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Managing the supply chain during disruptions: Developing a framework for decision-making

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ABSTRACT

Business-to-business firms have traditionally encountered disruptions, but the scale of the COVID-19 pandemic was extraordinary as it interrupted global supply chains by causing unprecedented shocks to supply and demand. Firms experienced extraordinary pressure and struggled to minimize the immediate and long-term impact of supply chain disruptions. Applying chaos theory, this study employs a single-case method to understand the disruptions to the business-to-business oil and gas supply chain. We make three major contributions. First, we examine firm decision-making during significant disruptions. Second, we use chaos theory to better understand the decision-making process. Finally, we develop a framework to explicate the decision-making process and provide guidelines for decision-making during disruptions. Our findings provide theoretical insights and have important implications for practitioners addressing supply chain disruptions during crises.

1. Introduction

Given the dramatic increase in global connectivity between people and markets, the potential for global industry disruptions has increased (Sharma, Rangarajan, & Paesbrugghe, 2020). Recently, the world has faced crises of finance, security, and health that threaten connectivity and the globalized economy (Biggs, Biggs, Dakos, Scholes, & Schoon, 2011). The COVID-19 crisis is an unprecedented disruption; it has caused firms to shift to remote work, reduce new endeavors, and change communication patterns.

In post-World War II history, global economies have not witnessed a disruption comparable to the COVID-19 pandemic (König & Winkler, 2021). Disruption management is an important consideration in supply chain management (Bode & Wagner, 2015; Snyder et al., 2016), but the impact of the COVID-19 pandemic has been dramatic as it has disrupted global supply chains due to changing supply and customer demand, new government lockdown regulations, and extreme uncertainty (Haren & Simch-Levi, 2020; Pedersen & Ritter, 2020). Uncertainty affects the perception of context based on the collective experience of individuals who represent various stakeholders (Artinger, Petersen, Gigerenzer, & Weibler, 2015; Guercini & Medlin, 2020), and intra-country complexities exacerbated uncertainty. The scale and scope of the impact of the Covid-19 pandemic on supply chains require a reexamination of supply

chain performance during global disruptions.

The objective and contribution of this study are threefold. First, we examine the decision-making by firms during significant disruptions. COVID-19 is regarded as the most significant disruption since World War II in both its scope and duration. Second, we use chaos theory to better understand the decision-making process during an unprecedented crisis. We also aim to understand the strategic, tactical, and operational decision-making that firms can use to address supply chain disruptions in times of crisis. Finally, we develop a framework to understand the decision-making process and provide guidelines for decision-making during disruptions. Specifically, the framework can answer questions such as “What can we do?” and “How can we do it?” when faced with a crisis similar to COVID-19.

We conduct an in-depth investigation of a Fortune 500 oil and gas firm in India that faced significant disruptions to its supply chain due to COVID-19 and examine its successful response by applying chaos theory. The unprecedented combination of supply and demand shocks during COVID-19 dramatically affected the oil and gas supply chain, and the upstream, midstream, and downstream supply chains faced unprecedented challenges. Also, governmental decisions to implement lockdowns led to a dramatic reduction in oil and gas usage. The immediate impact on the supply chain was compounded by restricted logistics (movement of products) and the uneven demand for petroleum products

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across industries. We examine this context, investigate the disruption's antecedents, and collect data on decision-making, tactical plans to address the revenue and profit shortfall, and strategies to address potential threats.

The following section provides a brief overview of the literature on supply chain disruptions, followed by a literature review on chaos theory, including its stages. In the research methodology section, we present a single-case approach and discuss the data collection and analysis processes. This is followed by our findings and a discussion. We conclude with managerial implications, theoretical implications, the limitations of the study, and future research directions.

2. Literature review

2.1. Supply chain disruptions

Disruptions are “a low-probability, high-impact event that threatens the viability of the organization and is characterized by ambiguity of cause, effect, and means of resolution, as well as by a belief that decisions must be made swiftly” (Pearson & Clair, 1998, p. 60). Such crises have a low probability of occurrence, but they pose threats to the organization's survival, as the organization has limited time to successfully respond to the disruptions (Quarantelli, 1988; Ritter & Pedersen, 2020; Shrivastava, Mitroff, Miller, & Miclani, 1988). Disruptions in supply chains due to events such as tsunamis and financial crises have led researchers to study the resiliency of systems at both the firm and network levels (e.g., Bode, Wagner, Petersen, & Ellram, 2011; Kim, Chen, & Linderman, 2015). Key factors examined by this research include design, agility, and risk management culture (Christopher & Peck, 2004), collaborations in the supply chain (Datta & Christopher, 2011; Tang, 2006), the visibility and accuracy of information (Li et al., 2006; Sheffi & Rice Jr, 2005), the design and structure of supply chain networks (Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007; Kim, Realf, & Lee, 2011), and the self-assessment of all stakeholders and the role of reverse logistics channels (Pettit, Croxton, & Fiksel, 2019).

The literature on crisis management has predominantly focused on crisis failures detailing why and how organizational activities were affected by a crisis (Bierly III & Spender, 1995; Hittle & Leonard, 2011; Liska, Petrun, Sellnow, & Seeger, 2012; Ma & Xie, 2018; Pearson & Clair, 1998; Wilding, 1998). Key learnings from the research on crisis failures are that an incident in an isolated system can lead to system failure (Bierly III & Spender, 1995); failures have psychological, social-political, and technological-structural perspectives (Pearson & Clair, 1998); uncertainty and chaotic decision-making systems drive crises (Ma & Xie, 2018; Wilding, 1998); and, environmental aspects, bankruptcies, and loss of clients drive supply chain crisis (Richey, Natarajathinam, Capar, & Narayanan, 2009; Wilson, 2007).

There has been extensive learning from studying failures during crises. An under-researched area is understanding how firms successfully navigated crises and developing key learning for firms (Bundy, Pfarrer, Short, & Coombs, 2017). For example, Zhang, Bai, and Gu (2018) examined how contracts can be adjusted ex-post an exchange disruption to renew interfirm relationships to enhance our understanding of contractual exchanges. Our study extends our understanding of successfully addressing a major supply chain crisis.

2.2. The nature of the COVID-19 pandemic

The degree of disruption created by the COVID-19 pandemic is unprecedented since World War II. The pandemic dramatically impacted most countries and industries due to its global nature, its impact on economies due to shut-downs, and dramatic supply chain disruptions. The COVID-19 pandemic also severely affected traditional supply chain functions, such as warehousing, transportation, and labor (Araz, Choi, Olson, & Salman, 2020; Cankurtaran & Beverland, 2020), leading to declining industrial productivity and affecting labor markets (Brinca,

Duarte, & Faria-e-Castro, 2020; Harris, 2020). For example, the healthcare system was under tremendous stress, as the supply and demand of essential items, including ventilators, were unpredictable (Govindan, Mina, & Alavi, 2020; Ivanov & Dolgui, 2020).

The COVID-19 pandemic has highlighted challenges beyond our current understanding of supply chain disruptions. These challenges focus on maintaining inventories, backup supply, flexibility in production, and real-time monitoring systems (Ivanov & Dolgui, 2020). Cankurtaran and Beverland (2020) suggest that such disruptive situations are wicked problems whose understanding and solutions require unconventional thinking.

2.3. The nature of supply chain disruption research

Our literature review suggests that studies examining supply chain disruptions have focused on individual elements of supply chains but have not comprehensively examined the antecedents and consequences of significant disruptions (Bundy et al., 2017). Examples of focus areas include disaster management centers, infrastructural restoration, and transportation management (Dekle, Lavieri, Martin, Emir-Farinas, & Francis, 2005; Richey et al., 2009). There has been a call to enhance the theoretical perspective on supply chain disruptions and develop a framework for a deeper understanding (Bundy et al., 2017; Hittle & Leonard, 2011; Richey et al., 2009). The non-linear nature of major disruptions requires a fresh perspective, and we propose that chaos theory can be used to develop a deeper understanding of disruptions in the supply chain.

