, the late response to the disruptions affected the resilience of SCs. Craighead et al. [61] proposed imitating successful responses given by other SCs and improving the allocation of resources used in those responses as a strategy to deal with the late response.

Farooq et al. [62] stated that product manufacture was affected by phenomena such as worker absenteeism and excessive increases or decreases in the manufacture of certain products. Magableh [63] identified that the effects of COVID-19 on SC caused disruptions, delays in receiving products, and difficulties related to information management, while Chowdhury et al. [64] affirmed that the execution of strategies, such as the increase in production capacity, temporary storage, the strategic location of manufacturing plants supported by logistics processes, and the implementation of fast delivery modes, improved the response to the disruptions that SC faced during the pandemic. Butt [65] and Weber [66] identified other responses that companies used to lessen the impact of the pandemic on SCs. The first stated that purchasing companies used agile production strategies, increased visibility of information, and the closure of production plants to face the effects of COVID-19, while distribution centers modified inventory policies and evaluated routes differently to deliver orders and select new suppliers. The second identified that retailers responded to interruptions using strategies such as the implementation of the use of technology in the purchase, payment, and delivery of products, increased storage capacity, and planned actions to be carried out in the long term. Kiers et al. [67] identified that the COVID-19 pandemic affected aspects of SCs such as product supply and demand, increased bullwhip effect, increased transportation costs, and delayed product delivery. They also proposed strategies to mitigate the impact of COVID-19 on SCs, such as dual sourcing, defining new locations for SC processes, increasing SC visibility, redefining safety stock, and improving manufacturing capacity. Table 1 summarizes the effects of COVID-19 on the SC and the response to them.

Table 1. Effects of COVID-19 and SC responses.

Effects of the COVID-19 Pandemic on the SC	SC Responses
<ul style="list-style-type: none"> • Disruption in the processes of demand, supply, manufacturing, and distribution in the food SC • Restrictions on mobility for people and modes of transport • Conditions for the manufacture, distribution, and sale of products. • Reduced production and availability of food, groceries, and medicine • Consumers changed the way they purchase products • Non-compliance with the demand • Inventory obsolescence • Abuse of power between buyer and seller • Inadequate response plans • Employee absenteeism • An increase or a decrease in demand for products • Delays in the delivery of products • Difficulty in information management • An increase in the bullwhip effect in the SC • An increase in transportation costs 	<ul style="list-style-type: none"> • Execution of strategies to reduce costs, assets, or products • Execution of product innovation strategies. • Retirement of business lines or products • Market development • Expansion of product lines • Product diversification • Control of operating expenses • Smart financial management • An increase in agility and robustness in SC processes • Elimination of non-essential tasks • Exploit internal and external bottlenecks • Reassignment of priorities in processes • Reduction of working times • Additional salary payment • Sick leave payment • Re-structuring of work shifts • Supplier management • Strategic and local sourcing • Restricted use of raw material • Customer relationship management • Use of digital platforms • Implementation of digital marketing and online business • Analysis of large volumes of data • Cooperation between members of the SC • SC Integration • Learning from experience • Compliance with social responsibility • Creation of industrial conglomerates

Six aspects stand out in these effects identified by previous research: (1) COVID-19 altered SC process management (including customer and supplier relations), demand, order fulfillment, and manufacturing flow; (2) governments imposed priorities on companies for manufacturing and distributing certain products and providing services to the community; (3) consumers were forced to change the way they bought products and services; (4) the previous studies are limited in showing a response of SCs to a stimulus caused by the COVID-19 pandemic; (5) the SC responded to the effects of COVID-19 by executing strategic decisions such as the expansion, retirement, and innovation of products and the implementation of online transactions. It also executed tactical decisions related to the sourcing of essential raw materials in the manufacturing process and increased the number of local suppliers. Concerning operational decisions, the response involved changes in work shifts, overtime work, the elimination of tasks that did not add value, and the elimination of bottlenecks. The SC managers also responded to the requests of the workers, making decisions such as paying bonuses, paying workers for their disabilities, and reducing the working day. The response of the SC involved, on the one hand, improving the agility and robustness of the processes and, on the other hand, cooperation and integration between the members of the chain. In addition, the response contributed to compliance with the social responsibility of the SC; and (6) the answers previously commented on are limited because they do not address aspects such as detection, planning, and evaluation of the SCR.

3. Research Methodology

According to Bloomberg and Volpe [68], qualitative research promotes a deep understanding of the topic being investigated from the perspective of the research participants. Therefore, this approach is appropriate because it facilitates knowing from the managers' point of view the way in which companies responded to the effects caused by the COVID-19 pandemic on SCs. Based on the SC's day-to-day response to each affectation, we used the common case study method, as it makes it easier to capture the circumstances and conditions of an everyday situation [23]. A case study can reveal general patterns of the

subject under study [69]. The COVID-19 pandemic affected both manufacturing and service SC; therefore, it was appropriate to use multiple-case studies, as they facilitate the logical replication and contrast of results between cases [23]. The case study has already been successfully applied in studies carried out by Kaeo-Tad et al. [25] and Ivanov [70]. The first study identified the strategies that improved manufacturing resilience in times of COVID-19, while the second proposed four strategies to improve SC viability during the pandemic. Coelho et al. [24] used the case study to find out the impact on the logistics processes of changing the way food rations are delivered to children in the province of Victoria (Brazil).