2.4. Gaps addressed by this study

This study addresses three gaps in the literature by developing a deeper understanding of disruptions in the supply chain. The first gap that we address is examining supply chain disruptions during an unprecedented period (COVID-19 pandemic). The second gap that we address is using a fresh perspective to better understand major disruptions. Earlier research has focused on the use of chaos theory to understand supply chain issues (e.g., Hwang & Xie, 2008; Ma & Xie, 2018; Shih, Hsu, Zhu, & Balasubramanian, 2012; Wilding, 1998), and we propose that chaos theory is ideal for studying unprecedented disruptions. Additionally, studies used chaos theory in qualitative and case-study-based research (e.g., McBride, 2005; Paraskevas, 2006; Speakman & Sharpley, 2012), guiding our study. Finally, there is also no comprehensive framework that examines and addresses major supply chain disruptions. Therefore, the third gap we address is the development of a comprehensive framework that seeks to enhance our understanding of major supply chain disruptions.

2.5. Review of chaos theory

We suggest that the impact of the COVID-19 pandemic can be uniquely understood from the perspective of chaos theory, which is the theoretical underpinning of this study. Chaos theory is ideal to understand strategy when long-term planning is very difficult; industries do not reach a stable equilibrium and solutions are complex; dramatic change can occur unexpectedly; short-term forecasts and predictions of patterns are made, albeit with inaccuracies; and adaptive guidelines are needed to cope with complexity (Levy, 1994). Conducting business through traditional processes may be impossible under chaotic conditions, and chaos theory can help understand disruptions and decision-making (Cartwright, 1991; Liska et al., 2012; Murphy, 1996; Sellnow, Seeger, & Ulmer, 2002), including in the supply chain (e.g., Levy, 1994; Stapleton, Hanna, & Ross, 2006). Researchers have applied chaos theory to analyze the impact of health-related crises, including the Mexican AH1N1 influenza outbreak's effect on destination marketing (Speakman & Sharpley, 2012) and the role of public administration in the Ebola virus context (Keyes & Benavides, 2018).

Table 1
Sample research that uses chaos theory in social science research.

Author(s)	Journal	Context	Major finding(s)
Levy (1994)	<i>Strategic Management Journal</i>	Dynamic evolution of industries and the complex interactions among industry actors in the context of the supply chain of a California-based computer company.	Understanding industries as complex systems, organizations can improve their decision-making process and find innovative solutions.
Thietart and Forgues (1995)	<i>Organization Science</i>	Organizational evolution in a chaotic and unstable condition.	In chaotic conditions, small changes in organizations can have significant consequences that are beyond prediction.
Wilding (1998)	<i>The International Journal of Logistics Management</i>	Uncertainty in the supply chain scenario.	The paper defines deterministic chaos and exhibits how supply chains can display some key attributes of chaotic systems.
Stapleton et al. (2006)	<i>Supply Chain Management: An International Journal</i>	The examination of forecasting, product design, and inventory management challenges faced by supply chain practitioners.	Chaos theory explains why unpredictability occurs within nonlinear systems and helps researchers develop better and more accurate models to understand supply chain management decisions.
Hwarng and Xie (2008)	<i>European Journal of Operational Research</i>	The examination of supply chain factors in complex dynamics and chaotic behaviors in a beer distribution model.	The adjustment parameters for inventory and supply line discrepancies need to be comparable to manage the quantum of chaos in the supply chain. The paper also suggests a phenomenon of chaos amplification as the bullwhip effect.
Speakman and Sharpley (2012)	<i>Journal of Destination Marketing & Management</i>	Destination marketing during the Mexican AH1N1 influenza crisis.	A chaos theory-based perspective on crisis management helps destinations respond to disruptions.
Liska et al. (2012)	<i>Southern Communication Journal</i>	Crisis communication during the Kingston Coal Ash Spill in 2008 at Tennessee.	A major element of chaos theory, bifurcation, revealed a significant failure in an organization's policies and procedures in dealing with the crisis.
Shih et al. (2012)	<i>Information & Management</i>	Examination of the importance of knowledge sharing in a downstream two-echelon supply chain.	Knowledge-sharing practices can be beneficial for downstream operations of a supply chain.
Hung and Tu (2014)	<i>Research Policy</i>	The technological progress of incremental, continuous change and radical, discontinuous change at the industrial level.	The paper examines the non-linearity of the processes of technological change, suggesting that under the conditions of chaotic dynamics, even an incremental change can generate disproportionate results leading to a new paradigm.
Hwarng and Yuan (2014)	<i>European Journal of Operational Research</i>	Application of chaos theory in a time series when the underlying structure is unknown.	The result exhibits chaos characterization aids in deterministic and

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Table 1 (continued)

Author(s)	Journal	Context	Major finding(s)
Ma and Xie (2018)	<i>Communications in Nonlinear Science and Numerical Simulation</i>	The examination of a supply chain system's stability comprising one supplier and one bounded rational retailer.	stochastic categories of demand. The paper finds that adaptive exponential smoothing does not affect system stability. In contrast, bounded rationality expectations render the system stability susceptible to the retailers' loss sensitivity and the decision adjustment speed.
Keyes and Benavides (2018)	<i>International Journal of Organization Theory & Behavior</i>	Public administration in the Ebola virus situation and coordinating learning for organizations to overcome situations of uncertainty.	The findings suggest that public entities were more likely to arrange organizational learning by coordinating professionals, access to quality information, and participation in daily communication in a crisis.
Yuan and Nishant (2019)	<i>Journal of Business Research</i>	Chaotic behavior shown by firms having growth driven by their R&D.	The findings indicate that the investment in R&D has more complex impacts on growth than on the firms, and decisions about such investments can cause fluctuations and erratic growth patterns in a nonlinear and complex business environment.

Chaos theory, originally proposed by Lorenz (1963), is contrary to the linear and causal perspectives and highlights the collapse of the balanced perspective (Tsoukas, 2005). With its genesis in physical science, chaos theory characterizes a nonlinear dynamic system that reconciles the elements of unpredictability (Cartwright, 1991). It is synonymous with the postmodern paradigm that questions deterministic positivism, which ignores most systems' complexity and diversity (Hassard & Parker, 1993; Levy, 1994). Chaos theory accentuates the basic tenets of unpredictability and suggests that nonlinear systems are difficult to model and forecast. Understanding how to address a crisis based on less severe disruptions may not be relevant in a major crisis such as COVID-19, leading to exploring a new paradigm (Kuhn, 1962). The pandemic's disruptions posed new tactical and strategic challenges for organizations, and chaos theory can help understand complex systems and managerial decision-making (Alshammari, Pavlovic, & Qaied, 2016).

Building on Laszlo's (1987) work on biological evolution, Goerner and Combs (1998) argued that chaotic conditions can self-organize into extremely complex structures that can mutate beyond common understanding. Researchers across different disciplines have used chaos theory to understand disruptive contexts, and Table 1 provides examples from the social sciences. The table finds that chaos theory is increasingly used to understand uncertain and dynamic environments as well as major disruptions.

In the context of supply chains, the actions taken by one supply chain member would be known and predictable. However, in a time of crisis, external conditions are uncontrollable and individual reactions to the crisis vary. This causes the supply chain to enter a state of chaos and leads to outcomes that follow an unpredictable and nonlinear path. Based on our previous discussions, chaos theory would be ideal for studying supply chain disruptions during unprecedented disruptions.

Chaos theory suggests that crises follow four stages: bifurcation, fractals, self-organization, and strange attractors (e.g., Freimuth, 2006;

Liska et al., 2012; Murphy, 1996; Sellnow et al., 2002). These stages are described in the subsections that follow.

2.5.1. Bifurcation

Bifurcation signifies a basic disturbance of the status quo. When an increasing number of variables with differing frequencies come together, the basic state of equilibrium changes. When the relative strength of the variables changes, the overall system moves from a state of equilibrium to a periodic and then a chaotic situation (Thietart & Forgues, 1995). The ever-increasing number of variables with different frequencies creates more complicated behavior, leading to apparent randomness or chaos. The shift indicates a fundamental change in the existing system wherein stakeholders are left in a complete state of disorientation.

Once in a chaotic condition, organizational actors can only predict short-term impacts due to changes in the underlying factors. Even a small change at this stage initiates a multiplier effect that causes exponential instability in the system. This is described as a state where "previous assumptions, methods, patterns, and relationships can no longer function" (Seeger, Sellnow, & Ulmer, 2003, p. 31), and it leads to a reexamination of many assumptions used to address the issues. The bifurcation state warrants a salvage plan from organizational actors who, themselves, do not understand such disruptions.

2.5.2. Fractals

Fractals help to identify the emerging pattern that follows the state of bifurcation. They act as a source of information in a state of crisis. At the fractal stage, understanding and gathering evidence about a challenging situation is very important, as it assists in addressing failures that arise during bifurcation. The fractal stage requires truthful and accurate data, as their absence may lead to confusion at a later stage (Sellnow et al., 2002). The stage involves organizational actors who describe and measure the impact of the complex system. These actors are required to

implement a holistic approach to decipher the larger picture.

It is important to note that the typically readily available cues to understand disruptions may not exist (Liska et al., 2012), and executives may use misleading information or proxy heuristics to make incorrect inferences (Guercini, 2019; Murphy, 1996). The key to attaining success in this phase is identifying the stage and quickly understanding and responding to the disruption. Research suggests that it is better to focus on information and communication flows and make deliberate decisions (Speakman & Sharpley, 2012).

2.5.3. Self-organization

Self-organization is a key stage in chaos theory. It allows the chaotic system to reorient with the help of communicative structures and relevant procedures (Sellnow et al., 2002). A new structural form emerges to restore the overall system through complexity, new structures, processes, and hierarchies. Although the relationship between order and chaos is dynamic, inherently complex systems exert a pull towards each other to achieve balance. As this stage is quasi-evolutionary, organizations may make short-term tactical decisions that lead to strategic decision-making with a long-term perspective (Kauffman, 1995).

In the context of a business crisis, firms must adapt by changing their structure, processes, and routines (Horsley, 2008). The concept of self-organization is critical for recognizing and managing crises. Wheatley (2007) identified three conditions for self-organization to excel: identity, information, and relationships. In this phase, firms rely on a combination of tactical and operational tasks to repair the damage caused by the disruption.

2.5.4. Strange attractors

The strange attractors, a central idea of chaos theory, proposes that order will emerge from the chaotic state (Thietart & Forgues, 1995). Attractors are the basic values and principles that unite individuals in attaining their common goals. Managers act as strange attractors by developing vision and facilitating appropriate communication structures and cooperative relationships and by creating conducive conditions for new orders to prevail (Speakman & Sharpley, 2012; Zahra & Ryan, 2007). Firms need to quickly develop policies to restore the confidence of stakeholders, such as customers and employees (Beirman, 2003).

Wheatley (2007) suggested that the attractors' ability to maintain the underlying thread among organizational members lies in communicating the correct meaning or action through fractals. To ensure that the underlying values are established, a deployment strategy is required to enhance the community and avoid misinterpretation.

3. Research methodology

3.1. Research strategy

We used a single-case-study approach as the research strategy in this study. According to Yin (2014), a case study approach is the preferred research method when exploring a real-life phenomenon in which the boundary between the context and phenomenon is blurred. A single-case research method is used, which is relevant for investigating a rare and extreme context (e.g., Easton, 2010; Eisenhardt & Graebner, 2007; Järvinen & Taiminen, 2016; Miles, Huberman, & Saldaña, 2013). In this study, “case” refers to the supply chain disruption caused by the COVID-19 pandemic.

3.2. Selection of the case company

As suggested by Järvinen and Taiminen (2016), we followed an “extreme case sampling” approach. This approach is akin to purposive sampling, wherein the selected cases outline notable success. We chose a leading Indian oil and gas Fortune 500 firm that is well regarded for implementing best practices in handling supply chain disruptions and

Table 2

Source of the primary data – Interview of the respondents. Description of respondents.

Title and role/responsibility	Representative of	Interview duration
General Manager: Responsible for overall supply chain planning and strategy at a state level	Marketing department	32 Minutes
Deputy General Manager-1: Responsible for overall supply chain planning and monitoring at a state level	Marketing department	26 Minutes
Deputy General Manager-2: Responsible for overall supply chain planning and monitoring at a state level	Marketing department	25 Minutes
Chief Manager: Responsible for supply chain planning, monitoring, and customer contact at a division level	Marketing department	22 Minutes
Senior Manager: Responsible for ensuring the smooth supply of products to customers. The first line of contact for customers.	Marketing department	38 Minutes
Chief Operations Manager: Responsible for operations –ensures planning and supply of products to customers.	Operations department	35 Minutes
Senior Operations Manager: Responsible for day-to-day operations–ensures timely supply of products to customers.	Operations department	30 Minutes
Purchase Manager (Pharmaceutical firm): Point of contact for the marketing department of the case company. Purchases petroleum products from the case company.	Customer–pharmaceutical firm	18 Minutes
Purchase Manager (Construction firm): Point of contact for the marketing department of the case company. Purchases petroleum products from the case company.	Customer–construction firm	16 Minutes
Supply chain partner of the case company: A key logistic partner involved in the transportation of petroleum products from the case company to the customers	Supply chain partner–transportation	20 Minutes
Supply chain consultant (Mentioned as “Expert”): An expert on various aspects of supply chain	Supply chain consulting firm	35 Minutes

Source of secondary data: Media coverage of the oil & gas industry and the case company on the topic of research. Contents from the social media pages of the case company on the topic of research. Website of the case company.

successfully addressing the COVID-19 disruption. The firm's net profit increased in the second quarter of the crisis (July–September 2020) compared to the previous year, and its gross refining margin increased by 17% during the first two quarters of the crisis (April–September 2020) compared to the previous year. The case company's selection was based on the impact of the disruption on the supply chain, the firm's response, and our access to key informants. Hereafter, “case company” refers to the company that witnessed the supply chain disruptions and about which this study was conducted.

Table 3
Steps in data analysis.

Stage	Details
<i>Comprehensive preparation for the coding process</i>	
1	Reading the interview data. We transcribed the interviews verbatim and read them carefully to gain a preliminary understanding of their content. During the process, important phrases were underlined, and the details needed to understand the analysis at a later stage were written down. We also made observational notes on all other secondary information, such as media coverage and social media content.
2	Understanding the interview data. Following de Casterlé et al. (2012), we proceeded with this stage after conducting a few interviews. We then began articulating our understanding of the content.
3	Identification and evolution of concepts. In this stage, we began to filter important data and aggregate them into concepts. This stage was critical, as it helped us arrive at a more abstract analysis based on the interview narratives. As shown in Table 4, this stage highlighted the relevant concepts that aided our understanding of the phenomena and addressed the research objective.
4	Verification of concepts. In this stage, we reexamined interviews with the highlighted concepts to identify additional meaningful concepts and connect the conceptual scheme with the interview data. This stage was also the beginning of the iterative process involving forward and backward movement in examining the data.
5	Comparison of concepts. We reexamined the conceptual schemes by comparing them with the data emerging from the interviews. Any themes or concepts present in the new interviews were reviewed to determine if they were similar to those in previous interviews and were refined as necessary.
<i>Coding and analysis</i>	
6	Listing of concepts. We drew up a list of concepts representing different ideas. These concepts were reviewed for any overlap or ambiguity; conflicts, if any, were resolved through mutual consensus.
7	Coding of concepts. Following de Casterlé et al. (2012), all interviews were reread with the list of concepts. The concepts aided in identifying important paragraphs and quotes in the interviews, which were highlighted. The coding ensured that the concepts encompassed all important ideas and implicit messages. This stage was a refinement of the previous stage, which focused on listing concepts.
8	Analysis, description, and aggregation of concepts. We analyzed and carefully explored the coding process, examining all relevant information across all the interviews. This step allowed us to examine whether concepts needed to be aggregated or split into sub-concepts. As a result, the concepts were further refined and described based on the available interview data (see Table 4).
9	Shaping the structure. We integrated the concepts by structuring them into a meaningful conceptual framework to address the research objective. In the context of this study, we structured the findings using the 4-C framework of crisis management under the tenets of chaos theory.
10	Description of the findings. Using the conceptual framework and analysis of the concepts, we systematically delineated the findings to achieve the research objective. Following de Casterlé et al. (2012), we added notable quotes to explain the concepts and the framework.

3.3. Data collection

We collected the primary data by conducting semi-structured telephone interviews. Following Eisenhardt and Graebner (2007), we interviewed knowledgeable key informants in the case company who held senior positions and were involved in various supply chain planning and management stages during the crisis. We used snowball sampling to identify key informants and then interviewed them (Järvinen & Taiminen, 2016; Salganik & Heckathorn, 2004). This process resulted in seven interviews with informants. Among them, five belonged to the marketing department, and two were from the operations department. The marketing and operations departments are responsible for supply chain elements, including the receipt, storage, and dispatch, and delivery of the products. The marketing department regularly interacts with customers and defines the supply chain parameters.