To carry out this case study, two phases were executed. In phase one of the methodology, the following steps were followed: (1) definition of the research questions; (2) selection of the unit of analysis; (3) general description of the SC that participated in this study; and (4) description of the interviewees' profiles. Phase two consisted of the definition of the procedure to collect the data and the technique to analyze it.

3.1. Defining the Research Questions

To understand the response that companies gave to the stimuli that affected the SC, the following research questions were asked: How did companies in Santiago de Cali respond to the stimuli that affected SCs during the COVID-19 pandemic? In trying to answer this question, four sub-questions targeting different aspects of SCR were established: (1) which stimuli affected SCs during the COVID-19 pandemic? (2) how did SC managers detect these stimuli? (3) how was the response to the stimuli planned? (4) how was this response assessed?

3.2. Case Selection

The multiple-case study was carried out in the city of Santiago de Cali, Colombia. According to a city competitiveness report, Santiago de Cali ranks fourth among Colombia's 32 cities [71]. Based on the purpose of knowing how companies responded to the impacts caused by the COVID-19 pandemic on SC, the authors of this study decided that the analysis units were either manufacturing or service companies. The companies for the case study were selected because they stated that their SC was affected by COVID-19 and they expressed their willingness to participate in this study. Table 2 shows the characteristics of the participating companies, namely their economic sector, industrial activity, number of employees, destination of exports, and duration of the interview.

Table 2. Characteristics of the companies that participated in the case study.

Case	Economic Sector *	Industrial Activity	Number of Employees	Product Exportation Destination	Interview Duration (Minutes)
A	Secondary	Pharmaceutical	1200	Andean Region	70
B	Secondary	Ready-to-assemble modular furniture manufacturer	700	South and Central America	108
C	Secondary	Aluminum profiles for various uses	900	The United States and the Caribbean	63
D	Tertiary	Marketer of products and services	5500	None	66
E	Secondary	Production of nutrition, hygiene, and personal care products	1200	Ecuador, Central America in the North Triangle, and Peru	48

Note: * In Colombia, companies are classified as belonging to one of three economic sectors. The companies that belong to the primary sector are dedicated to the extraction of natural resources. Companies that transform raw materials are classified as the secondary sector, and companies that provide non-material goods and services belong to the tertiary sector.

3.3. Supply Chain Overview

3.3.1. Case Company A

The company in Case A had an operating income of 198,834,315 pesos in 2020 and offered products such as multivitamin supplements, oral care, personal care, home care,

pharmaceuticals, cotton, and natural products. The company's product catalog is divided into four categories: antiseptic alcohol, creams, dietary supplements and bleaches, and household cleaning supplies. Their SC comprises product design and development, marketing, supply, manufacturing, transportation, and distribution. The product design and development processes are led by a multidisciplinary team to create multifunctional products. Their supplies consist of raw materials such as plastic containers, covers, labels, and corrugated cardboard. The manufacturing process for each product line varies between one and two work shifts of 8 h each. The production strategies that are executed include both production to maintain inventory and production upon order. The product distribution process is outsourced.

3.3.2. Case Company B

The company in Case B had an operating income of 140,061.003 pesos in 2020 and is dedicated to the manufacture of modular furniture; it has a product catalog with more than 7800 furniture references. Their SC comprises research and product development, marketing and sales, suppliers of raw materials and other supplies, manufacturing, and logistics. The research and product development processes aim to develop new products and analyze the production costs of a reference. Marketing and sales are executed by the commercial or export management departments. Modular furniture exports are made to countries such as Costa Rica, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Trinidad and Tobago, France, and the United Kingdom. The procurement process is accomplished through the main supplier of both raw materials and other supplies. Products for national consumption are manufactured to maintain inventory, and those for export are made upon order. The manufacturing process is carried out in 8 h or 12 h shifts. The number of product units pending manufacture determines the scheduling of work shifts. The manufacturing process begins if it is assessed to be economically viable and raw materials are available in the warehouse. Total manufacturing capacity at the start of the pandemic varied between 30,000 and 50,000 units of furniture per month. At the end of the pandemic, the production capacity was 110,000 units per month. The logistics area is responsible for managing containers for both export and national dispatch of the product to large stores. Logistics operates with a subcontracted transport fleet.

3.3.3. Case Company C

The company in Case C had an operating income of 166,200.375 pesos in 2020 and is dedicated to manufacturing aluminum profiles. Their SC comprises research and development, marketing and sales, manufacturing, and logistics. The research and development process generates new product lines for all customers. It is also in charge of analyzing any claims made by customers relating to product quality failures. The marketing process is in charge of commercializing products and serving different clients, including industrial, wholesale, and retail clients. Marketing personnel receive feedback from customers on the cutting, installation, and use of aluminum profiles. The manufacture of aluminum profiles involves extrusion, rolling, and aluminum casting. The manufacturing plant's production capacities for extrusion, rolling, and aluminum casting are 2338, 200, and 100 tons/month, respectively. Case Company C has two production plants. The Yumbo plant is dedicated to the aluminum transformation process, and the Medellín plant finishes the profiles. In both plants, production is scheduled 24 h a day, 7 days a week, and distributed in 8 and 12 h work shifts. It also has factories in Ecuador and Miami. Both international plants are engaged in the manufacture, sale, and distribution of hurricane protection systems.