The interview process included open-ended questions centered on the subject of the study. The interview questions were based on the following: recognition of the antecedents of the supply chain disruption; gathering information on the extent of the damage to various links of the supply chain; the impact of the crisis on the businesses of the company's

customers; the role of prior relationships with the customers; the short-term response by the company to repair the damage; the company's plan to manage the potential threat to the supply chain in the immediate future; and the impact of the crisis on the physical and psychological well-being of the people involved in operations and the supply chain.

Using data from multiple sources helped us in triangulation, which enhanced the study's reliability and the saturation of the data (Dubois & Gibbert, 2010; Fusch, Fusch, & Ness, 2018; Stavros & Westberg, 2009). Apart from interviews with key informants, we also gathered secondary data from media coverage of the oil and gas industry and the case company, the social media pages of the case company, and the company's website to understand its disruption management practices during the COVID-19 pandemic. The secondary data allowed for a deeper understanding of the actions taken by the firm.

To further substantiate the informants' narratives, we also interviewed two customers and one supply chain partner of the case company. One of the customers belonged to the pharmaceutical industry and the other to the construction industry. We also interviewed a supply chain consultant (referred to as the "expert") who specializes in supply chain issues and has consulted with different firms on supply chain management during the crisis. The interview with the consultant also helped us evaluate the external validity of the results. The details of the primary and secondary data collection are summarized in Table 2.

3.4. Data analysis

The data analysis process started with a review of the entire dataset by the authors and two independent researchers unfamiliar with the study to enhance confidence in the coding scheme (Harris, 2001; Miles & Huberman, 1994; Myhal, Kang, & Murphy, 2008). Differences among coders, if any, were resolved through mutual discussion until an agreement was achieved (Miles & Huberman, 1994). The role of the independent researchers was limited to the check-coding process; the rest of the analysis was done by the authors themselves, as they were familiar with the context and the theory used in the study.

Following de Casterlé, Gastmans, Bryon, and Denier (2012), the data analysis is described in Table 3 and exemplars are provided in Table 4. First, we conducted a preliminary but comprehensive preparation of the coding process, including reading and understanding the data, followed by identification and evolution, verification, and comparison of the concepts. Second, we focused on the coding process and analysis by listing, coding, and analyzing concepts, designing the structure, and describing the findings. The process matches the thematic analysis suggested by Miles et al. (2013), which includes data condensing, data display, and drawing inferences. Since data collection and analysis cannot be completely segregated, the process was iterative and involved delving deeper into the data and moving back and forth between various stages (de Casterlé et al., 2012; Froggatt, 2001). The analysis was continued until data saturation was reached. The details of the process are described in Table 3. Using a part of the overall data, Table 4 depicts an illustrative example of the different stages of the coding and analysis process relating to chaos theory in the context of the current study.

3.5. Evaluation of study quality

As suggested by Yin (2014), we considered three criteria—construct validity, external validity, and reliability—to ascertain the quality of the study. Construct validity indicates the "extent to which a study investigates what it claims to investigate" (Dubois & Gibbert, 2010, p. 132). We used multiple information sources in the present study, including interviews with case company informants, customers, and an expert. We also referred to secondary sources, including media coverage and social media content, to triangulate the data by examining the research phenomenon from various perspectives (e.g., Beverland & Lindgreen, 2010; Järvinen & Taiminen, 2016; Piekkari, Plakoyiannaki, & Welch, 2010). Following Yin's (2014) approach, we provided

Table 4
Exemplars of the coding and analysis process in the context of the chaos theory.

Stages of chaos theory ⇨		Bifurcation	Fractals	Self-organization	Strange Attractors
Tenets of the process model ⇨		Scrutinizing the Cause of the crisis	Scrutinizing the Consequences of the crisis	Managing the crisis through Coping	Managing the crisis through Caution
Comprehensive preparation of the coding process	Stage 1	Reading the transcribed text of the interviews and secondary data			
	Stage 2	<p>Reading the interview data</p> <p>“Well...this goes beyond our normal understanding. I can't believe what I am watching currently [sic]. None of us ever dreamed of something like this. I don't think we can conduct business as usual in this situation.”</p> <p>“We are facing difficulties in cross-country transportation due to a lot of confusion. Although we are transporting an essential product, many issues arise when we are on the way...yes, our crewmembers are scared of the exposure to the disease...no one knows what may happen.”</p> <p>“We did not have accurate information, at least at the start of [the] pandemic. The lack of knowledge about the nature of [the] disease and inadequate information were reasons behind holding up some decision-making at our end.”</p>	<p>“Our long-term relation with some of our key customers helped us in understanding the real crisis [that the] coronavirus pandemic could create at their end...our customers faced an emergent issue of shortage of products needed to run their operations.”</p> <p>“Our firm invested in information technology-enabled infrastructure, such as enterprise resource planning, that could even track the status of stocks [sic] at our customers' end in [sic] real-time basis.”</p> <p>“Our petroleum product supply chain is highly dependent on our logistic[s] partners who provide tank trucks, and their crew members are at the core of timely delivery of the product in the right quality and quantity. I found them also in a state of confusion, and, at the same time, they are worried about health issues, too.”</p> <p>“We fear that continuation of the current condition will affect our supply chain arrangements”</p>	<p>“We have many hierarchical levels in our organization structure, and everyone works as per the delegation of authority... Many of us didn't need to look towards our bosses as we were delegated with right authority to take action in this time of crisis.”</p> <p>“We have set up command centers in our offices which keeps a tab on information provided by the government agencies. We also pass on useful information to our customers and our logistic partners.”</p> <p>“It was important to gather right information about coronavirus disease as our logistic partners were worried...”</p> <p>“For many of our valuable customers, we shifted the base of our supply location by identifying alternate sources to provide uninterrupted supplies.”</p>	<p>“We are continuously watching the government guidelines and understanding their meaning for ours [sic] as well as for our customers' business[es]. We are contemplating when there can be a conducive environment for safe movement of our supply chain partners and what infrastructure we need to put in place.”</p> <p>“We are dedicating appropriate resources to fight with any potential crisis emanating in future [sic]. We are also in the process of identifying permanent alternative sources that could be activated in the time of crisis for serving our customers”</p> <p>“It should be augmented with regular feedback, and they shall also be prepared to do course corrections if results are not as anticipated.”</p> <p>“The company took swift steps to provide insurance cover to its 'corona-warriors' working on the front lines of its business”</p> <p>“focus on 'technological immersion' has proven to be a promising enabler in the 'new normal”</p> <p>“...empowering customers as well as channel partners with digitally-aided logistics, supply and distribution network.</p> <p>“They need to really act fast and their inherent properties, like the structure of the organization, shall be responsive enough to act quickly”</p>
	Stage 3	<p>Identification / Evolution of concepts</p> <p>Identifying the likely concepts from the text data as depicted above using highlighted text.</p>	<p>Identifying the likely concepts from the text data as depicted above using highlighted text.</p>	<p>Identifying the likely concepts from the text data as depicted above using highlighted text.</p>	<p>Identifying the likely concepts from the text data as depicted above using highlighted text.</p>
	Stage 4	<p>Verification of concepts</p> <p>An iterative process that involved re-examining interviews with highlighted concepts.</p>	<p>An iterative process that involved re-examining interviews with highlighted concepts.</p>	<p>An iterative process that involved re-examining interviews with highlighted concepts.</p>	<p>An iterative process that involved re-examining interviews with highlighted concepts.</p>
	Stage 5	<p>Comparison of concepts</p> <p>This stage involved re-examination of the conceptual schemes by comparing them with the data emerging from the interviews.</p>	<p>This stage involved re-examination of the conceptual schemes by comparing them with the data emerging from the interviews.</p>	<p>This stage involved re-examination of the conceptual schemes by comparing them with the data emerging from the interviews.</p>	<p>This stage involved re-examination of the conceptual schemes by comparing them with the data emerging from the interviews.</p>
Coding and analysis	Stage 6	<p>Listing of concepts</p> <p>List of concepts representing different ideas -</p> <ul style="list-style-type: none"> • Unpredictable situation • Problem beyond thinking • No business as usual • Inadequate information • Lack of knowledge about the disease • Scared of the exposure to the disease 	<p>List of concepts representing different ideas -</p> <ul style="list-style-type: none"> • Pressure on supply chain infrastructure • Inventory problem at customer • Shortage of products • Issue with timely delivery • Operational issues with customers • Dependence on supply chain partners • State of confusion with stakeholders • Worry related to health issues 	<p>List of concepts representing different ideas -</p> <ul style="list-style-type: none"> • Hierarchical levels in the organization structure • Delegation of authority in the organization • Authority for decision-making • Setting of command centers • Passing of information to customers and logistic partners • Gathering of right information • Information management • Alternate source of supply • Uninterrupted supply 	<p>List of concepts representing different ideas -</p> <ul style="list-style-type: none"> • Overview of government guidelines • Scanning of the environment • Resource deployment for future potential crisis • Permanent alternative sources • Evaluation of permanent alternative sources • Regular feedback mechanism • Course correction for unanticipated result • Planning for health hazard • Responsive organizational structure • Need to act fast • Digital intervention in logistic and supply chain network • Empowering customers and channel partners
	Stage 7	<p>Coding of concepts</p> <p>Selection of concepts encompassing all important ideas and inherent messages -</p> <ul style="list-style-type: none"> • Unpredictability of the crisis (sub-concept: problem beyond thinking) • Conflicting and non-coherent information dissemination • Health and psychological problems 	<p>Selection of concepts encompassing all important ideas and inherent messages -</p> <ul style="list-style-type: none"> • Strain in supply chain infrastructure • Inventory related problems (sub-concepts: shortage of products) • Resulting internal and external (at customers' end) operational issues • Confusion among different stakeholders (sub-concept: worry about health issues) 	<p>Selection of concepts encompassing all important ideas and inherent messages -</p> <ul style="list-style-type: none"> • Organizational structure • Delegation of authority (Sub-concepts: authority for decision-making) • Information dissemination (Sub-concepts: information management) • Business continuity plan (Sub-concepts: uninterrupted supply, alternate source of supply) 	<p>Selection of concepts encompassing all important ideas and inherent messages -</p> <ul style="list-style-type: none"> • Examination of macro / micro-environment (sub-concept: scanning of the environment) • Emergency planning including planning for health hazard • Formulation and evaluation of strategic alternatives • Implementation of responsive organizational structure (sub-concept: Need to act fast) • Resource mobilization and management • Understanding and collaborating with stakeholders (sub-concept: empowering customers and channel partners)
	Stage 8	<p>Analysis, description, and aggregation of the concepts</p> <p>At this stage, we combined the similar concepts/sub-concepts into an aggregated concept. Based on the analysis, the aggregated concept is “Recognizing the antecedents of crisis”</p>	<p>At this stage, we combined the similar concepts/sub-concepts into an aggregated concept. Based on the analysis, the aggregated concept is “Recognizing the consequences”</p>	<p>At this stage, we combined the similar concepts/sub-concepts into an aggregated concept. Based on the analysis, the aggregated concept is “Measures taken to respond (to a crisis that has already occurred)”</p>	<p>At this stage, we combined the similar concepts/sub-concepts into an aggregated concept. Based on the analysis, the aggregated concept is “Measures taken to prevent/minimize (the impact of potential crisis)”</p>
	Stage 9	<p>Shaping of the structure</p> <p>At this stage, we integrated the concepts by structuring them into a meaningful conceptual framework to answer the research objective. In the context of this study, we structured the findings using the 4-C framework of crisis management under the tenets of chaos theory. Additionally, for the strange attractors part, we also aligned the concepts under the realm of the structure of strategic decision-making that includes strategic analysis, strategic direction and choice, strategy implementation and control, and strategic evaluation and feedback. Similarly, the self-organization part aligns the concepts using identity, information, and relational efforts as part of tactical decision-making. The framework based on the overall analysis of data is presented in Figure 1.</p>			<ul style="list-style-type: none"> • Continuous monitoring & evaluation of strategies (sub-concept: regular feedback on the actions taken) • Learning for course correction & reimplementation of modified strategy
Stage 10	<p>Description of the findings</p> <p>Using the conceptual framework and analysis of the concepts, we systematically delineate the findings to answer the research objective. We discuss and describe the framework in section 4.3 under the heading 'the crisis management framework'.</p>				

evidence demonstrating the study's progression from its objective to its findings. We also discussed the findings with the case company informants to verify the validity of the results. Finally, following Guba and Lincoln (1981), we conducted a member check to ensure the quality of the analysis.

External validity is described as whether there is a “domain to which a study's findings can be generalized” (Yin, 2014, p. 46). We used chaos theory and a process model (Shrivastava, 1993) to frame our findings. The respondents' responses were largely in support of the framework. Transparent and systematic data collection and analysis enhanced the study's reliability (Batt, 2012; Dubois & Gibbert, 2010). Additionally, to ensure reliability and validity, we also followed the verification strategies suggested by Morse, Barrett, Mayan, Olson, and Spiers (2002). We ensured “methodological coherence” by establishing congruence between the research objective and selecting the appropriate methodology. In our study, the single-case research methodology helps achieve the research objective of understanding disruptions in the supply chain. As suggested, we also checked the “appropriateness of the sample.” This methodology is mentioned in detail in Section 3.3 on data collection. The other aspects, like “collecting and analyzing data concurrently,” “thinking theoretically,” and “theory development,” were followed extensively in our data analysis process, which is also reflected in Table 4.

4. Findings and discussion

Based on the analysis of all the available data, we present our findings in the subsequent subsections. The findings also form the basis of a framework that can be used to understand the entire crisis scenario, from awareness to developing a management approach (Fig. 1). To provide a structure for our findings, we utilized the 4-C framework of crisis management proposed by Shrivastava (1993), also referred to as the process model. This model consists of *cause*, signifying the event that triggered the crisis, including the antecedent conditions; *consequences*, signifying the immediate and long-term impacts; *coping*, describing measures taken to respond to a crisis that has already occurred; and *caution*, indicating measures taken to prevent or minimize the impact of a potential crisis.

The overall findings are structured using elements of the 4-C framework of crisis management with the theoretical underpinning of chaos theory, which comprises four factors: bifurcation, fractals, self-organization, and strange attractors. The framework was developed from a process model proposed by Shrivastava (1993), but the attributes of the framework have been driven by our analysis. We discuss each element of the findings in the subsequent sections.

4.1. Scrutinizing the causes and consequences of the crisis

We focused on gathering the firm's understanding of the disruption and its consequences. The findings were based on responses to the interview questions. The details are described in the following section.

4.1.1. Bifurcation

The oil and gas supply chain system and buyer-seller relationships were severely affected by the COVID-19 pandemic. The entire industry was in shock, and the pandemic left stakeholders confused. One of the senior managers who was interviewed for this study made a similar observation:

Well...this goes beyond our normal understanding. I can't believe what I am watching currently [sic]. None of us ever dreamed of something like this. I don't think we can conduct business as usual in this situation. (Deputy General Manager-1).

The crisis created unpredictability for the oil and gas supply chain, as demand declined sharply when many customers of the case company

suspended their operations. One of the managers made the following observation:

Many customers' businesses were also closed temporarily during pandemic...so that was also a reason of concern as where to send our products. We cannot shut down production from our refinery, a minimum production level will be maintained always. (Deputy General Manager-2).

The firm in the case study supplies petroleum products to different industries, and it was unable to understand the demands of its customers, at least in the immediate term. These issues were amplified by the important role of the case company's logistics partners, who faced initial curbs in cross-country transportation due to the lockdowns imposed by central or state governments and had concerns about their people being exposed to COVID-19. A supply chain partner expressed these feelings:

We are facing difficulties in cross-country transportation due to a lot of confusion. Although we are transporting an essential product, many issues arise when we are on the way...yes, our crewmembers are scared of the exposure to the disease...no one knows what may happen. (supply chain partner).

A similar concern was expressed by one of the managers of the case company:

Our supply chain partners, their crew are highly concerned about saving their life first from covid. They travel long distance and if everything is closed across the country, where will they get food...where will they get other necessary things. (Deputy General Manager-2).