The distribution service provider is subcontracted and meets three conditions: (1) the vehicles can comply with the maximum weight that can be transported in Colombia; (2) the supplier does the packing work in the distribution center; and (3) the vehicles can transport profiles of greater lengths than the standard length. The distribution is made to hardware stores, industrial window clients, and retail clients.

3.3.4. Case Company D

Case Company D is dedicated to the commercialization of products and services through a portfolio of more than 45,000 references. The portfolio includes medication, cleaning supplies, books, furniture, and gym products. Case Company D has more than 800 points of sale. The SC includes storing, supplying, and distributing the finished product to points of sale or directly to the customer. Sourcing is executed in three ways: (1) buying directly from the supplier or distributor (both for delivery to the point of sale); (2) receiving purchases at the distribution center and separating orders to subsequently be dispatched to points of sale; and (3) making centralized purchases that are received at the distribution center and dispatched to the point of sale without separating orders. The company has various sales channels, both face-to-face and non-face-to-face (i.e., over the phone or online). Both sales channels are available 24 h a day, 7 days a week. Distribution is conducted using a mixed fleet: their own fleet is used for short-haul deliveries, while long-distance deliveries are outsourced. The sales promise is to deliver the order within an hour. Distribution centers work 8 h a day, 6 days a week.

3.3.5. Case Company E

Case E is a multinational company dedicated to providing professional food services for chefs. The products manufactured by Case Company E include tomato sauce, cornstarch, soups, concentrated broths, and creams. The SC comprises research and development, marketing and sales, manufacturing, and logistics. Marketing is in charge of the entire process of promoting and selling the products; it is also responsible for giving feedback to the production department on any complaints and claims received from the client, whether it is a wholesaler, supermarket, or the final consumer. The raw materials used by Case Company E were imported from Europe. Local suppliers only provide corrugated and laminated packaging material. The plant is located in Santiago, Cali, and produces sauces, spreads, and cereals. Manufacturing is performed in three 8 h work shifts. Occasionally, 12 h work shifts are implemented with the authorization of the Ministry of Labor. The company works 7 days a week. The distribution of products to supermarkets and retailers is outsourced.

3.4. Profile of the Interviewees

Each of the participants in the case study met the following four criteria: (1) education level (minimum undergraduate academic degree in engineering, business administration, or an area related to engineering); (2) leading a process or area of the SC at their company; (3) willing to participate in the case study and sign the informed consent form; and (4) able to describe their company's SC. These SC descriptions comprised all comments in the interviews describing which processes are part of the company's SC. Table 3 summarizes the profiles of the interviewees.

Table 3. Profiles of the interviewees.

Case	Educational Level	Position	Experience (Years)	Interview Date
A	Industrial engineer	Planner and buyer	More than 4	11 January 2022
B	Industrial engineer	Programming manager of production	More than 3	28 January 2022
C	Marketing specialist	Technical advisor in the central region of the country	More than 4	21 January 2022
D	Industrial engineer	Demand planning analyst	More than 8	13 January 2022
E	Industrial engineer	Production supervisor	More than 6	19 January 2022

3.5. Data Collection

The case study was carried out using a protocol that was applied to each interaction between the authors and the selected companies. It also facilitated the definition of the data sources that were used to answer the research questions and inform the findings. During data collection, the following steps were followed: (1) preparing the questionnaire;

(2) sending invitations to participate in the case study to professionals and organizations via emails and phone calls; (3) scheduling interviews with those who agreed to participate; (4) sending the questionnaire to the interviewee a few days before the interview; (5) conducting the semi-structured interview based on open-ended questions; (6) transcribing the audio- or video-recorded interviews using AtlasTi software; (7) sending the completed interview transcript to the interviewee to review and verify that the information was truthful and corresponded to the interview contents; and (8) analyzing the interview data (steps 7 and 8 ensure the validity of the construct); ref. [23,72]. The analysis of the information collected in the interviews was carried out using thematic analysis and cross-case analysis. The thematic analysis facilitated answering the research questions posed in this study. Through the cross-analysis of the cases, the similarities and differences between them were known. Phase one of the thematic analysis began with the transcription of the interview and continued with the completion of the protocol for each interview; both allowed familiarization with the data. In phase two, we defined codes that made it easier to group the answers obtained in each interview. In phase three, we reviewed the information coded in phase two to identify themes. In phase four, we verified that each theme defined in phase three could be linked to one of the research questions posed in this study, and in phase five, we defined four themes named thus: stimulus, detection, response, and evaluation.