The overall ambiguity, confusion, and lack of understanding of the situation were visible in the narratives of one of the case company informants:

We have seen many ups and downs, but that did not ever hinder our efforts in serving our customers. Although cultivated over long time and great efforts [sic], we really faced a tough time in managing our relationship with our key customers. It was a time when we were uncertain about supplying and serving our customers. (Chief Manager).

The interviews also revealed that the way information about the disease was disseminated created confusion among different stakeholders, leading to constrained decision-making. One of the customers interviewed for this study mentioned the following:

We did not have accurate information, at least at the start of [the] pandemic. The lack of knowledge about the nature of [the] disease and inadequate information were reasons behind holding up some decision-making at our end. (Purchase Manager, construction firm).

One of the managers of the case company also voiced a similar narrative:

Towards the start, neither we nor our customers had clarity about what is going on...customers did not know what to operate what not to operate...information management at their end was also not clear. (General Manager).

Overall, the magnitude and unpredictability of the COVID-19 crisis led to supply chain disruptions, following the principles of bifurcation.

4.1.2. Fractals

Respondents were asked about their understanding of the situation and their initial reaction to the disruption due to the COVID-19 crisis. We gathered information on the extent of the damage to various links in the supply chain. Based on the analysis of interviews and other sources, we first examined how the company observed the pattern of the crisis and evaluated the company's initial actions. During our interviews, one

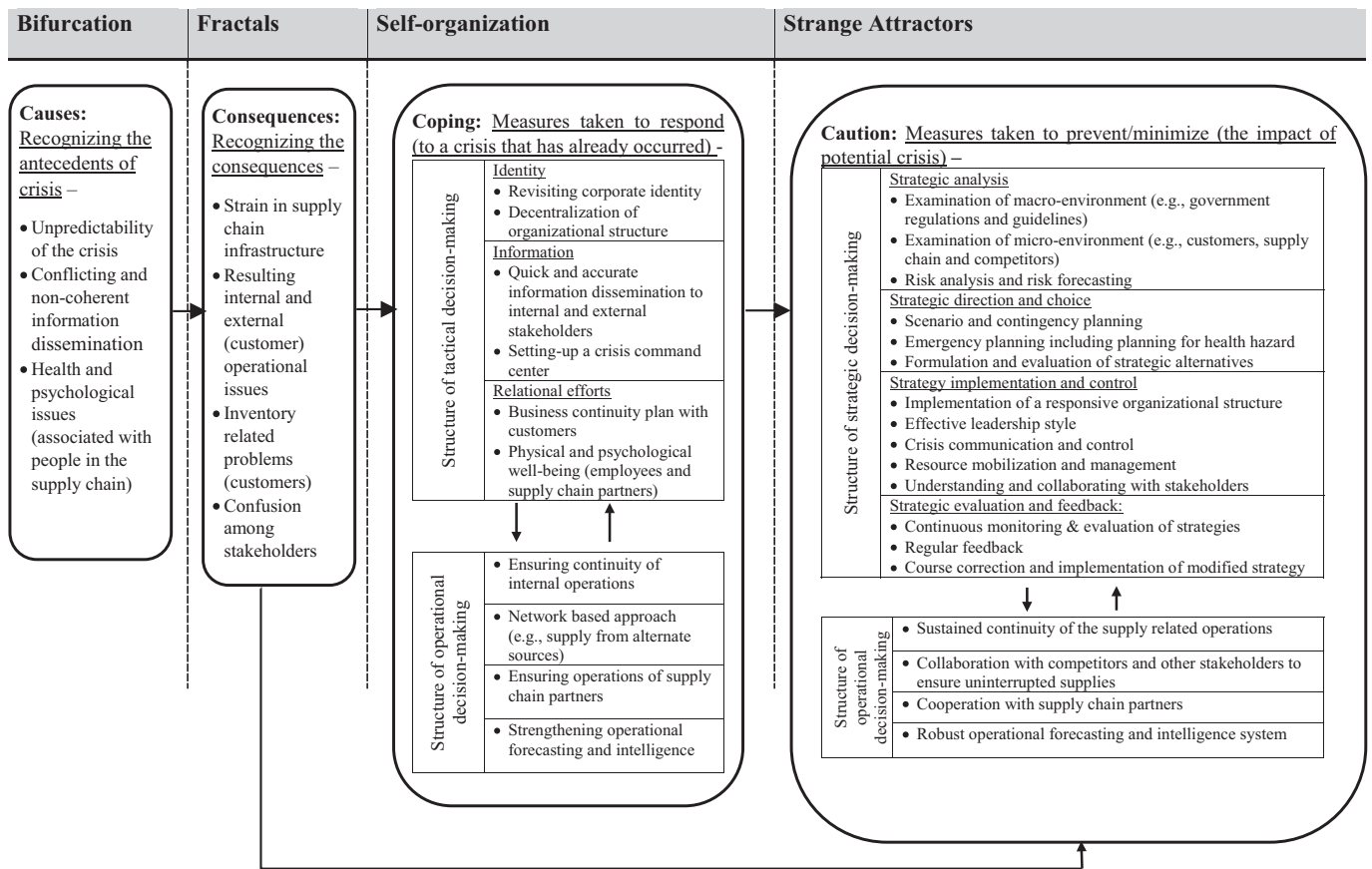


Fig. 1. Framework.

of the managers stated the following:

Our long-term relation with some of our key customers helped us in understanding the real crisis [that the] coronavirus pandemic could create at their end...our customers faced an emergent issue of shortage of products needed to run their operations. (Deputy General Manager-2).

The case company quickly assessed customers' issues because of its investment in relationships and related infrastructure. One respondent described this investment as follows:

Our firm invested in information technology-enabled infrastructure, such as enterprise resource planning and automation, that could even track the status of stocks [sic] at our customers' end in [sic] real-time basis. (Senior Operation Manager).

With the disruption of the supply chain, customers expected the company to respond rapidly. As one customer stated, one immediate solution was the timely delivery of critical products:

We told the company to supply at least some minimum quantity of products so that we could run our operations. We had shared a valued relationship, and we expect[ed] the company to help us in this time of crisis. (Purchase Manager, construction firm).

Another customer of the case company also raised concerns about the impact on their supply chain if the lockdown condition continued for a longer duration, as described by its purchase manager:

We need many raw materials as ingredients for manufacturing the products at our factory and we do the centralized purchasing...like many solvents, fuel...other products. We fear that continuation of the current condition will affect our supply chain arrangements. (Purchase Manager, pharmaceutical firm).

The case company quickly realized that to help its customers, it needed to support its logistics partners, who were the backbone of the supply chain. One of the managers stated the following:

Our petroleum product supply chain is highly dependent on our logistic[s] partners who provide tank trucks, and their crew members are at the core of timely delivery of the product in the right quality and quantity. I found them also in a state of confusion, and, at the same time, they are worried about health issues, too. (Deputy General Manager-1).

There were also health-related concerns at the case company's supply location, creating pressure on the supply chain infrastructure. A senior executive responsible for supplying products to customers explained this challenge:

Although we are trying our best, our operating staff and other human power involved in [the] supply[ing] of products to our customers are also in a state of anxiety due to uncertainty and related health issue[s] due to coronavirus spread. (Senior Operations Manager).

Through our secondary sources, we also observed discussion of the stress on the oil and gas supply chain in the context of COVID-19:

The pandemic risk can and has not only triggered and amplified the already recognized risks such as economic risk, financial risk, security risk, but also created new risks such as stressed supply chains, high percentage of workforce exposed to risk. (Secondary source: IIFL Securities, 2020).

The pandemic also affected the internal supply chain arrangements of the case company, which was evident in the narratives of one of the managers:

At the start of pandemic, we faced some issues due to overall confusion about how to work at our locations in view of fear of exposure to coronavirus and also due to hindrances faced in moving tank trucks to different supply locations from our large oil terminals. (Chief Manager).

Based on information from interviews and secondary sources, we found that the crisis interrupted supply chains and caused confusion among stakeholders, including logistics partners. A significant reason for the company's quick understanding of the crisis was its preparedness for such situations and its balanced approach towards risk mapping.

4.2. Managing the crisis through coping and caution

Organizational crisis management is a systematic attempt by organizational members in partnership with external stakeholders to avert crises or effectively manage those that occur (Pearson & Clair, 1998). In the next sections, we focus on organizational crisis management to describe the steps taken by the company to manage the COVID-19 crisis, including tactical, strategic, and operational decision-making.