In this case study, multiple sources of data were used (data triangulation), including reports from the Superintendence of Companies of Colombia, SCR academic literature, newspaper articles, information from participating companies' websites, and market information. The multiple data sources were used in three ways: (1) through the reports of the Superintendency of Companies of Colombia, the information on the economic activity of the company and operating income was verified; (2) the review of the literature made it easier for the authors to compare the findings with the results of other studies; and (3) the information shown in newspaper articles, information from the websites of the participating companies, and information from the market facilitated the comparison between the information commented on by the interviewee and that shown in the previously mentioned media. Based on the interviews and external information sources, a case study database was created. The development of the case study protocol, the database, and the maintenance of the chain of evidence in data processing and analysis increased the reliability of our case study [23].

4. Results

This section presents our findings on how companies responded to the COVID-19-related impacts on SC. Four aspects of the SCR are described: (1) stimuli that affected the SC; (2) stimulus detection; (3) response planning; and (4) response evaluation. In addition, the response alternatives of SCs to a stimulus have been shown. Response alternatives are an additional result that was identified when the interviewees' responses were analyzed.

4.1. Stimuli that Affected Company SC

The results found in this multiple-case study confirmed that stimuli such as increases and decreases in customer demand, absenteeism of workers, and changes in the way customers buy products and services affected the SC of companies in Santiago de Cali during the COVID-19 pandemic. In addition, decreased contact between customers and company personnel was first identified as a stimulus that prompted the SCR.

4.2. Detection of the Stimuli that Affected Company SC

Concerning the detection of stimuli, it was identified that this was performed through the analysis of information such as sales reports, indicators of best-selling references, pending orders to be delivered, delivery time to the customer, comparison of units sold in person against units sold through online channels, analysis of production indicators and human resources, an increase in complaints and warranty requests, a change in the law that deals with the presentation of the products, and mobility restrictions. Additionally,

comments expressed by sales staff in work meetings and client complaints made by email or other digital means were used to detect the stimuli. In particular, the interviewee in Case A expressed that “the marketing area observed in the sales reports of March 2020 shows that people began to consume much more alcohol, the clinics began to consume more alcohol, and then the increase in alcohol consumption exceeded 200 percent of what they had been consuming historically over the previous years”.

4.3. Planning of the Response to Stimuli Affecting Company SC

The analysis of the data showed that the planning of SCR responses to the stimuli was carried out through meetings in which personnel from various areas of the company participated, such as production and logistics, general management, and administration. Response planning involved sharing information both internally and externally with the SC. External information was provided by suppliers, customers, the news media, and social networks, while internal information was comprised of each SC’s indicator process and the opinions of SC managers. In addition, information on positive and negative responses was shared among SC managers.

It was also identified that in response planning, the increase in the permitted number of overtime hours and additional work shifts and the extension of the working day to include Saturdays and Sundays were the first decisions made to respond to stimuli such as the increased demand for antiseptic alcohol, antibacterial gel, and ready-to-assemble desks. These strategies were implemented in manufacturing and logistics processes. In addition, it was identified that manufacturing increased the frequency of preventive maintenance of the machines to guarantee the operation of the production equipment. Worker absenteeism was observed in two ways. First, companies applied strategies such as the temporary transfer of personnel between SC processes, providing additional training, certifying personnel in the operation of machines, and hiring additional support personnel. Secondly, the execution of the previously mentioned strategies involved departments that support SC management, such as human resources and budget.

It was also evident that the suppliers, purchasing, transport, and distribution process managers participated in the planning of the response. Agreements between buyers and suppliers facilitated changes in the quantities of orders, product delivery dates, and suppliers’ production capacity. Planning operational decisions such as scheduling overtime, adding work shifts, and constantly reviewing inventory levels facilitated the response of transportation and distribution processes. The interviewee from Case Company D stated that various modes of transportation were used to fulfill the delivery of orders in the last mile. Additionally, the delivery process was made more efficient with the use of georeferencing technology. This interviewee also responded that in meetings held to plan the response to the decrease in demand for digestion-related products, it was agreed to review the product purchase contracts with the supplier. It was also decided that a revision of inventory levels in the distribution centers and at the points of sale was necessary.

This multi-case study confirmed that response planning also took place in the product design and development process. Regarding the planning of the response that involved the design and development of beds for intensive care units (ICU) in Case Company C, the interviewee commented that this decision involved executing activities such as sketching and 3D drawing, prototyping, and testing; budgeting costs; and projecting profits. Case Company D responded to the loss of customer contact by developing tutorials for the company’s website. Topics such as cutting and assembling aluminum products were covered in the tutorials, which were designed taking into account aspects of visual and content design, functionality and usability testing, and the ability to update the tutorials.

Regarding the change in the way products were acquired, the results showed the use of different approaches to planning and decision-making. Case Company B took advantage of the opportunity to start an online sales process, so it had to provide all the necessary resources to make this sales option available. Meanwhile, Case Company D strengthened its online sales platform by expanding its product portfolio. Furthermore,

it was confirmed that response planning and decision-making caused friction among the company's personnel. This friction was resolved by constructing arguments based on data and explaining the benefits of the entire SC responding positively to the stimuli.