4.2.1. Self-organization

Self-organization is the process of recognizing and coping with the unprecedented changes that a crisis causes. It is synonymous with a company's short-term response to disruption. In the present study, the content of the interviews and data from other sources revealed the important role of the firm's tactical and operational decision-making. Three conditions are necessary for self-organization to excel: identity, information, and relationships (Wheatley, 2007). We present our findings on managing the crisis from this perspective.

In a crisis, organizational leaders often need to revise or reinvent their organization's identity to respond to the altered dynamics (Hearit, 2006). Leaders may also reference their past encounters with a crisis to handle current challenges. One of the respondents acknowledged this:

We have many hierarchical levels in our organization[al] structure, and everyone works as per the delegation of authority...I think our top management is visionary enough to create a quick decision-making process to handle critical supplies for our customers. Many of us didn't need to look towards our bosses, as we were delegated with [the] right authority to take action in this time of crisis. (Chief Manager).

The case company created a decentralized structure that facilitated rapid decision-making. A key executive of the case company told us:

We have set up command centers in our offices, which keep [sic] a tab on information provided by the government agencies. We also pass on useful information to our customers and our logistic[s] partners. (Deputy General Manager-1).

The company also focused on managing information about the pandemic and the availability of products for its customers:

It was important to gather [the] right information about [the] coronavirus disease, as our logistic[s] partners were worried...things were very uncertain, and the crew members were really worried about their exposure to the disease. We also have many small customers who needed our support regarding exact information about supply of critical products to maintain their operations. (Senior Manager).

Another important component of self-organization, relational effort, facilitates creating and forming organizational identity, which further benefits stakeholders. An important pharmaceutical industry customer of the case company validated our earlier observations:

Medicines being the essential necessity, we were required to run our operations despite all problems in the lockdown condition...our established relationship with the company helped us in continuing our business operations. They ensured the supply of critical products despite all problems. (Purchase Manager, pharmaceutical firm).

One of the essential aspects of the relational effort was to assist people involved in business continuity efforts, which included taking care of the physical and psychological well-being of employees and supply chain partners. One senior executive of the case company described this initiative:

We got the medical insurance done for all crew members of our logistic[s] partners involved in transportation of the products. We also distributed necessary products for their hygiene, like sanitizer, masks, and hand gloves. The same was done for our employees, too, who were handling supply operations at our end. (Chief Operations Manager).

These efforts were also discussed in the media and on social media platforms. One respondent from the case company stated the following:

The crew members need to travel to [sic] long distance to supply products to our customers...as it was difficult to get food on such long hauls in lockdown condition, we also facilitated [sic] them by providing food packets for en-route consumption. We also arranged food for them in their long haul through our other business partners. (Chief Manager).

This tactical facilitation helped preserve the physical and psychological well-being of the people involved in the supply chain and smoothed operational decision-making. Additionally, valuing past relationships with key customers, a senior executive shared some innovative approaches they used:

In lockdown, in a few instances, we faced some challenges due to restricted movement of our employees and logistic[s] partners...For many of our valuable customers, we shifted the base of our supply location by identifying alternate sources to provide uninterrupted supplies. (Deputy General Manager-2).

A case company senior executive described an incident that reflects collaborative buyer-supplier relationships:

In this time of crisis, we parked the excess products beyond our capacity in the storage tanks of our key customers. This was a unique decision never taken before...but you know unique times need unique approaches. All this was possible as we cultivated great relationships with our customers. (General Manager).

We also observed (through secondary sources) that the case company invested heavily in forecasting and intelligence gathering, which strengthened its operational decision-making during the crisis. Overall, tactical and operational decision-making allowed the company to recover to a great extent from the disruptions in its supply chain.

4.2.2. Strange attractors

This section focuses on understanding the measures used to prevent or minimize the impact of a potential crisis. Strange attractors aim to build and enhance resilience in the entire system to manage a future crisis successfully and develop strategic and operational decision-making structures to reduce the potential impact of a future crisis. Strategic decision-making is preceded by strategic planning and management with four main elements: strategic analysis, strategic direction and choice, strategy implementation and control, and strategic evaluation and feedback (Richardson & Richardson, 1992; Ritchie, 2004; Viljoen, 1994).

Strange attractors are important as they provide an understanding of the strategy that emerges to address future disruption. Strange attractors are also important because they reflect the basic values and principles that unite individuals in attaining their common goals. This facet of designing a strategic response to disruptions has attracted limited attention in previous supply chain research, requiring a deeper examination of strange attractors.

After analyzing the data from the case company, the expert, and other sources, we observed some emerging patterns. We present our findings by structuring them under the purview of strategic planning

and management. The executives of the case company used their learnings during the crisis in their strategic planning process. One key respondent from the case company stated the following:

We are continuously watching the government guidelines and understanding their meaning for ours [sic] as well as for our customers' business [es]. We are contemplating when there can be a conducive environment for safe movement of our supply chain partners and what infrastructure we need to put in place. (Deputy General Manager-2).

The expert believed that firms must have a strong risk analysis and forecasting mechanism to handle any potential threat in a crisis:

The risk analysis and forecasting shall also be complemented with a right contingency and emergency plan to avert any potential threat. (Expert).

To understand the strategic direction and choice in a given situation, firms must resort to scenario planning and formulate and evaluate strategic alternatives to sustain their business. One senior manager at the case company described the company's strategy:

We don't want a potential crisis to keep us paralyzed...we are getting better with each learning [sic] and hence working with different possibilities to cope up [sic] any future eventuality. We value our relationship with our customers and hence [are] keeping all alternatives open to sustain our relationship and business. (General Manager).

Once the strategy is clear, firms need to focus on implementation. The expert whom we interviewed for this study also validated this narrative:

Organizations need to remove any barrier in strategy implementation in a crisis. They need to really act fast, and their inherent properties, like the structure of the organization, shall be responsive enough to act quickly. (Expert).

We observed that the case company had facilitated a decentralized organizational structure for fast decision-making. Another important factor was the ability to mobilize and manage appropriate resources:

We are dedicating appropriate resources to fight with [sic] any potential crisis emanating in future [sic]. We are also in the process of identifying permanent alternative sources that could be activated in the time of crisis for serving our customers...yes, we also aim to prepare our workforce to cope up [sic] with such kind of potential eventualities. (General Manager).

The expert interviewed for the study identified evaluation and feedback on the entire process as important:

Firms need to strictly monitor and evaluate the strategies that they put in place. It [sic] should be augmented with regular feedback, and they shall also be prepared to do course corrections if results are not as anticipated. (Expert).

Since strategic decision-making affects operational decision-making, we examined the structure of the operational decision-making process and its various factors. The expert noted the following:

The strategic decision-making process shall ensure that internal operations at the supply company shall not be hampered in any case. [The] company shall be looking at its competitors and other stakeholders to collaborate in the time of crisis, and a formal mechanism shall be kept in place. (Expert).

In addition to operational decision-making, the case company's manager pointed out the company's new approach:

Our firm is taking one step forward and creating a cooperative approach to help our supply chain partners. We will continue to invest in their physical and psychological well-being. (Deputy General Manager-1).

The insights about the strange attractors in this study were distinct from the previous research on crisis response. Most studies limit the discussion on strange attractors on restoring trust (Liska et al., 2012), structure (Speakman & Sharpley, 2012), and chaotic and random behavior (Hung & Tu, 2014). In contrast, the current study provides a more in-depth and multi-layered structure of strange attractors focusing on long-term strategic and operational decision-making.

We summarize all the findings in the form of a framework (Fig. 1). This framework advances the theoretical understanding of supply chain disruptions and their management during crises.

4.3. The crisis management framework

We developed a crisis management framework using chaos theory and a process model. The cause and consequence components of the process model (Shrivastava, 1993) reflect the bifurcation and fractal stages of chaos theory. The causes of supply chain disruption include the unpredictability of the crisis, conflicting and noncoherent information dissemination, and health and psychological problems. The consequence of the crisis is the failure of the supply chain infrastructure, which immediately affects the company's operations and customers. The overall situation triggers a state of confusion among stakeholders.