Concerning the planning of the response, the interviewee in Case B commented that “the first response was to work overtime and for 24 h per day and seven days per week. That meant that logistics had to hire more people to be able to respond with the delivery, product design had to work an additional shift to start generating the bill of materials, and purchasing had to hire more people to expedite the purchase of supplies and materials. Furthermore, one of the packaging suppliers had to expand its production capacity. When conflicts arose between human resources and manufacturing, management intervened by explaining the importance of having people available to work in the company”.

4.4. Evaluation of the Response to the Stimuli

Analysis of the case study data showed that the SCR was assessed using quantitative and qualitative indicators of the processes involved in the response. The quantitative SC indicators that were used to evaluate the response were the total cost of the response, the return on investment, the response time, the invoiced value per process, the manufacturing cost, the cost of guarantee fulfillment, the cost of product rework, the delivery time, the complete delivery, destroyed product, product inventory available on hand, the quantity of product out of stock, and the availability of machinery. The impact on sales of changes in the way customers bought products and services was evaluated, comparing sales indicators through traditional and online channels. The response to the absenteeism of the workers was evaluated through the indicators of days of worker absenteeism, staff turnover, productivity per worker, and days of attendance at work. The response to the loss of contact with the client was evaluated with the indicator of a decrease in requests for guarantees and post-sale claims.

SCR was also evaluated by qualitatively assessing the comments of suppliers, distributors, and customers about the availability of products, their prices, and the ways of acquiring products and services. These comments were transmitted directly to the sales staff in work meetings or on company social networks.

In one particular case, the response to increased demand for ICU beds (Case Company C) showed a different type of evaluation. Although the product went through all stages of product design and development, the response was late and unsuccessful. Therefore, response evaluation was carried out to determine failures in the product design and development process. Failures were determined in each design process and the interfaces between design and sourcing, design and manufacturing, and between supply and manufacturing. Additionally, the number of resources invested in labor, machinery, and raw material storage that the company lost due to their late response, were evaluated. Finally, the cost of keeping unsold beds in stock at the company was evaluated.

Regarding the evaluation of the response, the interviewee in Case D commented: “in the company, the evaluation of the response to the stimulus is performed with indicators. The indicators that the company has implemented are the return indicator, the destruction indicator, the supply indicator, the level of service on time, the on-time in full, out-of-stock indicator, the excess indicator, and the inventory level indicator. All the indicators are constantly monitored because it is our information tool. The company has a system of requests, complaints, suggestions, and claims (RCSC) both at points of sale and in virtual channels to meet specific requirements and address difficulties through an order.” Table 4 shows the previously described results.

Table 4. Characteristics of the SCR to the stimuli that affected the SC in Santiago de Cali during the COVID-19 pandemic.

CASE	Stimuli	Detection	Planning	Evaluation
A	Increased demand for antiseptic alcohol, dietary supplements, and antibacterial gel	Increased product sales units Inventory rotation	Development of a new product	Business objectives and those of each area
			Increase in production capacity through overtime	
			Increased maintenance frequency	
			Agreement with suppliers on modification in quantity and date of supply	
Work absenteeism	Lack of staff on the lines of production	Staff loan between production lines	Days of absenteeism per worker staff turnover	
		Increased disabilities due to the spread of COVID-19		
		Extension of work shifts		
B	Increased demand for ready-to-assemble desks	Pending orders	Staff training	Production costs Billing level Production indicators Brand recognition by clients
			Increased production capacity through overtime, hiring of personnel in production processes and product packaging	
			Increased frequency and quantities of supply	
			Increased supplier production capacity	
			New production plant	
			New distribution center	
			Outsource production	
			Purchase of machinery	
			Implementation of online sales and service channels	
			Salary bonus to production and logistics staff	
Work absenteeism	Lack of staff on the lines of production	Extension of work shifts	Days of absenteeism per worker Productivity per worker Work-attending days	
		Increased disabilities due to the spread of COVID-19		
		Staff training		
	Mobility restrictions	Increased staff availability		

Table 4. Cont.

CASE	Stimuli	Detection	Planning	Evaluation
C	Increased demand for beds in intensive care units in Colombian hospitals	Increased occupancy levels of intensive care beds in Colombian hospitals Government request to increase the capacity of intensive care rooms in Colombian hospitals	Design and development of intensive care beds	Product launch time Cost of holding inventory Failures in the product design and the development process
	Loss of contact with the end customer and with shop assistants	Increased warranty claims Increased complaints and claims	Design and development of online tutorials, which show cutting and assembling products.	Decrease in warranty cost Decrease in requests, complaints, suggestions, and claims
D	Increased demand for antiseptic alcohol, and antibacterial gel	Increased product sales Information provided at the point of sale	Supply at the distribution center, at the point of sale, or direct delivery to the customer	Fulfillment of the promise Product delivery
	Decreased demand for the products that improve digestion	Decreased product sales Information provided at the point of sale	Supply renegotiation Product destruction Product return	Return indicator, destruction indicator, supply indicator, service level indicator, on time delivery indicator, on time in full, out of stock indicator, excess indicator, and inventory level indicator
	Change in the way of purchasing products	Increased sales by online channels	Availability of the website Order traceability	Sales comparison by traditional channels versus online channels
E	8 g packets of tomato sauce, mayonnaise, and pink sauce in places such as restaurants and cafes	Change in the law that deals with the presentation of 8 g products in restaurants and cafeterias Increased demand for products packaged in 8 g sachets.	Supplying an increase in production capacity by extending work shifts and overtime	Compliance with the production schedule Production indicators
	Work absenteeism	Lack of staff on the production lines	Staff training	Days of absenteeism per worker Work-attending days
		Increased disabilities due to the spread of COVID-19	Increase in staff availability	
		Mobility restrictions	Certification for personnel handling the machines	

Note: column 1 shows the case; column 2 shows the stimulus that was dealt with in the interview; column 3 shows the information used to detect the stimulus; column 4 shows the response planning decisions; and column 5 shows the information used to evaluate the response.

4.5. Response Alternatives

An unforeseen result that emerged from the analysis of the data collected in this case study was the concept of response alternatives, understood as the alternatives that the SC has to respond to a stimulus. The stimulus, the functions, the management processes, the objectives of the SC, and the evaluation of the response are part of an alternative response. The response alternatives are a guide for response planning. The selected alternative depends on the type of stimulus and the resources with which the SC can respond. The alternatives that were identified to respond to the increased demand for antiseptic alcohol and increased worker absenteeism are discussed below.

Response path A to the increase in the demand for antiseptic alcohol began with the review of sales reports that showed an increase in sales of antiseptic alcohol. Stimulus detection was carried out using the information provided by retailers to sales representatives and the information issued by the Colombian Ministry of Health, which called for the constant use of antiseptic alcohol and antibacterial gel for washing hands (hand washing was widely discussed as a measure to prevent the spread of COVID-19). This analysis made it easier for the SC managers to detect and understand the stimulus because the reason for both the increase in demand and the lack of products on retailers' shelves was understood. The managers met to plan the SCR. At the meeting, it was decided to adapt the production process to produce more units of antiseptic alcohol. The adaptation consisted of working overtime, scheduling additional work shifts, and extending the working day. The management of demand and manufacturing flow management were also adjusted. The objectives to be achieved with this SCR were maximizing profits, meeting the level of service, and guaranteeing a decent job for manufacturing personnel. The SCR was evaluated by reviewing manufacturing process indicators.

Response path B to the increase in the demand for antiseptic alcohol began with the review of sales reports that showed an increase in sales of antiseptic alcohol. In addition to analyzing the information described in response path A, information on the amount of inventory available in distribution centers and at points of sale was analyzed. Managers met to plan the SCR. At the meeting, it was decided to adapt the logistics processes of transport and distribution. The adaptation consisted of working overtime, extending the working day at the distribution center, and increasing the frequency of supply at points of sale. Customer relationship management and customer service processes were also adapted. The response objectives were to meet customer expectations and guarantee sustainable production and consumption of products. The response was evaluated using key performance indicators and by analyzing the requests, complaints, suggestions, and congratulations provided by those who received it.

Response path C involved responding to increased worker absenteeism in logistics processes. SC managers reviewed reports detailing workforce availability indicators, identifying the low availability of personnel in the manufacturing process. Information on other indicators, such as the average number of days of absenteeism per worker and the rate of absenteeism, was analyzed. Information external to the SC provided by entities such as professional risk managers and the Colombian Ministry of Labor (in charge of dealing with the impact of COVID-19 on companies) was also analyzed. This analysis confirmed to the SC managers that COVID-19 increased work absenteeism because several workers were infected, suspected of being contagious, or were in preventive isolation. The managers planned the SCR by making decisions on logistics processes such as hiring support staff, increasing work shifts, working overtime, and extending the workday to include weekends. In addition, order fulfillment and customer service processes were adjusted. These decisions were made to reduce the impact of worker absenteeism on the SC objective of minimizing costs. Human resources and financial departments participated in the execution of hiring decisions. The SCR was evaluated by analyzing compliance with SC process indicators relating to logistics processes and customer satisfaction. Figure 1 shows the response path alternatives A, B, and C.