The coping and caution components of the process model (Shrivastava, 1993) reflect the self-organization and strange attractors stages of chaos theory. We examined self-organization in terms of identity, information, and relationships (Wheatley, 2007). Our framework highlights the importance of quickly and accurately disseminating information to all stakeholders on the nature of the crisis and immediate responses. The business continuity plan and the physical and psychological well-being of the people involved in the process are equally important in this stage. Operational decision-making includes implementing a network utilizing supply from an alternate location and strengthening operational forecasting and intelligence systems.

In the framework, caution focused on long-term strategic decision-making. The elements of strategic decision-making are strategic analysis, strategic direction and choice, strategic implementation and control, and strategic evaluation and feedback. Macro- and micro-level environmental issues are important, including understanding government regulations and guidelines; and customers, competitors, and supply chains.

Other important attributes in long-term strategic decision-making include the role of scenario and contingency planning, emergency planning, and developing strategic alternatives. The framework also emphasizes implementing a responsive organizational structure, displaying an effective leadership style, and mobilizing appropriate resources, including crisis communication and control modalities. Organizations need effective, continuous monitoring strategies and systems to improve and perform course corrections when required. Within operational decision-making, the framework highlights the importance of collaborating with competitors and other stakeholders to ensure uninterrupted supplies and a robust operational forecasting and intelligence system.

In summary, traditionally, the focus of supply chains during periods of disruption is on supply chain elements such as production, warehousing, stocking, and inventory. Our framework suggests that firms need to take a more holistic view in addressing disruptions. First, the framework indicates that to manage disruptions, firms must recognize and understand their antecedents. The framework suggests that this information is usually unclear, and the path of disruptions is unpredictable. The second issue facing firms during disruptions is that the disruptions' impact on supply chains and firms is poorly understood. The framework advises that firms structure tactical decision-making and operational decision-making in a specific manner to cope with disruptions. Finally, to prevent and minimize future disruptions, firms must evolve the structure of strategic and operational decision-making in a particular way.

The framework provides additional insight from extant literature in three ways. First, the comprehensive nature of the theoretical framework examines different stakeholders and integrates knowledge from various disciplines such as marketing, organization behavior, strategy, and operations management. The cross-functional perspective has not been observed in extant literature and helps develop important insights about addressing a major disruption. Second, the framework provides a comprehensive theoretical understanding of supply chain during disruptions and suggests the necessary steps to handle the different facets of the disruption, an area that has not been addressed by extant literature. Third, the framework specifies a temporal perspective, from a short-term (self-organization) perspective to a long-term (strange attractor) perspective. A temporal perspective has not been observed in the literature.

5. Implications

The contribution of this paper is in three areas. First, we examine decision-making by firms facing significant disruptions. The COVID-19 disruption is regarded as the most significant disruption since World War II in both its scope and duration. Second, we use chaos theory to better understand decision-making processes under major disruptions. Finally, we develop a framework to understand the decision-making process during major disruptions and provide guidelines for decision-making.

5.1. Theoretical implications

There are four key theoretical implications of our research. First, we develop a comprehensive framework utilizing chaos theory to deepen our understanding of organizational responses to a major crisis like COVID-19. We suggest four major elements of our framework—causes, consequences, coping, and caution. Our research suggests that this is the first comprehensive framework that examines supply-chain disruption during a major crisis. This framework addresses the call by researchers to develop comprehensive frameworks that address the successful transformation of organizations (Bundy et al., 2017).

Second, our research theoretically delineates short-term and long-term decision-making during a major crisis. Short-term decision-making strategies focus on tactics, and long-term decision-making focuses on strategies. We did not observe this temporal division in previous research. We find that identity, information, and relational efforts structure short-term decision-making. We find strategic analysis, strategic direction and choice, strategy implementation and control, and strategic evaluation and feedback structure strategic decision-making.

Third, the paper explores supply chain disruptions by employing two theories/frameworks—chaos theory (Lorenz, 1963) and the 4-C crisis management framework (Shrivastava, 1993). There has been a call to unify and apply extant frameworks/theories to examine phenomena, and our study successfully applied two theories/frameworks to develop a deeper understanding of crisis management.

Finally, this study contributes to the literature by its applicability to buyer-supplier relationships and examining suppliers' responses during a disruption. In examining transactional *versus* relationship strategies, buyers seek some sellers for transactions and some for relationships. Applying the framework suggests that some firms are better at bifurcation, fractals, self-organization, and strange attractors. Firms that are better at these attributes will be better partners for long-term relationships. Buyers may seek to evaluate how firms performed on bifurcation, fractals, self-organization, and strange attractors attributes to evaluate the relationship potential. Firms that underperform on these attributes may be limited to transactional relationships or may be required to provide a dramatically higher level of offerings to satisfy customers.

5.2. Managerial implications

We undertook this study to understand how business-to-business firms could manage supply chain disruptions during crises like the novel coronavirus pandemic. Managers should recognize that there are four distinct aspects of managing crises: recognizing the antecedents of the crisis (bifurcation), recognizing its consequences (fractals), taking measures to respond to a crisis that has already occurred (coping), and taking measures to prevent or minimize the impact of potential crises (caution).

Recognizing the antecedents of the crisis. Our study suggests that firms sense crises but cannot accurately comprehend their size. We suggest that firms create a strategic initiatives team that is given the task of monitoring shifts in the environment. Such teams should meet frequently and discuss changes in the environment to quickly diagnose the beginning of a crisis. The teams can be trained to separate the signal from the noise by conducting scenario planning (Oliver & Parrett, 2018).

Recognizing the consequences. Our study suggests that firms that sense a crisis are often unable to accurately comprehend its consequences. We suggest that open communication can help mitigate this lack of understanding. First, as suggested earlier, a strategic initiatives team can help recognize the crisis's consequences. In addition, our findings suggest a closer relationship between supply chain partners. We suggest that firms create strategic teams with their supply chain customers and partners. Such teams should frequently meet to discuss current issues and should meet more frequently during a crisis.

Responding to the current crisis. Firms should develop plans to respond to a crisis when it is recognized. Our findings suggest that firms should set up a crisis command center to address two types of issues: tactical decisions (identity, information, and relationships) and operational decisions (continuity, network, customers, and intelligence).

Firms need to revisit their corporate identity, enforce this identity in all decisions, and decentralize certain decision-making processes. Firms also need to collect accurate information and disseminate the information through the crisis command center. Finally, firms must ensure the welfare of their customers (through continuity plans) and employees (financial, physical, and psychological well-being).

In operational decision-making, firms must first ensure the continuity of their internal operations. They need to use a network-based approach (using networks to ensure supply) and ensure that supply chain partners are operational. Finally, firms must develop stronger intelligence to forecast the immediate future of the crisis.

Responding to prevent and minimize the impact of future crises. Firms need to make fundamental changes to minimize the impact of future crises. First, firms must enhance their ability to conduct strategic analysis by developing better skills for understanding the macro-environment (economy, health, and regulations) and micro-environments (customers, supply chain partners, and competitors). We suggest that firms create a group to examine the environment and perform risk analysis and forecasting. Second, we suggest that firms conduct scenario and contingency planning, plan for emergencies, and develop strategic alternatives. Third, we suggest that firms create a responsive organizational structure and develop crisis leadership skills. Fourth, we suggest that firms consistently examine their crisis strategies and conduct dry runs. Finally, firms need to develop supply chains with more resiliency, which may include redundancy, including suppliers, inventory, and other logistics.

6. Limitations and directions for future research

We have focused on the supply chain's three main linkages: supplier, buyer, and supply chain partner. Future studies may include these context-specific intermediaries and their role in crisis management strategies. We used different stages of chaos theory to understand the disruption in the supply chain and the management of disruptions in a limited time frame. Future studies could explore the interrelation

between different stages of chaos theory under varying contextual factors and a long-term perspective.

We use the single-case-study method by selecting a case company as a sample. Future studies may explore the supply chain disruption or any similar disruption by collecting samples from multiple companies from diverse industries to create additional knowledge. Moreover, future studies may look beyond the case research method and incorporate other research techniques when studying crisis management. Future research questions may include the following: the impact of risk management strategies on buyer-seller relationships; leadership required for developing and implementing an effective crisis management strategy; collaborative approaches during a crisis; effective coping strategies at functional and business level; and, the applicability of the resource-based view in a time of crisis. We hope that this paper provides the impetus for future research in this area.

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