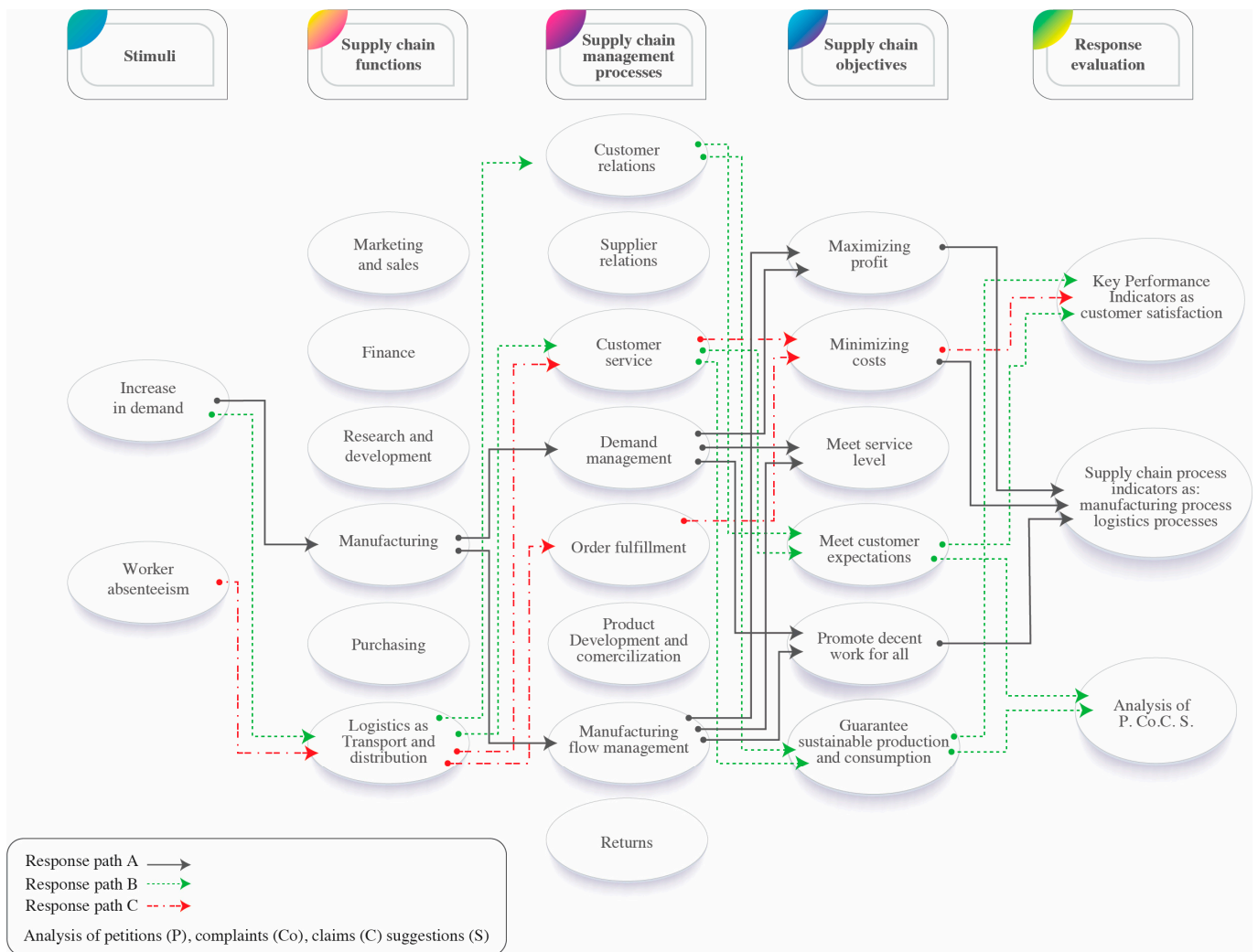


Figure 1. Supply chain response paths.

Figure 1 was designed based on the management functions and processes proposed by Lambert and Enz [73], while the objectives of the SC and the aspects of the evaluation of the response are taken from this case study. Figure 1, on the one hand, facilitates the identification of SCR alternatives and, on the other hand, extends the literature on SCR.

5. Discussion

Aligned with the purpose of this research, that is, understanding how companies based in Santiago de Cali responded to the stimuli that affected the SC during COVID-19, this multiple-case study presents findings from the experiences of SC experts that were expressed in interviews held at the selected Santiago de Cali companies. It is important to note that the SCR study was based on five aspects: (i) the stimulus to which the SC responded; (ii) stimulus detection; (iii) response planning; (iv) response evaluation; and (v) response alternatives.

This case study confirmed, from the perspective of the SC, the notion of stimulus that was proposed by Bak [2], who, from the point of view of electronic business, stated that the stimuli arise from the internal functioning of the chain. However, this study makes the argument that the stimulus arises both outside (e.g., increased demand for masks) and inside the SC (e.g., absenteeism of workers in the manufacturing plant). The SC adjusted several processes to respond to stimuli during the COVID-19 pandemic. The response to the increase in demand came from the processes of product design and development, production, and distribution, while the response to the decrease in demand came from

distribution. SCs responded to absenteeism by coordinating efforts across areas such as production, human resources, and finance. They responded to events such as loss of contact with customers and customer changes in the way they purchase products using information technologies. In this line of thought, Do et al. (2021) [10] expressed that the response to various stimuli, whether threats or opportunities, was linked to the modification of the SC processes. The authors of this study note that researchers have striven to study only one type of stimulus. For example, Kaeo-Tad et al. [25] and Vanany et al. [26] only dealt with the response to SC disruptions during the COVID-19 pandemic. However, this multiple-case study discouraged stimuli that were revealed as the loss of contact with customers and work absenteeism. The literature on these last two stimuli is scarce. The SCs also responded to business opportunities such as those generated by the government's call to produce antiseptic alcohol and beds for ICUs. In both cases, the response involved the participation of processes such as product design and development, manufacturing, and distribution. The response to business opportunities was also documented by Shokrani et al. [5], in which SCs responded to the government's call to design and produce face masks. According to Wenzel et al. [32], the response that entails product design and development is innovative.

Our analysis showed that the detection and understanding of the stimuli that affected SCs during the COVID-19 pandemic were carried out through information management. Regarding detection, Sombultawee et al. (2022) [50] highlighted that the stimulus does not become visible if it is not detected or defined. Concerning information management, Chowdhury et al. [64] stated that the management of information is useful to treat the effects of COVID-19 in SC. The management of the information carried out by the managers of the SC was useful because it promoted the sharing of external and internal data among different SC process leaders. In this sense, Mańkowski et al. (2022) [46] stated that sharing information among members contributes to the solution of complex problems in the SC. The sharing of information facilitated the response to the stimuli that affected the SC during the pandemic. We find similar reasoning on the one hand in Kiers et al. [67], who affirmed that the exchange of information facilitates the early reaction of the SC, and, on the other hand, Azyabi [8] identified that the use of information technologies increased the response options of the chain in times of the COVID-19 crisis.

Based on the capacities of the SC, the managers planned the response during the COVID-19 pandemic, making decisions in the short, medium, and long terms. In the short term, strategies such as overtime work, increased work shifts, and longer working hours in both production and logistics were implemented, while in the medium term, they outsourced production and expanded the capacity of the distribution center. In the long term, they designed products and opened new production plants. The increase in production capacities improved the SCR, along the same lines that Chowdhury et al. [64] expressed that increasing production and logistics capacities improve the SCR. Margherita and Heikkilä [12] go further and ensure that the continuity of companies during and after the COVID-19 pandemic depends on increasing and optimizing production capacity in the short, medium, and long term.

SC managers planned the response by linking other SC areas, such as human resources, finance, and maintenance. The linking of the previously mentioned areas facilitated the management of the SCR because it allowed managers who were not from the SC to understand why it was necessary to hire, train, and certify personnel in the manufacturing and logistics processes. In this same line of thought, Eldem et al. (2022) [49] suggest that the best practices to deal with the impacts of COVID-19 on the SC involve the identification, planning of operations, management of human resources, and execution of activities in which various areas of the organization participate. Kiers et al. [67] expressed that linking the members of the SC to the response improves the reaction to disruptions of the SC. The participation of various areas of the SC is described by Klöckner et al. [22] as a collaborative response.

Our study showed that the evaluation of the SCR during the COVID-19 pandemic was carried out using indicators of the SC and each of its processes. Additionally, requests,

complaints, suggestions, and claims were used to evaluate the response. The evaluation of the response made it easier for SC managers to take the necessary steps to improve future SC responses. The issue of evaluation in the COVID-19 pandemic has been addressed from various aspects of the SC, such as resilience (Alajmi et al., 2021) [74], risk (Jomthanachai et al., 2022) [75], and challenges and problems among retailers (Ul Islam et al., 2022) [76]. However, no studies were found that examined the evaluation of the SCR during the COVID-19 pandemic. Therefore, we believe that this study is a guide for researchers, professionals, and consultants to evaluate the response that SCs give to a stimulus.

We identified that the SC has various options to respond to a stimulus. We believe that the importance of this finding lies in the fact that we are proposing to the community interested in SC a tool to plan the appropriate response. SC managers must study, based on the information that facilitates the detection and understanding of the stimulus, all the alternatives with which they can respond. The selection of the response alternative depends on the desired objectives that the SC intends to achieve. In the SCR literature, we did not find any study that shows various response alternatives to the same stimulus.

6. Conclusions

First, in relation to the discussion section, we can draw some conclusions. On one hand, the COVID-19 pandemic had a significant impact on SC operations, mostly requiring SC managers to respond to various stimuli such as changes in demand, absenteeism, loss of contact with customers, and new business opportunities. Furthermore, the response to these stimuli involved multiple processes, including product design and development, production, distribution, and information management. Thus, effective information management, in particular, played a crucial role in detecting and understanding the stimuli that affected SCs during the pandemic, facilitating the sharing of internal and external data among SC members. On the other hand, SC managers planned the response by making decisions in the short, medium, and long term, linking various SC areas such as human resources, finance, and maintenance, and evaluating the response using indicators of the SC and each of its processes.

Secondly, the study identified various options for responding to a stimulus, highlighting the importance of SC managers studying all alternatives based on the information that facilitates the detection and understanding of the stimulus. Overall, this study provides valuable insights into how companies in Santiago de Cali responded to the stimuli that affected their SC during COVID-19. These insights can provide a guide for researchers, professionals, and consultants interested in evaluating and improving SC responses to stimuli.

Despite these contributions, the present study is limited in that it only investigated SCs in manufacturing or service-providing companies. Accordingly, to further develop the SCR process and response paths, we suggest four lines of research methods: (1) replicate this case study in other SCs to reinforce the reliability and validity of the findings; (2) demonstrate the usability of the response path in other SCs; (3) apply multi-criteria techniques that facilitate the selection of the best path for SCR; and (4) determine criteria that facilitate the selection and evaluation of the best response path.

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